

The impact of de-industrialization on the urban-rural income gap: evidence from China

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ABSTRACT

The global industrial structure is undergoing a profound transformation from tangible, production-based industries toward intangible, service-oriented sectors. As a central manifestation of this transformation, de-industrialization has important implications for income distribution and constitutes a key issue in development economics. However, existing research has paid insufficient attention to its effects on the urban-rural income gap, and systematic city-level evidence remains scarce. This study identifies de-industrializing Chinese cities based on changes in the manufacturing share and uses the system generalized method of moments (SGMM) to assess the association between de-industrialization and the urban-rural income gap. The results show that city-level de-industrialization in China is widespread, regionally heterogeneous, and often premature. De-industrialization is significantly and positively associated with the urban-rural income gap, particularly in central and western China, where premature de-industrialization is more prevalent. By contrast, in normally de-industrialized cities with higher levels of economic development, de-industrialization is negatively associated with the urban-rural income gap. Furthermore, a slowdown in the transfer of rural surplus labor and the increasing service orientation of the employment structure are identified as potential mechanisms underlying this association.

1. Introduction

De-industrialization refers to a structural economic shift in which an economy moves from the manufacturing sector to the service sector (Tregenna, 2014; Wang, Wang, & Du, 2011). It represents the process of industrial structural evolution by industrial upgrading and relocation within the context of the new international division of labor, and is typically characterized by a sustained decline in the share of manufacturing value added and employment (Rowthorn & Ramaswamy, 1998). China's manufacturing value added and the share of manufacturing employment peaked in 2011 and 2012, respectively, before beginning to decline, marking the transition to the late stage of industrialization characterized by de-industrialization (Huang & He, 2019). This shift implies that the manufacturing sector, which has

long served as a key pillar of non-agricultural employment for the rural labor force, has begun to contract, and the urban-rural income linkage once sustained by large-scale industrialization is weakening. Based on data from 288 prefecture-level administrative regions in China from 2000 to 2020, this study examines the impact of urban de-industrialization on the urban-rural income gap and reveals its underlying mechanisms, thereby providing insights into the income distribution effects of structural transformation in China's new stage of development.

While existing research has largely examined the impact of de-industrialization on overall income inequality, relatively few studies focus specifically on the urban-rural income gap. De-industrialization, as a process of factor reallocation in the material world (Wang et al., 2010), leads to a decline in the employment rate and exacerbates income

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inequality in both developed and developing countries (Gornig & Goebel, 2018; Liu & An, 2020). In this process, the shift of employment from manufacturing to services has led to the polarization of the employment structure: high-skilled managerial, professional, and technical positions have increased significantly, while semi-skilled, middle-income jobs have stagnated and low-end manufacturing jobs have continued to decline (Lombard & Crankshaw, 2017). This has resulted in a marked contraction of the middle-income group and a polarization of income distribution (Chiu, W., & Lui, 2004; Baum, 1997). These findings provide a theoretical basis for understanding the distributional effects of de-industrialization.

As a key component of income inequality in China, the urban-rural income gap has consistently accounted for approximately 50% of overall income inequality (Zhu et al., 2020). This implies that the persistent urban-rural divide exerts significant negative effects on social equity and economic development in China (Luo, 2017). Urban and rural areas are not two isolated sectors (Guo and Jin, 2025), but rather a highly integrated system connected through labor mobility and industrial linkages, with manufacturing serving as the key channel through which the rural migrant labor force enters urban employment (Han & Kong, 2020). However, the emergence of de-industrialization has forced a large number of rural workers, due to skill mismatches, to experience wage losses as they are pushed from shrinking middle-income manufacturing jobs into low-end service sectors (Qian & Wang, 2022). This stratification of the urban and rural labor force within the employment structure constitutes a direct manifestation of income inequality along urban-rural lines.

The impact of de-industrialization on the urban-rural income gap varies across different developmental contexts (Clark, 2022). Normal de-industrialization driven by industrial upgrading and relocation follows a progressive path from agriculture to manufacturing to services. Through the transfer of the rural labor force to high-productivity manufacturing sectors, workers are able to share in the dividends of industrialization, thereby narrowing the urban-rural income gap (Han & Kong, 2020). However, premature de-industrialization in regions with low per capita income disrupts this virtuous cycle. The relocation and contraction of manufacturing means that a key sector for absorbing labor is lost before alternative industries are fully developed, forcing the rural labor force to return to agriculture or low-end service sectors and experience significant income losses (Qian & Wang, 2022). Under premature de-industrialization, the reverse substitution effect exerts a stronger adverse impact on the rural labor force, leading to a persistent widening of the urban-rural income gap (Han & Kong, 2020; Qian & Wang, 2022). This indicates that de-industrialization is not merely an industrial shift, but a profound reshaping of urban-rural income distribution. However, empirical evidence on this process at the urban level remains limited.

Since the beginning of the 21st century, China's level of economic development has continued to improve, yet disparities between urban and rural areas remain pronounced. China has even been described as having the world's largest urban-rural income gap (Ding et al., 2019). Although a substantial body of research has examined the effects of de-industrialization on overall income inequality, studies focusing on the urban-rural income gap remain limited. Accordingly, this study uses an SGMM model to examine the association between urban de-industrialization and the urban-rural income gap in China by addressing three questions: (1) How is urban de-industrialization associated with the urban-rural income gap? (2) How do different types of de-industrialization differ in their associations with this gap? (3) Through which mechanisms is urban de-industrialization associated with the urban-rural income gap?

The unique contributions of this paper are as follows. First, based on changes in the share of manufacturing, this study identifies cities undergoing de-industrialization in China and examines its impact on the urban-rural income gap at the city level, providing empirical evidence from Chinese cities. Second, drawing on the concept of premature de-

industrialization (Rodrik, 2016), this study further explores the heterogeneous effects of premature, normal, and non-de-industrializing cities on the urban-rural income gap, thereby enriching the empirical evidence on this concept in developing countries. Third, drawing on two dimensions—the transfer of rural surplus labor and the degree of service orientation of the employment structure—this study examines the mechanisms through which de-industrialization affects the urban-rural income gap, as well as the relative importance of these mechanisms.

The paper is organized as follows. Section 2 reviews the relevant literature and develops the research hypotheses. Section 3 describes the research methods and data. Section 4 identifies the current state of city-level de-industrialization in China and presents the empirical results. Section 5 discusses the results and their policy implications, and Section 6 concludes the paper.

2. Literature review and research hypothesis

Changes in industrial structure reflect both industrial -structure rationalization and upgrading (Cheng, 2014). Existing literature has shown that the rationalization of regional industrial structure leads to a narrowing of the urban-rural income gap, while industrial structure upgrading widens that gap (Li, 2014). De-industrialization is a form of economic restructuring governed by the logic of capital accumulation and follows changes in industrial structure that depend on capital appreciation (Chen & Kang, 2015). As this process unfolds, changes in industrial location and a declining manufacturing employment share are transmitted through the labor market, thereby affecting the urban-rural income gap (Qian & Wang, 2022).

