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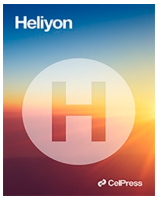

Research article

Are spatial imbalances in industrial structural change widening the common wealth gap?

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ABSTRACT

The evolution of China's industrial structure from 2010 to 2021 is assessed based on the rationalization and sophistication of its industries. The Theil index quantifies spatial variability, while the Quadratic Assignment Procedure (QAP) investigates if changes in industrial structure imbalance will increase wealth disparity. The study's findings indicate a noticeable spatial imbalance in industrial structure change. The overall level of common wealth is low but steadily increasing, following a stepped-down structure of "east-center-west." Additionally, the north and south regions exhibit a pattern of "high in the north and low in the south." There is a pattern of higher values in the north and lower values in the south. In terms of common wealth and its dimensions, there is a ladder-like pattern with high values at the core decreasing towards the west. Between 2010 and 2021, the common wealth development shifted from a lower level to a higher one. Beijing, Jiangsu, and Shanghai constantly ranked in the top echelon, while Guangxi remained in the fifth echelon. The speed and difficulty of transitioning between echelons vary. Moving from the fourth echelon to the third echelon takes longer, while transitioning from the third echelon to higher echelons presents tougher challenges. Spatial imbalances in industrial structure changes widen the gap in common wealth. In particular, the impact of the gap in the advanced industrial structure on the common wealth gap is significantly higher than that of the gap in industrial rationalization. Reducing disparities in advanced industrial structure is more effective in reducing the overall wealth gap.

1. Introduction and literature review

During the 20th National Congress of the Communist Party of China (CPC), General Secretary Xi Jinping emphasized that Chinese-style modernization aims to achieve common prosperity for all individuals. Advancing the shared prosperity of all individuals is not only the main objective in addressing significant social conflicts but also an essential requirement for meeting the people's aspirations for an improved quality of life. China has seen regional distinctions since ancient times due to its massive population and broad terrain. China faces a century-old problem in implementing strategic adjustments and structural optimization to eliminate inter-regional inequities and promote coordinated regional development for common prosperity. The concept of common wealth focuses on social growth through material success and the progressive enhancement of people's living conditions. The main goal is to ensure equitable distribution of wealth and resources among all members of society, reducing the disparity between the affluent and the impoverished, and allowing everyone to benefit from economic progress. Advancements in the economy and society result in both monetary and

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spiritual prosperity [1–3]. Yang et al. argue that common wealth encompasses both worldly prosperity and the advancement of spiritual civilization [4]. Realizing shared prosperity for all individuals involves the unification of progress, sharing, and sustainability [5–7]. In the early years of socialism, the basic meaning of the common wealth of all people was mainly the gradual reduction of the gap between the wealth of the members of society [8]. Xie T's study found that common wealth signifies both the increase in income and the decrease in income disparity. This suggests that common wealth encompasses the shared wealth and overall prosperity of all individuals, reflecting a harmonious combination of advancements in productive capabilities and the enjoyment of a fulfilling and pleasant life by the populace [7]. China has not finalized norms or measurements for common prosperity, although academic research on establishing an indicator system for common prosperity is increasing. Wan et al. believe that achieving affluence and guaranteeing commonness are the key aspects of common wealth, stemming from the interplay between growth and distribution, efficiency and fairness [8]. Schyns P. argues that shared wealth is a slow and ongoing process that involves various features such as universal prosperity, comprehensive prosperity, and advancing prosperity [9]. There are two primary perspectives on how to quantify shared wealth. One is to cite a single indicator, such as income, GDP, consumption expenditure and so on, to indirectly study the current situation and prospect of common wealth [10,11]. The second is the dynamic evaluation of common wealth. Zhang, J et al. constructed the micro common wealth index from three dimensions: material wealth, spiritual wealth, and social sharing, and found that the digital economy and inclusive finance are important ways to narrow the gap between urban and rural areas and promote common wealth [12]. Yun and Li differentiated the material and spiritual aspects of common wealth. Spiritual living conditions encompass social security capability, as well as science, education, culture, and health services. Material living conditions encompass factors such as money, lifestyle convenience, and quality of life [13]. Although most of the indicator systems constructed by scholars have rich theoretical connotations and are in line with China's national conditions, there is still some room for improvement in the selection of dimensions or the operability of indicators.

Since its reform and opening up, China has rapidly evolved from a predominantly agricultural country to an industry-led one and is actively transitioning to a service-oriented country, reflecting the rapid transformation of its industrial structure [14]. Economic development has now evolved from a phase of rapid growth to a phase of pursuing high quality, but unbalanced and inadequate development simply cannot meet the people's growing needs for a better life, and it is imperative that this major social contradiction be resolved. Based on the regional level, the industrial structure changes and the uneven regional economic development are obvious. On the one hand, the state is sparing no effort to implement the strategy of coordinated regional development and to bridge the gap in regional economic development. Although the trend of widening regional economic gaps has been effectively controlled, the imbalance of regional economic development is still a phenomenon that needs attention. Taking 2021 as a reference, Beijing leads the country's provinces with a per capita GDP of 184,000 yuan, which is 3.91 and 4.49 times that of Heilongjiang and Gansu, the last two places in the ranking, respectively. On the other hand, the imbalance in spatial distribution has become more and more serious with the domestic industrial restructuring. The transformation and upgrading of industrial structure in the central and western regions lag behind that of the eastern coastal regions, especially from the perspective of industrial structure and industrial scale, and the "inward migration" of labor-intensive industries has aggravated the spatial distribution imbalance of industrial structure change. Taking 2021 data as a reference, the proportion of tertiary industry in Beijing ranks first in the country, reaching 81.7 %. Shanxi and Inner Mongolia, the next two, account for only 44.7 percent and 43.5 percent, respectively. Beijing's economy is 1.82 times larger than that of Shanxi and 1.87 times larger than that of Inner Mongolia [15]. Therefore, to fully and adequately understand China's economic growth, industrial structural change is a key element that cannot be ignored, and the spatial distribution imbalance of industrial structural change also concentrates on insufficient and unbalanced economic development [16,17]. Therefore, explaining the gap in common wealth from the perspective of the spatial imbalance of industrial structure change is an important analytical perspective.

Promoting the common wealth of all people is essential for resolving societal disputes and ensuring a satisfying life for everyone. Currently, there is limited discussion in literature regarding the geographical imbalance of industrial structure development and the common wealth gap. Scholars have explored several angles to discover the road to achieve common wealth. Yang L et al. investigated how energy low-carbon transition can achieve common wealth by using industrial structure upgrading as a mediating variable [18]. Chen Z et al. Investigated the role and mechanism of the digital economy, industrial structure, and common wealth using the twofold difference method [19]. Most studies have mostly focused on upgrading industrial structure or investigating the way to achieving common prosperity by including the mediating variable of industrial structure. Studies have verified that optimizing and improving industrial structure does indeed help achieve common wealth. Industrial structure upgrading can be analyzed through rationalization and progress. There are disparities in the effects of these two on the general wealth. The precise impact of rationalization and upgrading of industrial structures on the wealth disparity remains unclear. Rationalization and modern industrial structure are crucial factors for significant economic progress [15]. Rationalizing industrial structure and advancing industrial processes can lead to the redistribution of human and natural resources. This may result in material losses during resource movement, ultimately reducing economic efficiency [20]. Moreover, the disparity in industrial structure can worsen the gap in urban-rural development and urban development discrepancies. Adjusting the industrial structure can aid in diminishing urban economic disparities [21]. When examining the connection between rationalization, progress, and common wealth, it is important to investigate if the spatial disparity in industrial structure will widen the common wealth gap.

In view of this, the innovations of this paper are mainly reflected in the following two aspects: firstly, based on the perspective of industrial structure rationalization and industrial structure sophistication, the characteristics of industrial structure change are analyzed in an all-round way with the help of Theil's index decomposition and other techniques. Secondly, with the help of the relational data analysis paradigm and the Quadratic Assignment Procedure (QAP), this paper explores whether the spatial imbalance of industrial structure change will widen the gap between the common wealth, which provides support for revealing the development of China's common wealth and exploring the path of synergistic enhancement. Rationalized and feasible countermeasures are

proposed.