2.1. Impact of de-industrialization on urban-rural income gap

De-industrialization has weakened the manufacturing sector's ability to absorb labor (Qian & Wang, 2022). The manufacturing sector is typically characterized by high labor productivity and relatively small income differentials across skill levels. As the share of manufacturing employment declines, workers formerly employed in manufacturing—particularly the rural migrant labor force—face re-employment pressure and gradually move into the service sector (Pike, 2020). Compared with the manufacturing sector, income inequality within the service sector is more pronounced. Differences in educational attainment and skill levels between skilled and unskilled workers determine the extent to which they are affected by de-industrialization (Liu & An, 2020). Due to constraints in education and skills, a large number of rural unskilled workers are excluded from advanced industries and are forced to move into low-wage segments of the service sector, where they experience income losses or even unemployment, thereby reducing the overall income level of rural residents (Qian & Wang, 2022). This, in turn, creates substantial disparities in earnings between heterogeneous urban and rural workers within the same sector, resulting in “labor market polarization” (Mehic, 2018) and further widening the urban-rural income gap.

Existing studies either use cross-country macro-level data to show that de-industrialization induces labor mobility and thereby exacerbates urban-rural income inequality, or focus on China's provinces and show that manufacturing relocation further widens the urban-rural income gap. However, these studies fail to adequately capture the relationship between the intra-urban differentiation of urban and rural labor—particularly across the manufacturing and service sectors—and urban-rural income disparities. By focusing on the urban scale, this study enables a more direct examination of the micro-level transmission mechanisms through which de-industrialization affects urban-rural income inequality. Accordingly, we propose the following *hypothesis 1*.

Hypothesis 1. Urban de-industrialization is positively associated with the widening urban-rural income gap.

2.2. Heterogeneity of the impact of de-industrialization on urban-rural income gap

Regional differences in development conditions result in varying levels of industrial development. Regions with higher levels of economic development and relatively mature industrial development typically experience normal de-industrialization, which is a natural outcome of industrial upgrading (Wang et al., 2024). Such cities generally exhibit high levels of urbanization, relatively well-developed rural areas, and relatively small differences in education and skills within the labor force. Industrial restructuring tends to become more rational, with the service and manufacturing sectors developing in tandem. This, in turn, may not significantly widen the urban-rural income gap and may even narrow it by creating new employment opportunities in the service sector (Kong, 2020). However, for regions with relatively low levels of economic development, this primarily represents a negative and premature de-industrialization (Andriyani & Irawan, 2018). There are significant disparities in labor force quality, and the manufacturing sector is already showing a declining trend even before it has fully developed. In such cities, de-industrialization leads to the premature weakening of the manufacturing sector's ability to absorb rural labor, while low-end service sectors are unable to provide sufficient well-paid jobs, thereby further widening the urban-rural income gap (Liu & An, 2020; Luo, 2018).

These studies mainly adopt a cross-country comparative perspective and emphasize heterogeneity in the distributional effects of de-industrialization between developed and developing economies. However, limited attention has been paid to heterogeneity in the effects of different types of de-industrialization on the urban-rural income gap at the meso and micro levels. Accordingly, we propose Hypothesis 2.

Hypothesis 2a. Normal urban de-industrialization is negatively associated with the urban-rural income gap.

Hypothesis 2b. Premature urban de-industrialization is positively associated with the urban-rural income gap.

2.3. The impact mechanism of de-industrialization on the urban-rural income gap

Changes in industrial structure are inevitably accompanied by the reallocation of labor across sectors and the reshaping of income distribution patterns (Yi et al., 2025), and de-industrialization affects the urban-rural income gap by altering the employment structure. On the one hand, de-industrialization affects the urban-rural income gap by reducing opportunities for rural surplus labor to enter the labor market (Bluestone & Harrison, 1982). As the sector with the highest productivity and the strongest labor absorption capacity, the expansion and relocation of manufacturing can absorb a large amount of rural labor, facilitating their shift from the agricultural sector to the industrial sector (Han & Kong, 2020), thereby increasing rural residents' income and narrowing the urban-rural income gap (Hu, 2021; Zhang & Xu, 2010). However, de-industrialization reduces manufacturing employment opportunities, leading to a shift of workers into the service sector, while the service sector has limited capacity to absorb labor displaced from manufacturing (Stockhammer, 2004). This is particularly evident for surplus rural labor, which either remains in agriculture, moves into low-wage service employment, or even becomes unemployed. Such changes in employment structure may be associated with the widening of the urban-rural income gap.

On the other hand, de-industrialization leads to a more service-oriented transformation of the employment structure, thereby affecting the urban-rural income gap. Significant wage polarization exists within the service sector (Kollmeyer, 2018), with highly skilled labor concentrated in high-wage producer services, while low-skilled labor is mainly employed in low-wage consumer services. As de-industrialization drives the shift of the labor force toward the service

sector, unskilled rural workers are increasingly absorbed into low-wage service industries. In particular, for workers in regions experiencing premature de-industrialization, their income is even significantly lower than during their previous employment in the manufacturing sector (Xiao et al., 2022). This income shift may exacerbate the income disparity between urban and rural labor within the service sector, thereby being positively associated with the urban-rural income gap.

Existing studies have primarily examined the impact of employment structure transformation on the urban-rural income gap from a qualitative perspective, with some studies testing individual mechanisms. However, there is a relative lack of research that examines and compares these two pathways separately at the urban level. Accordingly, we propose Hypothesis 3.

Hypothesis 3a. De-industrialization is positively associated with the urban-rural income gap by slowing the transfer of rural surplus labor.

Hypothesis 3b. De-industrialization is positively associated with the urban-rural income gap by increasing the service orientation of the employment structure.

3. Research methods and data sources

3.1. Identification of de-industrialized cities

3.1.1. De-industrialized cities

Existing studies generally regard the manufacturing shares of value added and employment as core indicators of de-industrialization (Rowthorn & Ramaswamy, 1998). Given data availability and the need for consistent statistical definitions, this study uses the share of industrial value added in city GDP and the share of manufacturing employment in total employment within urban non-private units (hereafter, the "manufacturing value-added share" and "manufacturing employment share," respectively) to capture city-level trends in manufacturing value added and employment. De-industrialization is then identified according to the persistence of these trends.

Previous provincial-level studies have defined de-industrialization as a continuous five-year decline in the shares of manufacturing value added and employment (Li, 2020). To mitigate short-term fluctuations, potential inconsistencies in statistical coverage, and the greater volatility of city-level data, this study classifies cities with a continuous four-year decline in manufacturing shares as de-industrializing. Given the study period and the risk of misclassification caused by right-censoring, cities exhibiting a sustained and significant decline in manufacturing shares since 2017 are also classified as de-industrializing.

3.1.2. Prematurely de-industrialized cities

Premature de-industrialization refers to a de-industrialization process that occurs before the normal turning point of economic structural evolution, and primarily arises in countries or regions where per capita income levels are significantly lower than those of developed economies (Wei & Wang, 2019). To identify prematurely de-industrialized cities, this study follows Wang et al. (2024) and draws on the approach of Rodrik (2016) by employing a fixed-effects model to examine the nonlinear relationship between the manufacturing share and per capita income across cities, and to determine the per capita income threshold corresponding to the peak manufacturing share. The results reveal a clear inverted U-shaped relationship between the manufacturing share and per capita income (as shown in Table A in the Appendix). Based on the estimated coefficients, the per capita income levels corresponding to the peaks of the manufacturing value-added share and the share of employment are calculated to be RMB 24,770.19 and RMB 28,844.38, respectively.