2. Theoretical framework

The impact of industrial structure on economic growth has attracted more attention from scholars since economists Clark began to explore the link between economic growth and industrial structure [22]. Maddison's [23]study confirmed that industrial structure is a key factor in economic growth. Lucas [21], Grossman and Helpman [24]and Kliestik [25]have considered the impact of industrial structure in constructing their economic growth models. The main reason why industrial structure change is regarded as a key factor in economic growth is that it can achieve the optimal allocation of labor from less efficient industries to more efficient industries in the process of change, so as to improve the overall efficiency of economic operation. Chenery et al. pointed out that the extent to which industrial structural change affects economic growth varies with the stage of development [26]. Thus, such differences can be observed at different stages of economic development in each country, as well as between different regions at the same stage of development.

Zhou Zhenhua [27]discussed the shift in industrial structure from two viewpoints: rationalization and advancement. Industrial structure rationalization pertains to the synergistic relationships among industries resulting from their interactions. During rapid industrial development, factors of production will be allocated to new industries, potentially boosting short-term output but risking inadequate resource allocation to other sectors, thereby reducing industrial structure rationalization. Based on the long-term perspective, when the technological conditions are mature, various factors of production will be reallocated to ensure the balance of the supply and demand structure and the stability of the employment structure [28]. And in this process, the integration capacity of industrial structures will be enhanced, and the economic growth rate will increase. It is worth paying attention to the fact that, due to uneven regional economic development, the impact of the rationality of industrial structure on regional economic growth varies in different regions [29]. Typically, regions with faster economic growth tend to have a higher level of rationalization of their industrial structure. However, the circularity between such linkages and development gaps can further increase development gaps between regions.

The advanced industrial structure can be understood as the gradual transition of the lower industrial sectors from a labor-intensive to a technology and capital-dominated model, i.e. the evolution of the industrial structure along an advanced development trajectory. From a long-term perspective, the optimal selection of technology absorption strategies, the refinement of industrial skills, and the enhancement of innovation capabilities can help promote the leap from quantitative to qualitative changes in industrial structure [30]. Advanced industrial structure is manifested in the following three aspects: high added value, high intensification, and high degree of processing. The advantages of the advanced industrial structure are numerous, not only facilitating the optimal allocation of factors of production among industries, promoting the steady increase of social labor productivity and truly realizing the structural economic effect, but also facilitating the flow of scarce resources to high value-added, highly intensive and highly processed industries, thus ensuring orderly economic growth and sustainable development [31]. However, it is important to note that the process of upgrading the industrial structure varies between regions, which may increase differences in the rate of economic growth and regional economic disparities [32].

Shared prosperity means that everyone is able to enjoy the fruits of reform and development achieved by the state in terms of material, spiritual, environmental, social, and public services. Wei X pointed out that the higher the degree of marketisation of the region, the more adequate market competition, which, to a certain extent, will promote the realization of the market allocation of resource factors in the region, and thus promote the realization of common wealth [33]. Income is the intuitive embodiment of economic affluence, income security reflects the degree of affluence of the people's lives, and is the most direct way to achieve the

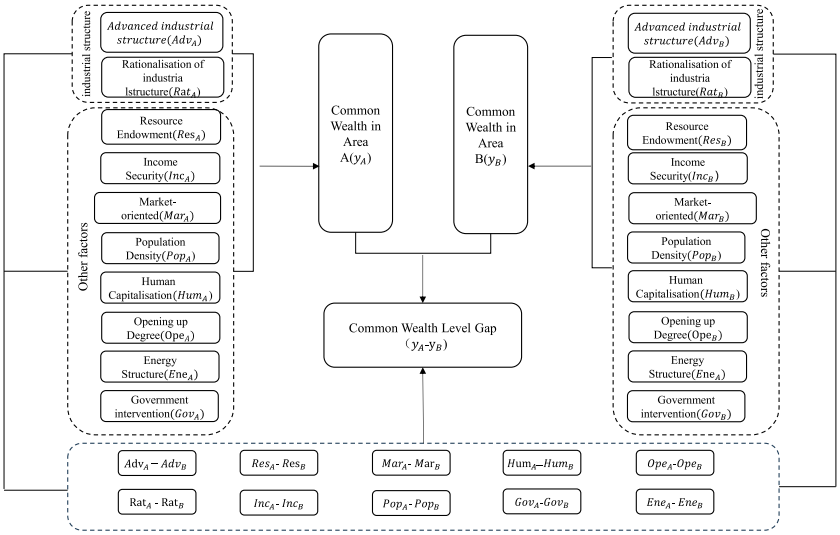


Fig. 1. Diagram of the theoretical mechanism.

fruits of development for all. In addition, with the continuous development of social economy, the degree of marketisation, energy structure, government intervention, degree of openness to the outside world, population density and the level of human capital have also become important factors affecting the realization of shared prosperity, and play an important role in understanding the gap of shared prosperity [34]. In order to be able to illustrate these influencing mechanisms in a simple and clear way, this paper constructs a theoretical mechanism diagram as shown in Fig. 1.

3. Model construction, indicator design and data sources

3.1. Modelling

3.1.1. Spatial imbalances in industrial structure change

This research utilizes the Theil index and its splitting method to assess regional disparities in the rationalization and progress of industrial structure, specifically focusing on spatial imbalance characteristics. The Theil index formula used in this study is derived on the research conducted by Theil, Bourguignon, and Shorrocks [35]. A smaller Theil index indicates less regional disparity, while a bigger index indicates greater inter-regional disparity. The precise phrasing is as follows:

$$T=\frac{1}{n}\sum_{i=1}^{n}\frac{y_i}{\overline{y}}\log\left(\frac{y_i}{\overline{y}}\right) \tag{1}$$

$$T_k=\frac{1}{n}\sum_{i=1}^{n}\frac{y_i^k}{y^k}\log\left(\frac{y_i^k}{y^k}\right) \tag{2}$$

$$T_w=\frac{1}{n}\sum_{k=1}^{m}\left(\frac{n_k}{n}\frac{\overline{y}_k}{\overline{y}}\right)T_k \tag{3}$$

$$T_b=\sum_{k=1}^{m}\frac{n_k}{n}\left(\frac{\overline{y}_k}{\overline{y}}\right)\ln\left(\frac{\overline{y}_k}{\overline{y}}\right) \tag{4}$$

The Theil index has a decomposable property, i.e., the total regional variation can be split into the sum of intra-regional and inter-regional variation $T = T_w + T_b$.In equations (1)–(4), T is the overall variance, T_w is the variance within districts, and T_b is the variance between districts. The level of rationalization and sophistication of the industrial structure of each province is referred to using y, and n represents the number of provinces in the selected sample. The level of rationalization and sophistication of the industrial structure of the provinces within region k and the total number of provinces within region k are denoted by y_i^k and n_k, respectively.

3.1.2. The impact of spatial imbalances in industrial structural change on the common wealth gap

This study aims to fill the gap in the analytical paradigm of previous studies by taking a relational data analysis perspective and using a quadratic assignment procedure to investigate how spatial imbalances in industrial structural change affect the common wealth gap.

The relational data metrics model constructed in this study is as follows:

$$Y=\alpha_0+\alpha_1X+\alpha_2Z+U \tag{5}$$

Where α_i is the parameter to be estimated, Z is the control variable, U is the residual term, and Y and X represent the explanatory and core explanatory variables. In accordance with equation (6), the relational data measurement model can be represented as a specific matrix form. where observations $y_{i,j}$, $z_{i,j}$ and $x_{i,j}$ in the matrix represent the gap between the two regions for the explanatory, control, and explanatory variables, respectively. Its exact value can be obtained by calculating y_i-y_j, z_i-z_j, x_i-x_j, and when i = j, the main diagonal elements of the matrix are all zero.