Based on these thresholds, a de-industrialized city is classified as premature if per capita income at the peak of its manufacturing share is below the corresponding full-sample turning point—RMB 24,770.19 for the manufacturing value-added share or RMB 28,844.38 for the

manufacturing employment share. It should be noted that this identification strategy is based on the level of regional economic development rather than the specific drivers of de-industrialization. In developed regions, the relocation of low-end manufacturing and industrial upgrading represent normal de-industrialization. By contrast, in less developed regions, a decline in the manufacturing share before the normal turning point—when manufacturing has neither fully developed nor fulfilled its employment-absorption function—constitutes premature de-industrialization. To reduce the influence of short-term fluctuations, the manufacturing-share series is smoothed using a three-year moving average. The classification results remain largely unchanged.

3.2. SGMM

The urban-rural income gap exhibits temporal persistence because its current level is influenced by its previous level. Accordingly, this study includes a one-period lag of the dependent variable to capture dynamic adjustment. To address the resulting endogeneity, we use an SGMM estimator within a dynamic panel framework to examine the association between de-industrialization and the urban-rural income gap. The model is specified as follows:

$$Gap_{it} = \beta_0 + \alpha Gap_{it-1} + \beta_1 \ln dman_{it} + \beta_2 \ln pgdp_{it} + \beta_3 \ln open_{it} + \beta_4 \ln urb_{it} + \beta_5 \ln hc_{it} + \beta_6 \ln tra_{it} + \beta_7 \ln gov_{it} + \beta_8 \ln agr_{it} + \beta_9 V_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (1)$$

$$Gap_{it} = \beta_0 + \alpha Gap_{it-1} + \beta_1 \ln dman_{it} + \beta_2 \ln (dman_{it} * pgdp_{it}) + \beta_3 \ln open_{it} + \beta_4 \ln urb_{it} + \beta_5 \ln hc_{it} + \beta_6 \ln tra_{it} + \beta_7 \ln gov_{it} + \beta_8 \ln agr_{it} + \beta_9 V_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (2)$$

In the equations, i represents prefecture-level administrative regions, and t represents the year. The term Gap_{it-1} represents the urban-rural income gap index of the previous year, which is a lagging variable; $dman_{it} * pgdp_{it}$ is the interaction term between de-industrialization and economic development level; V is the instrumental variable; μ_i represents individual effects; λ_t is the time effect; and ε_{it} is a random disturbance term.

3.3. Mediation model with IV

This study introduces a mediation effect model and, combined with an instrumental variable approach, constructs an instrumental variable mediation model to address the endogeneity inherent in a single mediation framework (Dippel et al., 2022). Fig. 1 illustrates the mediation pathways, where Y denotes the dependent variable, M the mediator, T the core explanatory variable, and V the instrument. The model specifications are provided in Appendix Formula A.

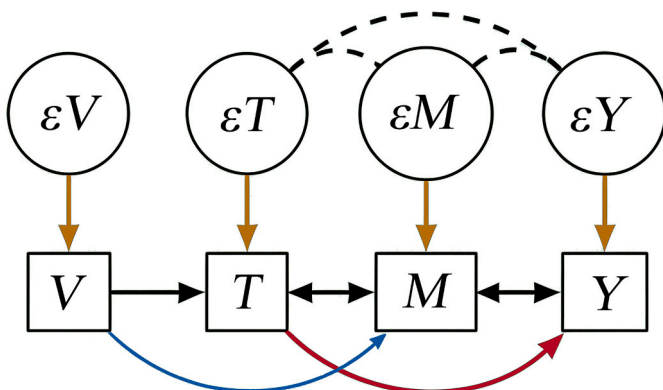


Fig. 1. Mediation effect path diagram.

3.4. Data sources

3.4.1. Variable selection

Dependent variable. The urban-rural income gap (Gap) is measured as the ratio of urban per capita disposable income to rural residents' per capita income. Because the statistical definition of rural income changed during the sample period, following Li et al. (2023), we use the per capita net income of rural residents for 2000–2012 and the per capita disposable income of rural residents for 2013–2020.

Core explanatory variable. The level of de-industrialization ($dman$) is the core explanatory variable and is defined as " $dman = 1 - Man$ " (Qian & Wang, 2022), where Man is the manufacturing employment share. To examine whether the association between urban de-industrialization and the urban-rural income gap varies with economic development, we also include the interaction between de-industrialization and the level of economic development ($dman * pgdp$).

Control variables. Based on the existing literature, this study controls for several factors associated with the urban-rural income gap. Regional economic development ($pgdp$) is measured by GDP per capita (Li et al., 2003); openness ($open$) by the ratio of total foreign trade to GDP (Koroso et al., 2020); urbanization (urb) by the share of permanent urban residents in the total population (Liao et al., 2023); human capital (hc) by the ratio of education expenditure to GDP (Peng, 2009); transportation infrastructure (tra) by highway mileage per capita (Lu et al., 2020); government intervention (gov) by the ratio of government fiscal expenditure to regional GDP (Chen & Gong, 2021); and agricultural transformation (agr) by the primary sector's share of GDP (Zhao & Yu, 2022). Policy intervention ($poli$) is represented by categorical variables corresponding to China's four major regional strategies: priority development of the eastern region, the rise of the central region, large-scale development of the western region, and comprehensive revitalization of the northeast.

Instrumental variables: To address potential endogeneity issues, including reverse causality and omitted variable bias, we use the lagged terms of the explanatory variables as internal instruments and additionally select four external instrumental variables. Regional topographic characteristics (roe) are measured using the regional average elevation. The railway opening status in the Republic of China period ($rail$) is defined as a categorical variable based on whether a city had railway access in 1933. Historical industrialization level ($hind$) is measured using industrial value added from 1990 to 2010. River density (riv) is measured by the ratio of total river length within a region to its land area. The selection of these instrumental variables follows the logic that historical and geographical characteristics shape the current industrial structure but are not endogenously determined by current income disparities.

Mediating variables. This study takes rural surplus labor transfer (ET) and the degree of service-oriented employment structure (ES) as mediating variables. Following Mcmillan and Rodrik (2014), we measure rural surplus labor transfer by the reduction rate in the share of primary industry employment, and proxy the degree of service-oriented employment structure using the ratio of tertiary industry employment to secondary industry employment. The specific calculation formula is shown in Appendix Formula B.

3.4.2. Data sources and processing

Data on manufacturing employment and total employment in urban non-private units are drawn from CEI Data (<https://ceidata.cei.cn/>) and city statistical yearbooks (2001–2021). Regional terrain data are calculated as mean elevation from China's digital elevation model. The remaining socioeconomic data come from the China City Statistical Yearbook (2001–2021), the China Population and Employment Statistical Yearbook (2001–2021), and the statistical bulletins of prefecture-level cities.

To retain as much sample information as possible, we first assessed missingness in the original data and then treated missing values as

follows. Single-year gaps were filled by linear interpolation; gaps longer than one year but no longer than four years were imputed using the corresponding provincial proportions; and missing observations at the beginning or end of a series were extrapolated using proportions from adjacent years and related indicators. Table 1 reports the descriptive statistics and interpolation rates for the original variables.

4. Results

4.1. Current state of urban de-industrialization in China

4.1.1. De-industrialized cities

During the study period, China remained broadly within the industrialization stage, and aggregate de-industrialization had not occurred at the national level. According to Huang and He (2019), China entered the late stage of industrialization around 2012, when the manufacturing share began to decline. This change, however, is better characterized as slower growth than as a persistent contraction in the absolute scale of manufacturing. China therefore remains a major manufacturing economy and has not yet experienced aggregate de-industrialization.

However, at the city level, de-industrialization has become a relatively widespread regional and structural phenomenon. Among the sample cities, 67.01% experienced a long-term downward trend in the manufacturing share. This decline is not driven by short-term economic cycles but instead reflects the cumulative effects of structural forces such as industrial restructuring, rising factor costs, and increasingly stringent regulatory constraints on production activities.

De-industrialized cities exhibit a pronounced spatial gradient (Fig. 2), with the highest number of de-industrialized cities located in the eastern region, where they are distributed in a continuous strip-like pattern. There is also a relatively large number of de-industrialized cities in the central region, with strong clustering distribution south of the Qinling-Huaihe line and scattered distribution north of that line. The smallest number of de-industrialized cities is in the western region, forming a de-industrialized city cluster that includes cities in Gansu Province, and a de-industrialized city cluster at the junction of Yunnan Province, Guizhou Province, and Sichuan Province. Overall, the spatial distribution of de-industrialized cities in China shows a clear spatial association with regional economic development levels. Cities with higher economic development levels are more likely to exhibit de-industrialization tendencies.

4.1.2. Prematurely de-industrialized cities

As noted above, premature de-industrialization occurs when the de-industrialization process begins at comparatively low levels of per capita income in developing economies (Dasgupta & Singh, 2007). China has

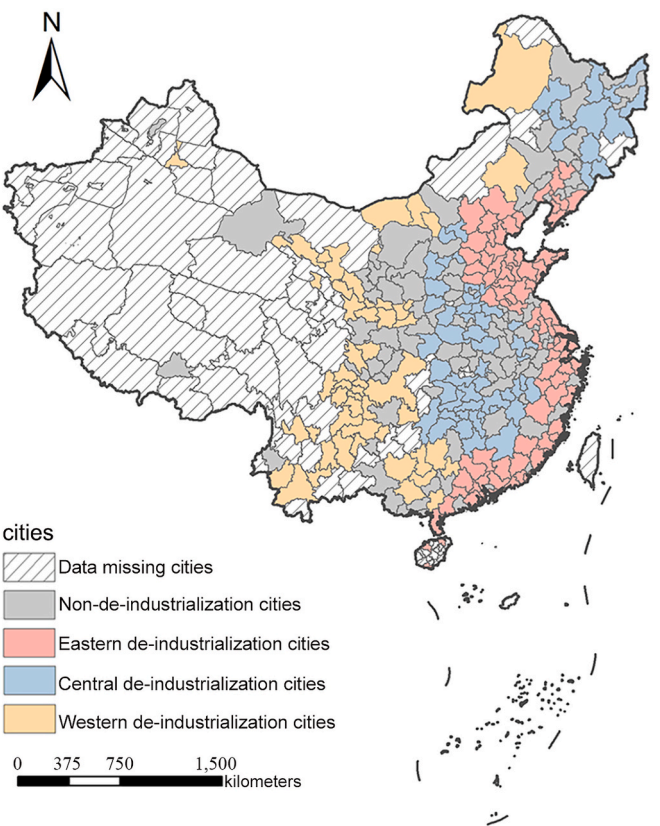


Fig. 2. Distribution of de-industrialized cities in China.

109 prematurely de-industrialized cities, accounting for 56.48% of all de-industrialized cities (Fig. 3). Unlike the east-to-west decline in the total number of de-industrialized cities, the proportion classified as premature rises from 32 cities (38.55%) in the east to 35 (59.32%) in the central region and 42 (82.35%) in the west. Resource-based cities account for 42.86% and 54.76% of prematurely de-industrialized cities in the central and western regions, respectively. Their structural rigidity and dependence on resource endowments make them particularly vulnerable to premature de-industrialization. In the eastern region, by contrast, the smaller share of resource-based cities and stronger locational advantages facilitate industrial transformation and upgrading, reducing the prevalence of premature de-industrialization. These descriptive findings are consistent with the heterogeneity proposed in Hypothesis 2.

Table 1
Statistical description of variables.

Variable	Obs	Mean	Std. Dev	Min	Max	Interpolation rate
Gap	6048	2.5596	0.6501	1.1125	8.3117	2.07%
dman	6048	75.9321	13.3991	18.6918	98.8800	1.52%
pgdp	6048	32786.55	28083.57	1200.00	188857	0.00%
dman*pgdp	6048	158.76	58.9892	20.7526	590.80	1.52%
open	6048	0.4653	0.1845	0.0541	0.9978	0.00%
urb	6048	19.7854	37.9063	0.0014	81.684	2.36%
hc	6048	3.0297	1.8172	0.2674	19.3671	9.87%
tra	6048	27.5055	18.3606	2.9352	177.76	1.49%
gov	6048	16.7979	9.9671	2.2048	102.67	0.00%
agr	6048	15.6128	10.3337	2.2048	102.68	0.43%
poli	6048	2.2361	10.3846	1.0000	4.0000	0.00%
roe	6048	533.24	649.52	7.3372	4826.61	0.00%
rail	6048	0.3160	0.4649	0.0000	1.0000	0.00%
hind	6048	2372245	4562197	1283.48	72182946	1.97%
riv	6048	0.2073	0.1466	0.0170	1.3994	0.00%
ET	5760	0.0350	0.3788	-4.0000	0.9828	5.43%
ES	5760	1.5699	1.1526	0.1823	21.2791	4.86%

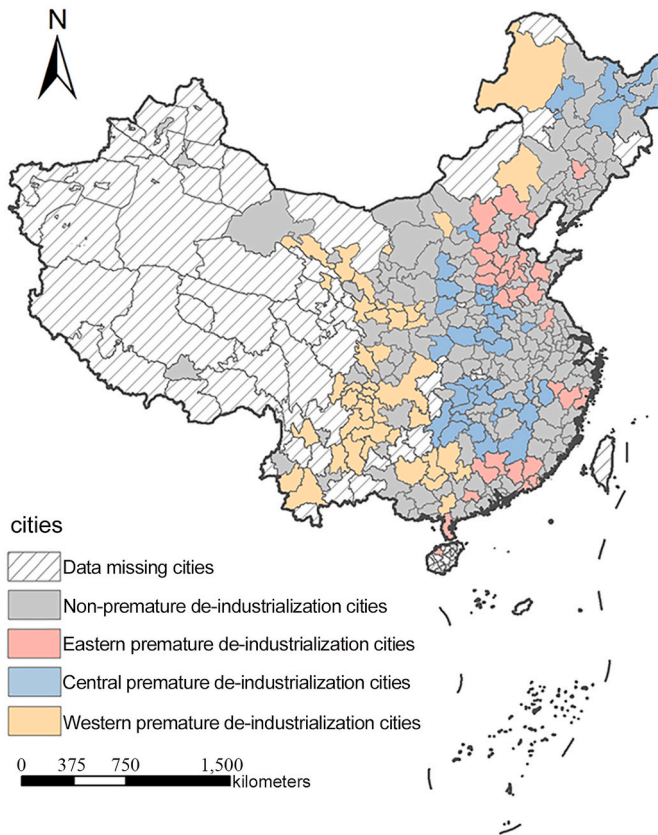


Fig. 3. Prematurely de-industrialized cities in China.