$$Y=\begin{pmatrix}0 & y_{1,2} & \cdots & y_{1,n-1} & y_{1,n}\\ y_{2,1} & 0 & \cdots & y_{2,n-1} & y_{2,n}\\ \vdots & \vdots & \ddots & \vdots & \vdots\\ y_{n-1,1} & y_{n-1,2} & \cdots & 0 & y_{n-1,n}\\ y_{n,1} & y_{n,2} & \cdots & y_{n,n-1} & 0\end{pmatrix},X=\begin{pmatrix}0 & x_{1,2} & \cdots & x_{1,n-1} & x_{1,n}\\ x_{2,1} & 0 & \cdots & x_{2,n-1} & x_{2,n}\\ \vdots & \vdots & \ddots & \vdots & \vdots\\ x_{n-1,1} & x_{n-1,2} & \cdots & 0 & x_{n-1,n}\\ x_{n,1} & x_{n,2} & \cdots & x_{n,n-1} & 0\end{pmatrix},$$
$$Z=\begin{pmatrix}0 & z_{1,2} & \cdots & z_{1,n-1} & z_{1,n}\\ z_{2,1} & 0 & \cdots & z_{2,n-1} & z_{2,n}\\ \vdots & \vdots & \ddots & \vdots & \vdots\\ z_{n-1,1} & z_{n-1,2} & \cdots & 0 & z_{n-1,n}\\ z_{n,1} & z_{n,2} & \cdots & z_{n,n-1} & 0\end{pmatrix} \tag{6}$$

Secondary assignment procedure. In relational data models, row and column element correlation can lead to autocorrelation problems in measurement models [36]. We can represent the autocorrelation structure of the residual matrix in Eq. (5) by the matrix $\Omega_{ij,kl}$, as shown in Eq. (7). where $\rho_{ij,kl}$ denotes the correlation coefficient between the residual terms (i、 j、 k、 $l = 1,2 \ldots, n$), and the presence of autocorrelation in the model implies that $\rho_{ij,kl} \neq 0$ (except for the main diagonal elements).

$$\Omega_{ij,kl} = \begin{matrix} \mu_{12} \\ \mu_{13} \\ \vdots \\ \mu_{n(n-1)} \end{matrix} \begin{pmatrix} \mu_{12} & \mu_{13} & \cdots & \mu_{n(n-1)} \\ 1 & \rho_{12,13} & \cdots & \rho_{12,n(n-1)} \\ \rho_{13,12} & 1 & \cdots & \rho_{13,n(n-1)} \\ \vdots & \vdots & \ddots & \vdots \\ \rho_{n(n-1),12} & \rho_{n(n-1),13} & \cdots & 1 \end{pmatrix} \tag{7}$$

Equation (8) displays both row autocorrelations and column autocorrelations present in the residual matrix. A row autocorrelation exists for observations in $\Omega_{ij,kl}$ that are in the same row if $\rho_{i,jl} \neq 0$. If $\rho_{j,ik} \neq 0$, then there is column autocorrelation for observations in the same column. Aside from the issue of autocorrelation, there is typically significant multicollinearity among the variables. Using typical statistical tests will result in an increase in the variance and standard deviation of the parameter estimations, leading to a loss of meaning in the significance tests of the variables [37]. The Quadratic Assignment Procedure (QAP) was presented as a non-parametric test employing stochastic permutations to address autocorrelation and multicollinearity in relational data models.

$$\rho_{ij,kl} = \begin{cases} 1 & \text{if} i = k \text{ and } j = l \quad (\Omega_{ij,kl} \text{ main diagonal}) \\ \rho_{i,jl} & \text{if} i = k \text{ and } j \neq l \quad (\text{Row autocorrelation coefficient}) \\ \rho_{j,ik} & \text{if} i \neq k \text{ and } j = l \quad (\text{Column autocorrelation coefficient}) \\ 0 & \text{Other} \end{cases} \tag{8}$$

3.2. Data sources and indicator design

3.2.1. Data sources

This research aims to investigate how the spatial imbalance of industrial structure development affects the wealth gap. The study analyzed data from 30 provinces in China (excluding Tibet, Hong Kong, Macao, and Taiwan) from 2010 to 2021 to ensure the indicators were scientific, comprehensive, and reliable, while considering data availability. The data used in this research are sourced from the National Bureau of Statistics, statistical yearbooks of each province, the China Statistical Yearbook, and the China Energy Statistical Yearbook. To ensure data completeness and study quality, the linear interpolation approach was selected to fill in missing data.

3.2.2. Indicator design

(1) Explained variable: level of common wealth

Based on Xie et al. [5–7]this paper constructs a common wealth evaluation index system with three dimensions of development, sharing, and sustainability and measures them with the entropy method. It is mainly based on the following principles: First,

Table 1
Common wealth evaluation indicator system.

Level1 indicators	Secondary indicators	Tertiary indicators	characteristic
developmental	affluence	Disposable income per inhabitant (yuan per person)	+
		Consumption expenditure per inhabitant (yuan per person)	+
		Engel's coefficient	–
		Gini coefficient	–
	commonality	Income multiplier for urban and rural residents	–
		Urbanization rate (%)	+
	cultural education	Public library holdings per capita (books/person)	+
		Average years of education (years/person)	+
	healthcare	Number of practicing (assistant) physicians per 10,000 population	+
		Number of beds in medical institutions per 10,000 population	+
shareability	infrastructure	Public transport vehicles per 10,000 population (standard units)	+
		Public toilets per 10,000 population (seats)	+
	information level	Number of Internet broadband access subscribers (10,000)	+
		Number of mobile phone subscribers at the end of the year (10,000)	+
	social security	Social security expenditure as a share of GDP (%)	+
	science, technology and innovation	RD input intensity (%)	+
		Patents granted per 10,000 people (pieces)	+
sustainability	ecological environment	Forest cover (%)	+
		Carbon intensity (million tones/billion dollars)	–
	Quality of development	GDP per capita (yuan per person)	+
		Labor productivity of society as a whole	+

developmental indicators, which are used to reflect the overall wealth of society, the growth of people's incomes, the level of spiritual culture, medical and health care, and material infrastructure construction, measure the wealth gap between groups and urban and rural areas. They cover all members of society and include such indicators as disposable income per capita, the difference between urban and rural incomes, and the number of beds in medical institutions per 10,000 people. Secondly, the sharing degree indicator is used to reflect whether the fruits of reform and development are fair and inclusive. They include such indicators as public toilets per 10,000 people and the number of mobile phone subscribers at the end of the year. Thirdly, sustainability indicators reflect the growth or depletion of the economy, society, resources, and environment and measure the long-term development potential of the common wealth, which are refined from a number of dimensional indicators, mainly including the forest coverage rate, GDP per capita, and other indicators. The final result is 21 common prosperity evaluation indicators, which are shown in Table 1.

(2) Core explanatory variables: rationalization of industrial structure, advanced industrial structure

Industrial structure rationalization is the level of alignment between different industries, indicating how well inputs and outputs are matched structurally. Researchers typically evaluate the rationalization of industrial structure by using the structural deviation degree when assessing the degree of matching, which corresponds to a certain formula.

In equation (9), where E represents structural deviation, Y represents output, L represents employment, i represents industry, and n is the number of industrial sectors. Based on the assumptions of classical economics, the economy will eventually reach a state of equilibrium in which the productivity of all industries is the same. Here Y/L is defined as the efficiency of production, so that when the economy reaches equilibrium, there is $Y_i/L_i = Y/L$, resulting in E being 0. Meanwhile, Y_i/Y depicts the structure of output, while L_i/L describes the structure of employment, which suggests that the value of E also represents the interconnection between the structure of output and the structure of employment. When the value of E increases, it means that the economy is more out of equilibrium and the industrial structure is less rational. Since unbalanced economies tend to be widespread and are particularly pronounced in developing countries [24], the value of E cannot be zero. However, the measure of structural deviation takes a perspective such as flatness for all industries, which ignores their importance to the economy, while the calculation of their absolute values is also problematic for the analysis. Therefore, we introduce the Thiel index. When the industrial structure is in equilibrium, TL is 0; if the degree of deviation of TL from 0 is greater, then the rationality of the industrial structure is lower.

$$E = \sum_{i=1}^{n} \left| \frac{Y_i/L_i}{Y/L} - 1 \right| = \sum_{i=1}^{n} \left| \frac{Y_i/Y}{L_i/L} - 1 \right| \tag{9}$$

This paper provides a new interpretation of the Thiel index based on existing research, see equation (10) for the relevant formula.

$$TL = \sum_{i=1}^{n} \left(\frac{Y_i}{Y} \right) \ln \left(\frac{Y_i}{L_i} \Big/ \frac{Y}{L} \right) \tag{10}$$

The essence of the advanced industrial structure actually reflects a change in the industrial structure towards a high level of development, that is, a transformation from low value-added and low-technology industries to high value-added and high-technology industries. Such a transformation not only improves the overall efficiency and competitiveness of industries, but also promotes the improvement of the quality of employment and the narrowing of the income gap, thereby promoting common prosperity. In view of the fact that the growth rate of the secondary industry lags behind that of the tertiary industry in the process of service-oriented economy, this paper makes reference to the research results of Gan C H [38]and takes the ratio between the output value of the tertiary industry and the output value of the secondary industry as a key indicator to measure the advanced industrial structure. This variable can effectively reveal whether the industrial progress shows the trend of service-oriented and can determine whether the industrial structure is evolving in the direction of "service-oriented," so it is a more accurate indicator. By observing the rising trend of the value of industrial structure sophistication, it is possible to determine whether the industrial structure is upgrading, which also means that the economy is moving in the direction of servicification.

(3) Control variable

Based on the existing literature and the structural characteristics of the common wealth gap, this paper selects the following influencing factors for study: Income security (Inc)、Degree of marketisation (Mar)、Resource endowment (Res)、Population density (Pop)、Human capital (Hum)、 Government intervention (Gov)、Opening up Degree (Ope) and Energy structure (Ene). The entropy method was used to determine the weight of each factor, and existing studies were cited as references to determine the corresponding index reference table, as detailed in Table 2.

4. Analysis of empirical results

4.1. Spatial imbalances in industrial structure change

Decomposing the results of the overall gap in industrial structure change(see Table 3 for details), it is obvious from the evolutionary trend of the Theil index of industrial structure advancement that the overall trend of industrial structure advancement shows a fluctuating downward trend. The Theil index in 2010 was 0.0801, and it declined to 0.0728 in 2021, with an annual average rate of

decline of 0.87 percent. During this period, the rate of decline in industrial structure sophistication was 1.29 percent in 2010–2015, while it was 0.35 percent in 2016–2021, suggesting a slowdown in the rate of narrowing regional disparities. In contrast, the Theil index of industrial structure rationalization rose from 0.1502 to 0.3728 in 2010–2019, experiencing a period of significant growth. Despite a gradual decline after 2019, the overall trend remains upward, with an average growth rate of 4.41 percent. Among them, the growth rate was 10.63 % in 2010–2019 and rose even higher to 11.60 % in 2020–2021, indicating an accelerated growth rate of regional disparities in the rationalization of industrial structure. The likely reason lies in the uneven accumulation of capital and technology. Capital and advanced technology tend to cluster in economically developed regions, which, through the introduction and innovation of high and new technologies, promote the development of local industries in the direction of high value added. At the same time, technological upgrading has given rise to new industries and business models, further promoting the optimization of industrial structure. In addition, higher education and R&D institutions are mostly concentrated in big cities and economically developed regions, providing these regions with abundant talent support and intellectual resources, which is conducive to rapid industrial upgrading and innovation. Other regions, on the other hand, may face a loss of talents, making it difficult to form effective technological innovation and industrial transformation. This may lead to a gradual increase in the gap between regions in terms of rationalization of industrial structure and advanced development.

From the perspective of structural decomposition, by analyzing the data for 2010–2021, it can be seen that the intra-regional differences resulting from the advanced industrial structure are much larger than the inter-regional differences. Specifically, although the contribution to intra-regional disparities is gradually shrinking while the contribution to inter-regional disparities is gradually expanding, the contribution to intra-regional disparities remains high at over 60 per cent during this period. Inequality in infrastructure development has a direct impact on balanced intraregional development. Developed areas within regions usually have better infrastructure, while areas with poorer infrastructure are unable to effectively attract investment and promote industrial development, placing them at a disadvantage in competing with other subregions and thus affecting the overall interregional economic balance. This finding reveals a fact that should not be overlooked: despite the increase in interregional differences, the main differences arising from the process of the advanced industrial structure are still the main contributors to intraregional differences across regions. On the other hand, the regional disparities in the rationalization of industrial structure mainly originate from the intra-regional disparities, the contribution rate of which is maintained within the range of 52.50 %–96.55 %. Further decomposition of the intra-regional Theil index reveals that the mean value of the Theil index of industrial structure rationalization level is highest in the eastern region and lowest in the central region, indicating that the imbalance of industrial structure rationalization level is largest in the eastern region and smallest in the central region.

4.2. Common wealth measurement results

4.2.1. Overall measurements of shared prosperity

The measurement results show that the level of common wealth in China's 30 provinces generally shows a fluctuating upward trend between 2010 and 2021 (Table 5 for details). Although the COVID-19 Pandemics will have a greater impact on the promotion of shared prosperity in some regions in 2020, the ten provinces leading the overall ranking are still mainly concentrated in the more economically developed eastern regions, such as Beijing and Shanghai, as well as in provinces featuring agriculture (Shandong) and industry (Liaoning). As for the bottom ten provinces, seven of them are in the western region, indicating that the level of economic development and special industries play a key role in promoting the people's realization of common prosperity. In terms of the average annual growth rate from 2010 to 2021, the average annual growth rate of the common wealth level nationwide reached 1.25 %, showing a stable and low growth trend. The growth rate in the western region is relatively fast, with Guizhou, Yunnan, Anhui, Henan, and Chongqing ranking in the top five with growth rates of 5.61 percent, 3.38 percent, 3.37 percent, 2.74 percent, and 2.45 percent, respectively. In the comparison of the overall growth rates of different regions, the growth rates of the western, central, and eastern regions were 1.72 percent, 1.60 percent, and 0.51 percent, respectively. This data reveals the phenomenon that the eastern part of the country has a relatively high degree of common wealth, while the western part has a faster rate of economic growth, showing a benign catching-up development trend. It also demonstrates that the state's policy of promoting regional economic development has achieved

Table 2
Control variable evaluation index system.

Primary indicator	Secondary indicator	Symbol
Income security	Per capita disposable income (+) Urban registered unemployment rate (−) Labor remuneration/GDP (+)	Inc
Marketability	FAN Marketisation Index	Mar
Resource endowment	Water resources per capita by region	Res
Population density	Total population of the region/area of the region's administrative division	Pop
Human capital	Educational structure = number of persons with college and bachelor's degree or higher/total population over 6 years of age	Hum
Opening up Degree	Actual utilization of FDI/GDP	Ope
Government intervention	General budget expenditures of local finances/gross regional product	Gov
Energy structure	Regional electricity consumption/national electricity consumption	Ene

Table 3
The advanced chemical Theil index and its contributions.

vintages	Theil's index						Theil's index contribution				
	nationwide	east	center	west	intra-regional	regional	east	center	west	intra-regional	regional
2010	0.080	0.140	0.029	0.014	0.016	0.065	77.65	7.52	6.31	19.49	80.51
2011	0.085	0.143	0.033	0.014	0.019	0.066	75.92	7.70	5.8	21.99	78.01
2012	0.082	0.140	0.024	0.011	0.020	0.062	78.22	5.90	4.64	24.47	75.53
2013	0.084	0.144	0.021	0.011	0.021	0.062	79.55	5.03	4.31	25.34	74.66
2014	0.079	0.141	0.016	0.010	0.019	0.060	82.07	4.07	4.12	24.6	75.40
2015	0.075	0.143	0.013	0.008	0.016	0.059	86.23	3.74	3.64	21.33	78.67
2016	0.074	0.140	0.014	0.007	0.017	0.058	85.57	4.14	3.27	22.21	77.79
2017	0.072	0.132	0.018	0.009	0.015	0.057	83.01	5.47	4.25	21.21	78.79
2018	0.069	0.132	0.015	0.008	0.014	0.056	85.70	4.81	3.93	19.79	80.21
2019	0.072	0.133	0.014	0.008	0.017	0.056	84.06	4.46	3.67	22.90	77.10
2020	0.071	0.130	0.015	0.008	0.016	0.055	83.67	4.67	3.67	22.93	77.07
2021	0.073	0.123	0.021	0.013	0.017	0.056	77.69	6.56	5.64	23.60	76.40

tangible results.