4.2. Impact of de-industrialization on the urban-rural income gap

4.2.1. Benchmark regression results

Panel unit-root tests indicate that most variables are stationary; those containing unit roots become stationary after first differencing. The cointegration tests reject the null hypothesis, indicating a significant long-run relationship among the panel variables and supporting the subsequent regression analysis.

Table 2 reports the baseline estimates of the association between urban de-industrialization and the urban-rural income gap. The p-values for the AR(2) and Hansen tests exceed 0.1 and are below 0.9, indicating no second-order serial correlation and supporting the joint exogeneity of the instruments. The results show a significant positive association

Table 2
Baseline regression results.

Variable	dman-GMM(1)		dman-GMM(2)	
	coef	std.err	coef	std.err
<i>L.Gap</i>	0.9329***	0.0907	0.0936***	0.0919
<i>Indman</i>	0.2071**	0.0941	0.2793***	0.1095
<i>lnpgdp</i>	−0.0786**	0.0394		
<i>ln(dman*pgdp)</i>			−0.0775**	0.0394
<i>lnopen</i>	−0.0076	0.0132	−0.0075	0.0134
<i>lnurb</i>	0.0368*	0.0216	0.0375*	0.0216
<i>lnhc</i>	−0.0281	0.0633	−0.0267	0.0629
<i>lntra</i>	0.0753*	0.0413	0.0703*	0.0411
<i>lngov</i>	−0.0518	0.0451	−0.0496	0.0446
<i>lnagr</i>	−0.0658***	0.0269	−0.0628**	0.0267
<i>poli</i>	−0.0452**	0.0210	−0.0441**	0.0211
P-Hansen	0.596		0.546	
P-AR(1)	0.000		0.000	
P-AR(2)	0.452		0.546	
N	6048		6048	

Notes: ***, **, and * are significant at 1%, 5%, and 10% levels.

between urban de-industrialization and the urban-rural income gap. In dman-GMM (1), a one-percentage-point increase in urban de-industrialization is associated with a 0.2071% widening of the gap. In dman-GMM (2), de-industrialization remains positively associated with the gap, whereas its interaction with economic development is significantly negative. Economically advanced cities tend to have mature manufacturing sectors, stronger integration between manufacturing and services, and a smaller, more highly skilled rural labor force with better access to well-paid service-sector employment. Once economic development reaches a sufficiently high level, de-industrialization may therefore narrow the urban-rural income gap. In China, however, de-industrialization often begins before urban manufacturing has fully matured and is thus frequently premature; under these conditions, it is associated with a wider urban-rural income gap. These findings support Hypothesis 1.

With respect to the control variables, economic development level, agricultural transformation, and policy intervention indicators have significant negative effects on the urban-rural income gap. In contrast, urbanization level and transportation infrastructure conditions exert significant positive effects on the urban-rural income gap. Indicators such as the level of openness, human capital, and government intervention are statistically insignificant.

4.2.2. Robustness tests

This study assesses robustness by adjusting the variables, changing the regression specification, and restricting the sample (Table 3). Models (1), (2), and (4), respectively, add a control for industrial relocation, replace the employment-based de-industrialization measure with an output-based measure, and exclude instruments related to natural factors. The estimated association between de-industrialization and the urban-rural income gap remains broadly consistent with the baseline results. The coefficient for value-added-based de-industrialization is positive but statistically insignificant, possibly because output-based measures are more sensitive to price fluctuations and inter-industry differences in profitability. Employment-based de-industrialization more directly captures changes in labor-market structure and is therefore used as the core measure.

Model (3) employs the spatial Durbin model to verify the robustness of the findings and further reveals that de-industrialization exerts a significant positive spatial spillover effect on the urban-rural income gap at the city level. This may be related to the reallocation of low-skilled labor induced by the decline in local manufacturing jobs. Some laborers may migrate to surrounding cities, thereby increasing market competition among low-skilled workers in neighboring cities and potentially affecting wage levels in local low-skilled jobs. This process is positively associated with changes in the regional urban-rural income gap. Model (5) reduces the regression sample, yet the results remain consistent with these findings. Overall, the empirical results of this study are robust.

4.3. Heterogeneity analysis

This section examines heterogeneity by distinguishing among prematurely de-industrialized, normally de-industrialized, and non-de-industrialized cities. Table 4 shows clear differences in the association between de-industrialization and the urban-rural income gap across these groups. For prematurely de-industrialized cities, the association is consistent with the full-sample estimates but larger in magnitude: a one-percentage-point increase in de-industrialization is associated with a 0.2501% widening of the gap. In China, premature de-industrialization may produce a form of “Baumol’s cost disease,” in which labor moves from high-productivity manufacturing to lower-productivity services. This transition slows the transfer of rural labor and is associated with a wider urban-rural income gap (Gong & Zhang, 2022). To reduce potential bias from a small number of cities undergoing functional transformation, we exclude Chongqing and eight provincial

Table 3
Robustness tests.

Variable	model (1)	model (2)	model (3)		model (4)	model (5)
			direct	indirect		
<i>L.Gap</i>	0.8972*** (0.066)	0.8396*** (0.167)			0.9281*** (0.107)	0.8355*** (0.072)
<i>Indman</i>	0.1453*** (0.052)	0.0524 (0.088)	0.0723*** (0.0151)	1.4831* (0.8126)	0.2152*** (0.096)	0.1188*** (0.057)
Control	Y	Y	Y	Y	Y	Y
P-Hansen	0.321	0.301			0.409	0.132
P-AR(1)	0.000	0.000			0.000	0.000
P-AR(2)	0.327	0.596			0.613	0.215
R ²			0.4938			
N	5760	6048	6027		6048	4674

Notes: ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively. Standard errors are reported in parentheses. Models 1 and 2 adjust the variables; Model 3 changes the model specification; and Models 4 and 5 reduce the number of instruments and the sample size, respectively.

Table 4
Heterogeneity tests of the effects of de-industrialization.