Taking the provincial common wealth index as the basic basis, the 30 provincial administrative units in China can be specifically subdivided into five different echelons: the first echelon ($0.71 \geq Com \geq 0.54$) in the eastern part of the economic leader in Shanghai, Beijing, Zhejiang, the degree of common wealth is relatively high; the second echelon ($0.54 > Com \geq 0.35$) in the eastern part of the economically advanced Guangdong, Liaoning, Shandong, Tianjin, Jiangsu; the third echelon ($0.35 > Com \geq 0.22$) 12 provincial-level regions, subdivided geographically into three subgroups: six provinces in the center, Hubei, Heilongjiang, Henan, Jilin, Anhui, and Hunan; two provinces in the east, Hebei and Fujian; and three provinces and one city in the west, Sichuan, Inner Mongolia, and Shaanxi, and Chongqing; and the fourth echelon ($0.22 > Com \geq 0.18$) five provincial-level administrations, Hainan in the east, the 4 provincial-level administrative regions in the central and western parts of the country, with a low degree of common wealth. The fifth echelon ($0.18 > Com \geq 0.13$) has five provincial-level administrative regions, all located in the western region, with a low level of common wealth. Overall, the first and second echelons of five provinces are all located in the eastern region, indicating that the regions in the east demonstrate a high level of common wealth.

In this paper, ArcGIS geographic information analysis software was selected to divide five different common wealth levels, which were divided by the natural breakpoint method with an interval of 12.60–70.68 (Table 4 for details). The distribution maps of provincial common wealth levels in 2011, 2016, and 2021 were drawn, respectively. With the help of the natural breakpoint method, four different levels of common wealth were divided, and the common wealth hotspot maps for different years were drawn. The specific distribution and hotspot maps are detailed in Fig. 2.

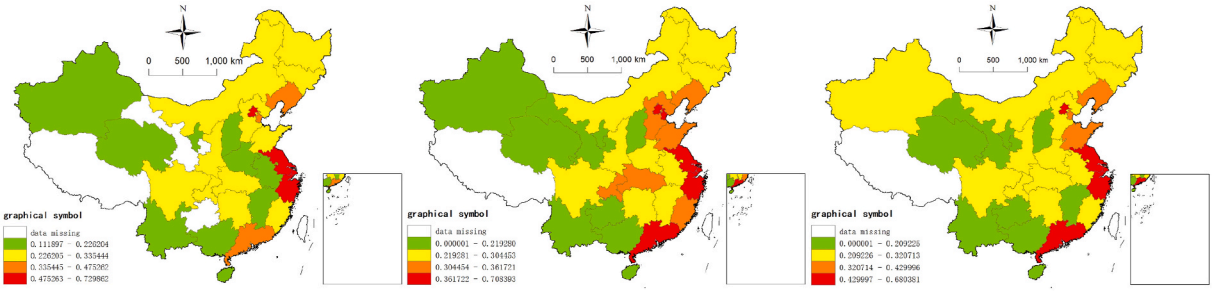
As shown in Fig. 2(a–c) there are obvious differences in the overall level of shared prosperity in different regions of China, with the spatial distribution showing an "east-center-west" stepped-down structure. Between 2010 and 2021, the development of common wealth experienced a transition from being mainly concentrated in the fifth and fourth tiers to being dominated by the fourth and third tiers. Among them, Beijing, Jiangsu, and Shanghai are in the first tier, while Guangxi remains in the fifth tier. In terms of the speed of conversion, the conversion from the fifth echelon to the fourth echelon is relatively fast and was basically completed between 2010 and 2012; however, the shift from the fourth echelon to the third echelon has gone through a long process. Only most of the conversions have been realized in the nine years between 2012 and 2021, and the transformation from the third echelon to the second and first echelons has been difficult until 2021, when the completion of the few regions has been achieved. Based on the spatial level, the distribution of the common wealth level in China is characterized as follows: firstly, in the eastern coastal belt (mainly including Jiangsu, Zhejiang, and Guangdong), the common wealth level shows a decreasing trend from one level to another and displays a ladder-like distribution pattern; secondly, the spatial distribution pattern stays relatively stable, which is mainly manifested in the

Table 4
Rationalization of the Theil index and its contribution.

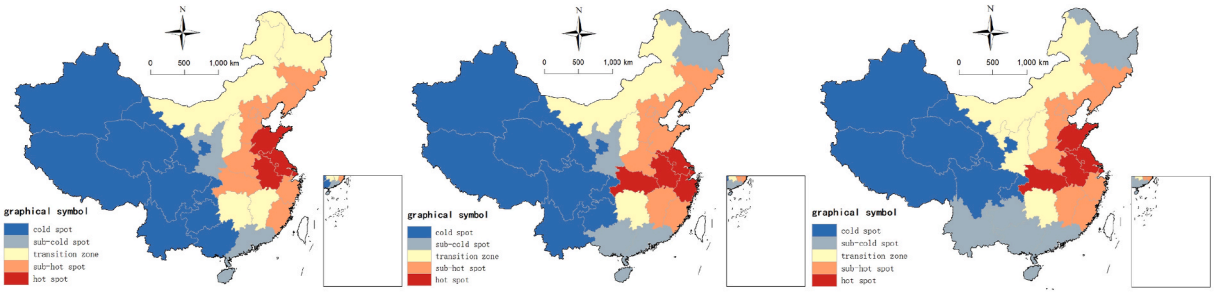
vintages	Theil's index						Theil's index contribution				
	nationwide	east	center	west	intra-regional	regional	east	center	west	intra-regional	regional
2010	0.150	0.149	0.051	0.045	0.084	0.066	18.75	9.68	15.6	55.97	44.03
2011	0.210	0.443	0.049	0.044	0.007	0.203	83.66	5.07	8.06	3.20	96.80
2012	0.223	0.470	0.036	0.040	0.009	0.214	85.78	3.46	6.95	3.81	96.19
2013	0.243	0.505	0.033	0.039	0.011	0.233	86.70	2.82	6.04	4.43	95.57
2014	0.261	0.528	0.029	0.039	0.014	0.247	86.88	2.26	5.59	5.27	94.73
2015	0.291	0.557	0.037	0.036	0.021	0.270	86.03	2.44	4.47	7.06	92.94
2016	0.315	0.583	0.050	0.039	0.024	0.291	85.12	2.98	4.31	7.59	92.41
2017	0.320	0.587	0.070	0.040	0.024	0.296	84.17	4.14	4.34	7.35	92.65
2018	0.334	0.602	0.071	0.048	0.025	0.309	83.46	3.98	4.99	7.57	92.43
2019	0.373	0.643	0.085	0.053	0.032	0.341	82.42	4.07	4.82	8.68	91.32
2020	0.216	0.261	0.121	0.065	0.101	0.115	21.36	15.15	16.62	46.87	53.13
2021	0.242	0.484	0.152	0.083	0.023	0.219	59.81	14.46	16.23	9.50	90.50

Table 5
Evaluating the level of shared prosperity in provincial areas, 2010–2021.