Variable	Premature de-industrialization		Normal de-industrialization		Non-de-industrialization	
	coef	std.err	coef	std.err	coef	std.err
<i>L.Gap</i>	0.7680***	0.1283	1.0456***	0.2270	0.8934***	0.1248
<i>Indman</i>	0.2501**	0.1162	−0.2242**	0.1144	0.1994*	0.1131
<i>lnpgdp</i>	−0.0443	0.0709	−0.0387	0.0530	−0.0316	0.1212
<i>lnopen</i>	−0.0111	0.0197	−0.0090	0.0194	0.0161	0.0156
<i>lnurb</i>	0.0056	0.0499	−0.0586	0.0960	0.0146	0.0152
<i>lnhc</i>	0.0663*	0.0417	−0.2317	0.2004	0.1018	0.1071
<i>lntra</i>	−0.0028	0.0359	−0.0270	0.0480	0.0533	0.0567
<i>lngov</i>	−0.0524	0.0727	0.2276*	0.1511	−0.0934*	0.0507
<i>lnagr</i>	−0.0762***	0.0288	0.0087	0.0360	−0.0401	0.0551
<i>poli</i>	0.0113	0.0302	0.0010	0.0226	−0.0188	0.0224
P-Hansen	0.437		0.511		0.892	
P-AR(1)	0.000		0.001		0.000	
P-AR(2)	0.561		0.297		0.137	
N	2289		1764		1995	

Notes: ***, **, and * are significant at 1%, 5%, and 10% levels.

capitals—Shijiazhuang, Hohhot, Harbin, Jinan, Guiyang, Kunming, Xi'an, and Xining—and re-estimate the models. The results in Appendix Table B remain robust.

The development of de-industrialization in normally de-industrialized cities has a significant negative effect on the urban-rural income gap, indicating that de-industrialization in cities with higher levels of economic development is negatively statistically associated with the widening of the urban-rural income gap. For every one percentage point increase in the level of de-industrialization in such cities, the urban-rural income gap decreases by 0.2242%. This may be attributable to the fact that normal de-industrialization occurs at the mature stage of industrial development. Cities at this stage mainly achieve de-industrialization through industrial upgrading, and its impact on rural surplus labor is far weaker than that in prematurely de-industrialized cities. In addition, in cities that have already largely completed the shift toward non-agricultural sectors, the skill gap between urban and rural labor is relatively small. In addition, manufacturing and service industries in such cities exhibit a trend of integrated development. A decline in the share of manufacturing does not necessarily imply a contraction in the absolute scale of manufacturing, but rather reflects an upgrading toward the higher end of the value chain. The wage premiums in high value-added manufacturing segments partially offset the impacts of low-end job losses and are overall negatively associated with the urban-rural income gap.

In addition, the de-industrialization in non-de-industrialized cities is positively associated with the urban-rural income gap, but both the magnitude of the association and its statistical significance are relatively low. These results indicate that the impact of different types of de-industrialization on the urban-rural income gap is heterogeneous. These findings support Hypothesis 2.

4.4. Mechanism analysis

Both de-industrialization and the indicator of the service-oriented transformation of the employment structure reflect important changes in the process of industrial restructuring, and they are associated with each other to some extent. It should be noted that the de-industrialization indicator used in this study primarily captures the relative contraction of the manufacturing sector, whereas the service-oriented transformation of the employment structure primarily reflects the reallocation of labor across different industrial sectors. Thus, the two measures emphasize changes in industrial sectors and adjustments in the employment structure, respectively. Furthermore, to reduce the potential mechanical correlation between the core explanatory variable and the mediating variables, we use value-added-based de-industrialization as an alternative measure to further examine the roles of rural surplus labor transfer and the service-oriented transformation of the employment structure in the association between de-industrialization and the urban-rural income gap.

Table 5 shows that de-industrialization is significantly and negatively associated with the transfer of rural surplus labor, while such transfer is significantly and negatively associated with the urban-rural income gap. Together, these relationships generate a significant positive indirect effect. Rural surplus labor transfer therefore plays a partial mediating role: de-industrialization may widen the urban-rural income gap by slowing the transfer of rural surplus labor, consistent with Qian and Wang (2022). Hypothesis 3a is supported.

Regarding the service orientation of the employment structure, de-industrialization significantly increases the service-sector share of urban employment, which is in turn positively associated with the urban-rural income gap, generating a significant positive indirect effect.

Table 5

Tests of the mechanisms linking de-industrialization to the urban-rural income gap.

Mediating Variables	ET-mediate	ES-mediate
Panel A		
Outcome: Gap		
β_Y^M	−8.3571** (3.5324)	0.9244** (0.4299)
DE: β_Y^T	0.0254 (0.0222)	−0.4229* (0.2197)
Panel B		
Model Parameters		
β_M^T	−0.1244* (0.0718)	0.3348*** (0.0786)
IE: $\beta_M^T \beta_Y^M$	1.0399** (0.4395)	0.3095** (0.1439)
TE	1.1629*** (0.3428)	0.3992*** (0.1344)
S	0.8942	0.7753
95% conf	[0.1784, 1.9015]	[0.0273, 0.5916]
Controls	Y	Y
N	5473	5473

Notes: ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively. Standard errors are reported in parentheses.

Although service-sector growth can partly offset manufacturing job losses, de-industrialization and service-sector expansion may produce an imbalance between the loss of well-paid manufacturing jobs and the growth of low-paid service jobs. This structural disparity is positively associated with a widening urban-rural income gap. *Hypothesis 3b* is supported.

This study estimates each mediator separately; consequently, the mediation proportions are not additive. The estimated mediation shares for rural surplus labor transfer (89.42%) and the service orientation of the employment structure (77.53%) are both high. This is because de-industrialization widens the urban-rural income gap through these mechanisms while also generating countervailing effects through channels such as industrial upgrading and policy adjustment. These opposing effects reduce the total effect and therefore yield comparatively large mediation shares.

5. Discussion

Before proceeding further, it is necessary to clarify the identification scope of this study. While the SGMM approach with instrumental variables alleviates potential endogeneity concerns, it does not establish strict causal identification. Therefore, the empirical findings should be interpreted as robust statistical associations between urban de-industrialization and the urban-rural income gap, rather than definitive causal effects. The subsequent discussion of mechanisms and policy implications is thus primarily interpretative.

5.1. The prevalence and spatial pattern of de-industrialization in China

De-industrialization, as a phenomenon of regional economic and industrial restructuring in the context of industrial transfer, industrial upgrading, and production globalization, has long been a matter of practical concern in China. Current research indicates that de-industrialization exhibits multi-scale and multi-type characteristics across different stages of development and economic contexts (Clark, 2022). At the meso- and macro-scales, regionality and prematurity are prominent features of de-industrialization in China (Wang & Wang, 2011; Sheng, 2020).

Further research at the city level in China reveals that the de-industrialization of Chinese cities not only exhibits regional and premature characteristics but also demonstrates prevalence and spatial regularity. This phenomenon is not evenly distributed across Chinese cities but gradually decreases from east to west. This gradient spatial

pattern is broadly consistent with the regional specialization and division of labor system that has developed in China over the long term. Eastern cities, benefiting from higher levels of development and network advantages, are more likely to achieve manufacturing restructuring through industrial upgrading; whereas some central and western cities, due to their weaker industrial foundations and insufficient development of alternative industries, are more likely to experience the coexistence of manufacturing contraction and inadequate industrial absorption capacity. This also provides an important background for the greater concentration of premature de-industrialization in central and western China.

Additionally, the observed spatial spillover effects may reflect regional linkages arising from industrial relocation and labor reallocation processes among cities. As urban industrial restructuring in China becomes embedded in regional division of labor and the reconfiguration of urban networks, de-industrialization in the focal city may affect neighboring cities through regional linkages, leading to industrial absorption and labor mobility. We further find that, unlike the aggregate de-industrialization observed in countries such as the United Kingdom and the United States, China, despite exhibiting widespread de-industrialization internally, remains a major manufacturing power on a global scale and has not yet exhibited aggregate de-industrialization. The current characteristics of de-industrialization in China are influenced not only by economic globalization but also by industrial upgrading, rising factor prices, and periodic overcapacity. The government should implement relevant policies to mitigate the risks posed by large-scale manufacturing offshoring, sluggish industrial upgrading, and the constraints of global value chain segmentation. It is worth noting that with rapid economic development, higher levels of industrialization, and the transformation and upgrading of industrial structures, the characteristics of aggregate de-industrialization in China will become increasingly evident in the future.

5.2. Heterogeneous effects of de-industrialization and discussion on its conceptual boundaries

De-industrialization is an inevitable economic phenomenon that emerges after economic development reaches a certain stage (Wang & Wang, 2011). Relevant studies both domestically and internationally have reported a positive relationship between de-industrialization and income inequality (Kollmeyer, 2018; Lombard & Crankshaw, 2017). Based on evidence at the city level in China, this study finds that the average effect masks the heterogeneous impacts of different types of de-industrialization, with normal de-industrialization and premature de-industrialization exhibiting opposite associations with the urban-rural income gap. This suggests that the income distribution effects associated with the decline in the share of manufacturing are not uniform, but may be influenced by differences in the stages of industrial adjustment and structural characteristics.

In this study, the identified “premature de-industrialization” is operationally defined as a decline in the share of manufacturing during the stage of low GDP per capita. This indicator captures the decline in the manufacturing share but does not directly identify the underlying causes. Such a decline may result from a genuine deterioration in local manufacturing competitiveness (premature de-industrialization in the conventional sense), proactive functional upgrading within the regional division of labor system (where manufacturing activities are transferred to other cities and cities shift toward high value-added activities such as research and development and services), or the spatial reallocation of manufacturing across cities (industrial relocation). Particularly in the context of deepening regional division of labor and the reconfiguration of urban networks in China, the decline in the share of manufacturing is not only driven by the deterioration of its own competitiveness but is also jointly influenced by factors such as regional industrial relocation, firms' establishment of production facilities in other cities, and adjustments in urban functional specialization (Ren & He, 2026; Wang et al.,

2020). However, because the macro-level statistical data used in this study cannot track firms' cross-city relocation or functional transformation, the three mechanisms mentioned above cannot be completely disentangled in the empirical analysis. Therefore, the findings may limit the precise interpretation of the effects and mechanisms of premature de-industrialization, and primarily reflect the average statistical association between the decline in the share of manufacturing and the urban-rural income gap.

If the decline in the share of manufacturing represents genuine premature de-industrialization—that is, a decline in manufacturing competitiveness before the completion of industrialization—it will reduce the capacity of the manufacturing sector to absorb low-skilled rural labor, while low-end services may fail to provide sufficient income replacement opportunities, thereby being associated with a wider urban-rural income gap. This is the logic supported by the mechanism analysis in this study. However, if the decline in the share of manufacturing results from proactive functional upgrading of cities—that is, cities relinquish low-end manufacturing activities and shift toward high value-added activities such as research and development and headquarters economy—the associated effects may be more complex. The employment opportunities created through upgrading may primarily benefit high-skilled labor and may also be positively associated with the urban-rural income gap in the short term, but may benefit broader groups through growth effects in the long term. Therefore, the mechanism analysis in this study primarily reflects the association between manufacturing restructuring and the urban-rural income gap, while the specific mechanisms underlying different pathways of industrial adjustment require further identification using firm-level microdata and urban network data.

5.3. Examination and reflection on China's de-industrialization

The Petty–Clark Law describes the industrialization stage in which industry replaces agriculture and the de-industrialization stage in which services replace industry as the industrial structure evolves with economic development. However, it is evident that China's de-industrialization cannot be simply equated with services replacing industry, nor with a straightforward upgrading of the industrial structure toward a higher level. In many cities that have undergone premature de-industrialization, the expansion of the service sector is not driven by high-end demand from manufacturing, but rather by the passive absorption of low-skilled labor displaced from manufacturing. This “passive servitization” is prone to low-end lock-in, making it difficult to achieve genuine efficiency improvements.

More importantly, the positive association between de-industrialization and the urban-rural income gap is not limited to local cities but also extends through spatial spillover effects, as de-industrialization may intensify competition among low-skilled workers in surrounding areas and be positively associated with the urban-rural income gap in neighboring cities. This implies that the costs of premature de-industrialization are not isolated, but are transmitted and amplified through urban network linkages, thereby accelerating the regional diffusion and mobility of labor. It can be anticipated that, with the continuous improvement in the level of economic development and human capital, the dilemma of low-end servitization lock-in may gradually be alleviated. However, at the current stage, manufacturing remains crucial for China's high-quality economic development. The further development of urban manufacturing and the coordinated development of manufacturing and services are vital for the advancement of high-level services.

5.4. Policy implications

Based on these findings, this study proposes the following policy implications. First, for cities experiencing premature de-industrialization, greater attention should be paid to the employment

adjustment risks associated with manufacturing contraction. Given the significant positive association between premature de-industrialization and the widening of the urban-rural income gap, and the fact that rural surplus labor transfer and service-oriented transformation of the employment structure represent important explanatory pathways, such cities should avoid rapid manufacturing contraction before alternative industries are sufficiently developed. Accordingly, policy interventions should focus on stabilizing manufacturing employment, enhancing labor reallocation capacity, and improving employment transition support systems to prevent a vicious cycle of manufacturing decline, the concentration of low-end service employment, and widening income disparities. In addition, efforts should be made to improve the vocational skills and employability of rural labor, thereby reducing the adverse effects of manufacturing contraction on rural employment and income growth.

Second, for normally de-industrialized cities, further efforts should be made to promote the coordinated advancement of industrial restructuring and employment structure optimization. For such cities, policies should avoid simply pursuing the expansion of manufacturing scale and instead focus on the coordinated upgrading and synergistic development between manufacturing and services. By promoting the deep integration of manufacturing and services, improving the quality of service-sector employment, and expanding high-skilled employment opportunities, industrial restructuring can be better translated into improved income distribution outcomes.

Third, in response to the spatial spillovers of de-industrialization, greater efforts should be made to strengthen interregional coordination in industrial adjustment and labor mobility. In response to the positive spatial spillover association between de-industrialization and the urban-rural income gap, governments should promote the establishment of cross-regional industrial cooperation and employment coordination mechanisms. During the process of promoting industrial upgrading in focal cities, coordination with neighboring cities in undertaking transferred industries and employment services should be strengthened to reduce the risk of regional income divergence associated with labor mobility during industrial adjustment. Meanwhile, neighboring cities should proactively plan industrial transfer reception arrangements and supporting public services, transforming the pressures associated with population mobility into drivers of development.