provinces	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Beijing	0.704	0.716	0.697	0.699	0.725	0.719	0.680	0.705	0.696	0.688	0.744	0.708
Tianjin	0.442	0.440	0.444	0.443	0.449	0.430	0.430	0.427	0.446	0.428	0.490	0.523
Hebei	0.257	0.249	0.279	0.262	0.253	0.247	0.245	0.261	0.264	0.270	0.343	0.313
Shanxi	0.193	0.201	0.213	0.224	0.200	0.177	0.167	0.179	0.180	0.194	0.224	0.219
Neimenggu	0.247	0.265	0.256	0.248	0.253	0.234	0.246	0.250	0.252	0.254	0.294	0.280
Liaoning	0.348	0.364	0.378	0.346	0.357	0.377	0.361	0.348	0.343	0.343	0.341	0.343
Jilin	0.257	0.277	0.256	0.244	0.262	0.250	0.241	0.217	0.216	0.236	0.292	0.276
Heilongjiang	0.292	0.303	0.328	0.306	0.317	0.302	0.274	0.253	0.255	0.281	0.247	0.266
Shanghai	0.757	0.730	0.661	0.646	0.608	0.613	0.650	0.647	0.620	0.592	0.672	0.673
Jiangsu	0.494	0.548	0.536	0.499	0.478	0.502	0.492	0.520	0.524	0.530	0.517	0.532
Zhejiang	0.554	0.559	0.550	0.557	0.560	0.563	0.532	0.528	0.549	0.548	0.495	0.511
Anhui	0.192	0.190	0.235	0.202	0.237	0.215	0.220	0.201	0.229	0.239	0.260	0.276
Fujian	0.301	0.303	0.307	0.310	0.325	0.360	0.321	0.344	0.357	0.380	0.370	0.362
Jiangxi	0.197	0.187	0.220	0.208	0.202	0.208	0.209	0.222	0.220	0.220	0.247	0.236
Shandong	0.321	0.335	0.334	0.351	0.349	0.361	0.383	0.357	0.343	0.372	0.349	0.357
Henan	0.224	0.226	0.254	0.219	0.239	0.264	0.233	0.255	0.255	0.264	0.320	0.302
Hubei	0.258	0.259	0.310	0.311	0.298	0.288	0.294	0.299	0.307	0.322	0.339	0.332
Hunan	0.253	0.268	0.284	0.243	0.281	0.298	0.299	0.287	0.296	0.311	0.326	0.304
hillsides	0.492	0.475	0.478	0.444	0.455	0.484	0.494	0.478	0.487	0.478	0.484	0.483
Guangxi	0.161	0.153	0.186	0.163	0.184	0.194	0.169	0.177	0.184	0.192	0.211	0.180
Hainan	0.179	0.187	0.192	0.181	0.195	0.176	0.169	0.166	0.201	0.218	0.247	0.200
Chongqing	0.240	0.264	0.258	0.265	0.266	0.272	0.282	0.294	0.299	0.306	0.329	0.313
Sichuan	0.244	0.273	0.267	0.288	0.262	0.287	0.278	0.289	0.289	0.282	0.319	0.296
Guizhou	0.077	0.081	0.093	0.100	0.133	0.136	0.163	0.156	0.168	0.163	0.146	0.140
Yunnan	0.139	0.147	0.162	0.167	0.165	0.161	0.170	0.192	0.208	0.223	0.234	0.201
Shaanxi	0.246	0.257	0.273	0.286	0.275	0.297	0.303	0.266	0.276	0.276	0.300	0.276
Gansu	0.110	0.112	0.159	0.128	0.127	0.106	0.121	0.117	0.122	0.149	0.132	0.128
Qinghai	0.160	0.162	0.183	0.192	0.176	0.150	0.170	0.160	0.163	0.163	0.199	0.180
Ningxia	0.148	0.150	0.167	0.178	0.194	0.195	0.175	0.184	0.182	0.186	0.179	0.189
Xinjiang	0.219	0.214	0.227	0.189	0.197	0.213	0.237	0.197	0.184	0.193	0.154	0.173



a. Distribution of common wealth, 2011 b. Distribution of Common Wealth, 2016 c. Distribution of common wealth, 2021



d. Common Wealth Hotspot Map, 2011 e. Common Wealth Hotspot Map, 2016 f. Shared prosperity hotspot map, 2021

Fig. 2. Spatial distribution of shared wealth and hotspots, 2011, 2016 and 2021.

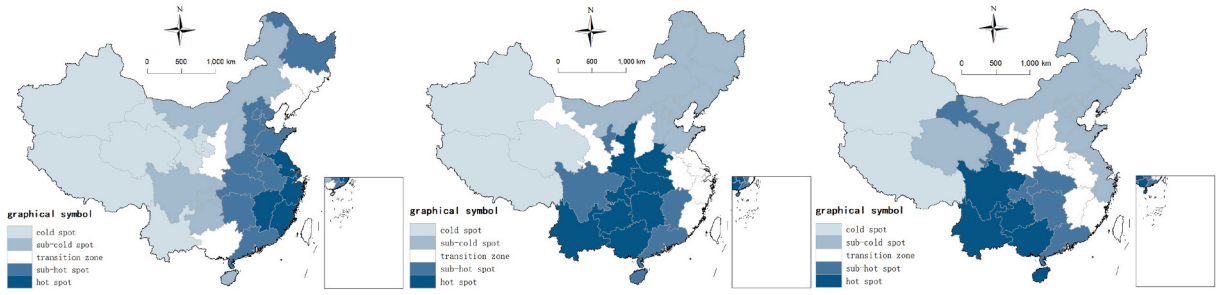
local adjustments of the boundaries of the various levels. Thus, on the road to a high level of development towards common prosperity, China is facing a series of complex challenges, especially in provinces lagging behind in development, which are making relatively slow progress. In order to achieve shared prosperity, it is necessary to establish a durable and efficient regional cooperation and development strategy.

The hotspot maps accurately characterize the stepped distribution of common wealth (see Fig. 2 d-f). As time advances, the phenomenon of local optimization and adjustment occurs at the edges of each region. The results of the study show that the more economically developed provinces, such as Jiangsu and Zhejiang, are the hotspots of common wealth at this stage. The northern coastal belt, the southern coastal belt, and the southern part of Liaoning are the sub-hot spots of common wealth. A number of sub-hot spot areas are scattered to the west of the hot spot areas, forming a transition zone between the hot spot areas and the sub-hot spot areas, from which the cold spot areas gradually extend outward.

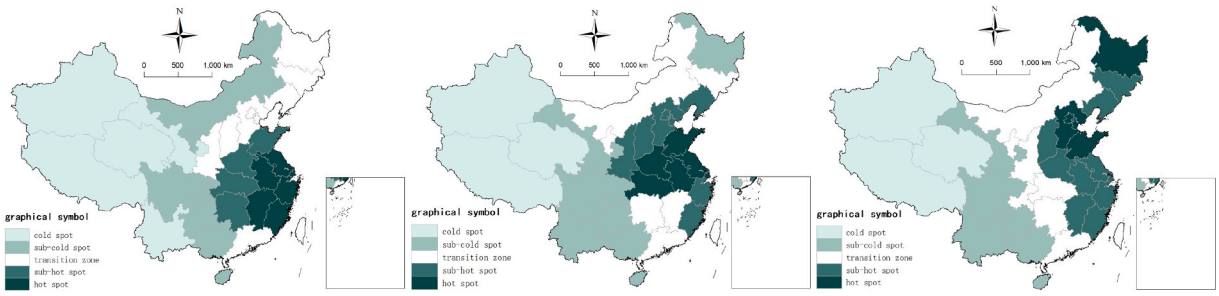
4.2.2. *Characteristics of the dimensions of common wealth*

The hotspot maps of the development level, sharing level, and sustainability level show that all three exhibit a ladder-like distribution, with the high value as the center decreasing outwards. In 2011–2021, the sharing level and the sustainability level gradually change from one center to two centers, while the development level always remains at one center (Fig. 3).

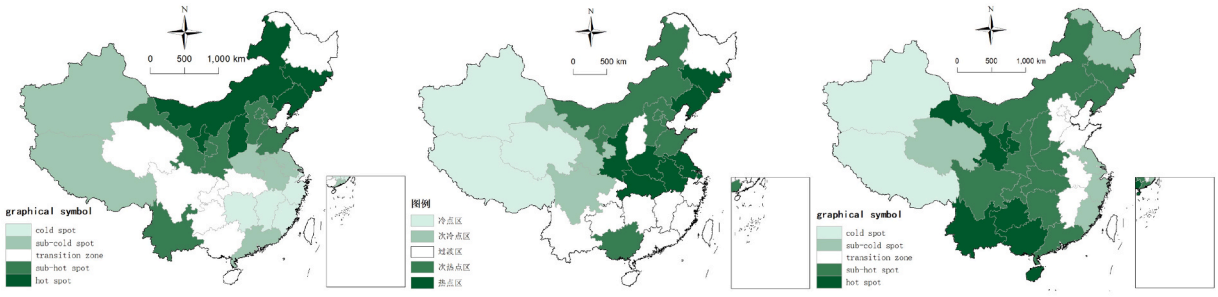
Development level hotspots include the Yangtze River Delta region, Yunnan, Guizhou and central Sichuan (see Fig. 3 a-c). In terms of spatial layout, sub-hot spots of development level cover Guangdong, Fujian, and Jiangxi, while areas with relatively slower economic development extend westwards into sub-cold spot areas and cold spot areas. In addition, there are scattered sub-hotspots with higher levels of development in central and western regions such as Sichuan, Gansu, and Hubei. In the time dimension, the pattern of



a. Hotspot map of development levels, 2011 b. Hotspot map of development levels, 2016 c. Hotspot map of development levels, 2021



d. Hotspot map of sharing levels, 2011 e. Hotspot map of sharing levels, 2016 f. Hotspot map of sharing levels, 2021



g. Hotspot map of sustainability levels, 2011 h. Hotspot map of sustainability levels, 2016 i. Hotspot map of sustainability levels, 2021

Fig. 3. Map of development, sharing and sustainability hotspots, 2011, 2016 and 2021.

spatial distribution of development levels has changed considerably, with the hotspot areas in the Yangtze River Delta region gradually transitioning to the central and western regions, such as Yunnan and Guizhou. The area of the cold spot region, centered on Turpan in Xinjiang, has shrunk, and the level of development in the western region has relatively improved.

Sharing level was only available in one hotspot, the Yangtze River Delta region, in 2011 (see Fig. 3 d-f). However, from 2016 onwards, the hotspot region centered on the Yangtze River Delta gradually extended northwards. As of 2021, two hotspot regions have been formed in Beijing-Tianjin-Hebei as well as some parts of Heilongjiang, both displaying ladder-like distribution characteristics. In terms of spatial layout, the eastern coastal region has the highest level of sharing, followed closely by central regions such as Shanxi and Henan. The western region has the relatively lowest level of sharing. In the time dimension, the area of cold spots in the west is gradually shrinking, while the boundaries of sub-cold spots located in its neighborhood, such as Yunnan, eastern Sichuan, and Guangxi, are gradually increasing. Meanwhile, the boundaries of secondary hotspot areas such as Hubei and Hunan are continuing to expand. The hotspot areas in the northeast are also increasing, making the sharing degree rise relatively upwards.

Sustainable levels 2011 only one hotspot centered on Inner Mongolia (see Fig. 3 g-i). However, since 2016, the hotspot has gradually expanded westward, forming two hotspots centered on western regions such as Gansu region and Yunnan by 2021. Possible reasons the state has continued to increase investment and policy support for ecological environmental protection in the western development strategy, and western regions such as Gansu and Yunnan have effectively promoted the construction of ecological civilization through regional cooperation, increased forest coverage and strengthened ecosystem service functions. In terms of spatial distribution, the central region has the highest level of sustainability. The area of sub-cold spots extends eastward, and the area of sub-cold spots in parts of Heilongjiang and the eastern coastal areas increases, with a relative decline in the sustainable level. In terms of temporal distribution, the area covered by sub-hot spots in the central region gradually expands, and the sustainable level relatively improves. The hotspot area in the northwestern region increases, and the sustainable level relatively improves.

4.3. The impact of spatial imbalances in industrial structural change on the common wealth gap

4.3.1. QAP correlation analysis

The results of the QAP correlation analysis between the common wealth gap and industrial structure change during the sample observation period are shown in Table 6. The results show that there is a significant positive correlation between industrial structure rationalization, industrial structure advancement, and the common wealth gap. And the correlation coefficient of industrial structure rationalization is significantly higher than that of industrial structure advancement. This further confirms the deeper connection with the common wealth gap.

The results of the QAP correlation analysis of the control variables are shown in Table 7 below. The results show that there is a significant positive correlation between the common wealth gap and the income security gap, the resource endowment gap, the openness gap, the energy structure gap, the population density gap and the human capital level gap. Specifically, the correlation coefficient between the income security gap and the common wealth gap is the highest, reaching 0.881, indicating the closest relationship between the two. Meanwhile, the correlation coefficient between the human capital level gap and the common wealth gap is 0.794, which is only lower than that of the income security gap. And the correlation coefficient between the energy structure gap and the common wealth gap is the smallest, which is 0.388. Besides, the marketisation and government intervention gaps have a negative impact on the common wealth gap, with the correlation coefficients of −0.521 and −0.544, respectively. it can be seen from the above research results that the change of the industrial structure is closely related to the difference of common wealth, and at the same time, the control variables have a significant correlation. The results of QAP correlation analysis of control variables effectively support the viewpoints of this study. In addition, there is a significant correlation between the core explanatory variables and the control variables. The possibility of multicollinearity exists if multiple influencing factors are considered in the empirical test, which may lead to biased regression results.

4.3.2. QAP regression analysis

QAP regression findings differ from usual regression results by providing both unstandardized and standardized regression coefficients. Standardized regression coefficients are chosen to objectively evaluate the impact of explanatory variables on the explained variables in QAP regression analysis. Standardized regression coefficients are consistent regardless of magnitude, allowing for a direct comparison of regression coefficients within the same model. This enables an unbiased evaluation of variable influence and an accurate ranking of distinct variables.

In Model 1 (Table 8), only two core explanatory variables, industrial structure rationalization and industrial structure advanced, are involved. The standardized regression coefficient of 0.310 for industrial structure rationalization and 0.448 for industrial structure advancement are both significant at the 5 % level. This suggests that the gap between industrial structure rationalization and

Table 6
QAP correlation analysis of common wealth gap and industrial structure change.

variant	Com	Rat	Adv
Com	1.000***		
Rat	0.545***	1.000***	
Adv	0.451***	0.314*	1.000***

Note: ***, ** and * indicate significant at the 1 %, 5 % and 10 % levels, respectively.

Table 7
QAP correlation analysis of common wealth gap and control variables.

variant	Com	Inc	Mar	Res	Gov	Ope	Ene	Pop	Hum
Com	1.000***								
Inc	0.881***	1.000***							
Mar	−0.521***	−0.368*	1.000***						
Res	0.788***	0.612**	−0.573***	1.000***					
Gov	−0.544***	−0.361**	0.976***	−0.559***	1.000***				
Ope	0.572***	0.485**	−0.489***	0.352**	−0.517***	1.000***			
Ene	0.388**	0.124	−0.563***	0.655***	−0.569***	0.038	1.000***		
Pop	0.716***	0.786***	−0.315**	0.389*	−0.293**	0.576**	0.086	1.000***	
Hum	0.794***	0.817***	−0.134	0.456**	−0.151	0.485**	−0.127	0.638**	1.000***

Note: ***, ** and * indicate significant at the 1 %, 5%and 10 % levels, respectively.

advancement significantly affects the common wealth gap. Specifically, the industrial structure rationalization gap has a relatively smaller impact on the common wealth gap compared to the advanced one. After the model correction, the value of R^2 reaches 0.384, which indicates that the rationalization and advancement of industrial structure have high explanatory power in explaining the common wealth gap. Common wealth pursues not only equality among different levels but also includes creating more wealth and distributing it widely. Rationalization of industrial structure is achieved mainly through optimizing the allocation of existing resources and improving utilization efficiency, but has limited effect in terms of increasing overall wealth. In contrast, the advanced industrial structure actually expands the size of the economy through technological innovation and value-added enhancement, producing higher-value products and services and raising the standard of living of society. This will create more employment opportunities, especially in high-income areas, and play a more positive role in promoting the realization of common wealth. Therefore, the advanced industrial structure has a more significant impact in narrowing the common wealth gap. After considering these factors, we conducted regression analyses using Model 2, the results of which, as shown in Table 8, demonstrate a significant increase in its overall explanatory power. Compared with Model 1, the coefficients of the industrial structure rationalization and advancement gaps on the common wealth gap are reduced from 0.310 to 0.448 to 0.013 and 0.256, but the direction of the influence remains unchanged and still plays a key role in reducing the common wealth gap. In addition, the standardized regression coefficients of the remaining control variables are positive and pass the significance test, except for government intervention and the gap in the degree of openness to the outside world, which have a negative impact on the common wealth gap. Therefore, a combination of these factors can significantly reduce the common wealth gap and further validate the hypotheses of the theoretical framework.