6. Conclusions and future prospects

6.1. Conclusions

As a structural feature of industrial evolution, de-industrialization is significantly associated with the urban-rural income gap. This study develops a framework for evaluating urban de-industrialization and uses an SGMM model to examine its association with the urban-rural income gap and the underlying mechanisms.

The results indicate that de-industrialization at the city level in China exhibits a spatial pattern that declines progressively from east to west. The direction of its impact on the urban-rural income gap depends on the stage of economic development at which it occurs. In regions with relatively high levels of economic development, de-industrialization is significantly and negatively associated with the urban-rural income gap, in contrast to existing studies that generally report that de-industrialization exacerbates income inequality. Combined with the positive association between premature de-industrialization and the urban-rural income gap, these findings suggest that the distributional effects of de-industrialization are not solely determined by the characteristics of de-industrialization itself, but depend to a large extent on the developmental stage of the manufacturing sector. This provides heterogeneous evidence at the city level for understanding the distributional effects of structural transformation. In addition, in terms of spatial effects, de-industrialization exerts a significant positive spillover effect on the urban-rural income gap. The contraction of manufacturing in

focal cities, accompanied by the cross-city mobility of low-skilled labor, is positively associated with the widening of the urban-rural income gap in neighboring cities. In terms of transmission mechanisms, the transfer of rural surplus labor plays a more significant role and exhibits a strong amplification effect.

6.2. Limitations and future prospects

This study has several limitations. First, the de-industrialization indicator is constructed using data from urban non-private units. Although this choice ensures consistent statistical definitions and data availability across periods, it limits sample coverage because manufacturing workers in private enterprises and self-employed businesses are excluded. These sectors play an important role in employment absorption and industrial organization within China's urban system, particularly in southeastern coastal regions and areas with active private economies. The indicator therefore captures structural change primarily through the contraction of manufacturing employment in the non-private sector. Because it excludes private and self-employed manufacturing employment, it may not fully represent changes in cities' manufacturing employment structures and may introduce measurement error into the classification of de-industrialization. Future research could integrate business-registration or firm-level microdata to construct a more comprehensive measure of manufacturing employment and improve the external validity and structural consistency of the de-industrialization indicator.

Second, the intertemporal comparability of long-term panel data is subject to certain limitations. Due to data limitations, this study cannot fully disentangle the potential effects of changes in statistical definitions and administrative boundary adjustments on the manufacturing share indicator. For example, the statistical system for urban and rural residents' income has undergone changes in different periods, resulting in potential inconsistencies in the time-series comparability of rural residents' income data. In addition, adjustments to administrative divisions may also introduce potential disruptions to the continuity of certain city-level indicators. Therefore, the current findings should be primarily interpreted as reflecting the overall association between de-industrialization and changes in the urban-rural income gap over a long-term time series. Future research could further integrate micro-level survey data and multi-source statistical materials to improve the accuracy of long-term time-series analyses.

Third, certain limitations remain regarding the conceptual identification boundaries and the characterization of underlying mechanisms. In the context of deepening regional division of labor and the restructuring of urban networks, the decline in manufacturing share at low-income stages may result from insufficient industrialization, but may also be associated with industrial relocation and functional upgrading. Although the nonlinear relationship between manufacturing share and per capita income enables this study to identify cities experiencing premature de-industrialization, it remains difficult to distinguish the different adjustment pathways underlying manufacturing contraction. In addition, although the change rate of employment share in the primary sector can capture the trend of rural surplus labor transfer, it cannot accurately identify the process of intersectoral labor mobility, and the validity of this proxy measure remains limited. Future research could further integrate firm relocation data, urban network linkage data, and micro-level labor survey data to achieve a more refined identification of industrial adjustment pathways and labor transfer mechanisms.

CRedit authorship contribution statement

Chengrun Cui: Data curation, Methodology, Writing – original draft, Writing – review & editing. **Xiaoxiao Pang:** Formal analysis, Methodology, Software, Writing – original draft. **Wengang Wang:** Conceptualization, Funding acquisition, Supervision, Validation, Writing – review & editing.

Data availability statement

The datasets generated and/or analyzed are available from the corresponding author upon reasonable request.

Declaration of competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendices.

Table A
Correlation between the share of manufacturing and per-capita income

Project	dman		Dmae	
	Model (1)	Model (2)	Model (3)	Model (4)
per-capita income	0.021*** (0.005)	0.761*** (0.016)	0.162*** (0.004)	0.299*** (0.014)
per-capita income ²		−0.031*** (0.001)		−0.008*** (0.001)
population	−0.024*** (0.006)	0.017 (0.046)	0.019*** (0.006)	0.133*** (0.043)
Population ²		−0.004 (0.004)		0.111*** (0.004)
F	100.06***	105.57***	119.93***	120.89***
R ²	0.8510	0.8522	0.8661	0.8684
N	6048	6048	6048	6048

Notes: ***, ** and * are significant at 1%, 5% and 10% levels, Standard errors are reported in parentheses.

Table B
Robustness tests

Variable	model
<i>L.Gap</i>	0.7236*** (0.163)
<i>Indman</i>	0.1869*** (0.092)
Control	Y
P-Hansen	0.289
P-AR(1)	0.000
P-AR(2)	0.512
N	2101

Notes: ***, ** and * are significant at 1%, 5% and 10% levels.

Formula A

First, a baseline regression model is specified to estimate the total effect:

$$Y_{it} = \alpha_0 + \alpha_1 T_{it} + \alpha_2 X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (A1)$$

where Y_{it} denotes the dependent variable, T_{it} represents the independent variable, and X_{it} is a set of control variables; α_1 captures the total effect (TE).

Considering the potential endogeneity of T_{it} , an instrumental variable M_{it} is introduced for estimation:

$$M_{it} = \gamma_0 + \gamma_1 T_{it} + \gamma_2 X_{it} + \mu_i + \lambda_t + \nu_{it} \quad (A2)$$

$$Y_{it} = \delta_0 + \delta_1 T_{it} + \delta_2 M_{it} + \delta_3 X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (A3)$$

where γ_1 captures the effect of the independent variable on the mediating variable, δ_2 reflects the effect of the mediating variable on the dependent variable, and δ_1 represents the direct effect (DE) after controlling for the mediating variable.

Within the instrumental variable framework, the indirect effect is given by:

$$IE = \gamma_1 \times \delta_2 \quad (A4)$$

Within the instrumental variable framework, the proportion of the mediating effect is given by:

$$S = \frac{IE}{DE + IE} \quad (A5)$$

Formula B

$$ET_t = \frac{EP_{1,t-1}}{EP_{t-1}} - \frac{EP_{1,t}}{EP_t} \quad (B1)$$

$$ES = EP_3 / EP_2 \quad (B2)$$

where EP_i represents employment in the i -th industry. ET indicates the degree of rural surplus labor transfer, and ES measures the degree of service orientation of the employment structure.

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