In Model 2 of Table 8, the factors are ranked in the following order of intensity of influence: degree of marketisation (0.465), human capital (0.389), advanced industrial structure (0.256), resource endowment (0.242), income security (0.241), energy structure (0.162), population density (0.146), rationalization of industrial structure (0.013), degree of openness to the outside world (−0.001) and government intervention (−0.584). It is worth noting that among all 10 factors, the influence of industrial structure rationalization and industrial structure sophistication is at the eighth and third place respectively, lower than that of the degree of marketisation and human capital. For the degree of marketisation, its influence intensity is 35.77 and 1.81 times higher than that of industrial structure rationalization and advanced industrial structure, respectively. For human capital, it is 29.92 times as strong as rationalization of industrial structure and 1.52 times as strong as advanced industrial structure. The study suggests that although the industrial structure rationalization and advancement gaps have a significant impact on the gap in common wealth during the sample observation period, factors such as marketisation and human capital levels remain the core causes of the gap in common wealth. It is worth noting that the

Table 8
Full sample examination of QAP regression analyses.

variant	Model 1					Model 2				
	Unstandardized coefficient	Standardized factor	*P*-value	P_{large}	P_{small}	Unstandardized coefficient	Standardized factor	*P*-value	P_{large}	P_{small}
intercept	0.064	0.000	–	–	–	0.000	0.000	–	–	–
Rat	0.215	0.310	0.006	0.006	0.994	0.006	0.013	0.069	0.069	0.931
Adv	0.061	0.448	0.005	0.005	0.996	0.044	0.256	0.007	0.994	0.007
Inc						0.200	0.241	0.008	0.008	0.992
Bus						0.655	0.465	0.041	0.041	0.960
Dig						0.610	0.242	0.019	0.019	0.981
Gov						−0.705	−0.584	0.023	0.978	0.023
Ope						−0.009	−0.001	0.559	0.441	0.559
Ene						0.843	0.162	0.013	0.013	0.987
Pop						0.000	0.146	0.097	0.097	0.904
Hum						0.682	0.389	0.001	0.001	0.999
Adjusted R^2	0.384					0.953				
sample size	870					870				

Note: ***, ** and * indicate significant at the 1 %, 5 % and 10 % levels, respectively.

gap in the degree of marketisation has the strongest driving effect on the difference in the level of common wealth and is the decisive force leading to the widening of the gap. The gap in the degree of marketisation affects the realization of common wealth in terms of resource allocation efficiency, economic growth model and wealth distribution mechanism. In order to promote common wealth, it is necessary to improve the market mechanism while increasing the degree of marketisation, establish effective social security and redistribution mechanisms, as well as strengthen the government's correction of market failures. Policymakers are required to promote market-oriented reforms while focusing on equity and sustainability to ensure that the fruits of economic growth benefit all members of society.

5. Conclusions and policy recommendations

5.1. Conclusions

Common prosperity is the fundamental principle of socialism and the ultimate objective of all ongoing endeavors and reforms. This study focused on 30 provinces in China to analyze common prosperity using the perspectives of "development," "sharing," and "sustainability." An index system was constructed to evaluate the level of common prosperity across the country from 2010 to 2021. The study examines the aspects of shared prosperity and its spatial, regional, and agglomeration characteristics. The study uses the Quadratic Assignment Procedure (QAP) to investigate if the spatial imbalance of industrial structure change contributes to widening the wealth gap. The primary findings are as follows:

(i) China's industrial structure exhibits a clear geographic imbalance. The regional disparity in advanced industrial structure has been consistently decreasing from 2010 to 2021, with intra-regional differences accounting for over 60 % of this trend. Consequently, variations in advanced industrial structure remain the primary source of differences within regions. The regional variation in the rationalization of industrial structure follows a pattern of initial increase followed by decrease, with intra-regional imbalance being the primary contributor to inter-regional discrepancy. The eastern region shows the most significant disparities in rationalization and sophisticated industrial structure, followed by the center region, with the western region having the least differences.

(ii) The overall trend of the Common Wealth Index is steadily rising. The first echelon includes Shanghai, Beijing, and Zhejiang, with a relatively high degree of common wealth; the second echelon includes Guangdong, Tianjin, Jiangsu, Liaoning, and Shandong, covering the economically advanced provinces in the eastern region, with a relatively balanced distribution; 12 provincial-level administrations, including Hubei, Heilongjiang, and Henan, are located in the third echelon; the fourth echelon and the fifth echelon, totaling 10 provincial-level administrations, are all located in the lower degree of common wealth, with the exception of Hainan in the east. From the perspective of spatial layout, the spatial distribution of common wealth and its dimensions show a ladder-like pattern of decreasing from east to west. With the eastern coastal region as the core, the spatial layout of the levels of common wealth, development, and sharing shows a similar pattern. In contrast, areas with high values of sustainable levels include the central region centered on Inner Mongolia and western regions such as Gansu and Yunnan. In terms of the time dimension, from 2010 to 2021, the development of shared prosperity achieves a switch from being mainly in the fifth and fourth echelons to the fourth and third echelons, with Beijing, Jiangsu, and Shanghai still belonging to the first echelon, while Guangxi remains in the fifth echelon. In terms of the speed of conversion, the conversion from the fifth to the fourth echelon was faster and was basically completed between 2010 and 2012; however, the shift from the fourth to the third echelon went through a long process. Only most of the conversion was achieved in nine years between 2012 and 2021, and the transformation from the third echelon to the second and first echelons was difficult until 2021. Few regions will be able to complete the conversion.

(iii) The difference between industrial structure advancement and rationalization significantly affects the common wealth gap. Among them, the impact of industrial structural advancement on the common wealth gap is more pronounced than industrial structural rationalization, as the pursuit of common wealth is not only about equality among different levels but also about creating more wealth and distributing it widely. Rationalization of industrial structure mainly optimizes the allocation of existing resources and improves the efficiency of resource utilization, but has a limited role in increasing overall wealth. On the contrary, the advanced industrial structure actually expands the economy through technological innovation and increased value addition, creating higher-value products and services and raising the standard of living in society. This leads to more employment opportunities, especially in higher-income areas, and creates a stronger impetus for shared prosperity. Therefore, narrowing the differences in the advanced industrial structure is more conducive to narrowing the common wealth gap. Among the other control variables, the standardized regression coefficients of the remaining control variables are all significantly positive, contributing to the reduction of the common wealth gap, except for government intervention and the gap in the degree of openness to the outside world, which have a negative impact on the common wealth gap.

5.2. Policy recommendations

Based on these findings, this paper draws the following policy implications:

(i) The industrial structure of the provinces has been increasingly shifting from labor to services, leading to a lack of convergence in labor productivity in the services sector. This could hinder efforts to reduce the regional economic disparity. Hence, it is

necessary to enhance the regional synergistic development approach and establish a regional economic layout characterized by complementary advantages and high-quality growth. Policies in regions with advanced service industries should prioritize innovation and improving service quality. In regions with less established service industries, support should focus on building industrial infrastructure, developing human resources, and introducing technology. Implementing region-specific policies to leverage the influence of advanced regions, incentivizing businesses in these regions to relocate service industry projects to less developed areas, particularly those related to information technology and high-end manufacturing. This strategy aims to facilitate the alignment of the industrial chain's upstream and downstream sectors and foster cluster development. Less developed regions should improve their ability to adopt advanced technology, boost investment in innovative scientific and technological research, particularly in technologies applicable to the service industry to enhance quality and efficiency. They should also enhance collaboration between universities, research institutes, and service industry companies to accelerate the conversion of scientific and technological advancements towards developed regions.

(ii) We should tap into the spillover effect and guiding role of advanced regions in the common wealth so as to achieve the development of relatively poor regions driven by rich regions. In view of the spatial autocorrelation between the common wealth and its subsystems, the influence and impetus of the core provinces of the common wealth should be made good use of to carry out talent exchange programs, such as oriented training and internships and practical training, between the affluent regions and the relatively impoverished regions, so as to improve the vocational skills of employees in impoverished regions. In order to strengthen the leadership capacity of the high-level common wealth areas in the central and western regions, it is necessary to establish reasonable and effective resource allocation channels among regions with different levels of economic development. An example is the establishment of a regional coordinated development fund dedicated to supporting interregional economic cooperation projects, such as common infrastructure development and major technological innovation projects. Through intergovernmental agreements, cross-regional industrial parks have been established, especially to extend the industrial chains of rich regions to neighboring poorer regions and form industrial clusters. It will help enhance the coordination and coupling of regional industrial structures, ultimately leading to the formation of regional clusters driven by common wealth. In order to achieve this goal, we can strengthen technical and financial support for less developed regions by establishing innovation funds to support cooperation projects between local research institutions and universities in the development of new technologies and products. Promote policies to support entrepreneurship and provide financial, technological and market entry support for small and medium-sized enterprises. Promote innovation-driven industrial development and foster industrial chains with comparative advantages.

(iii) It is crucial to support the coordinated development of regional economies by focusing on the rationalization and upgrading of industrial structures, which are more influential. We need to enhance central-level planning and establish an efficient system for industrial synergy to ensure the smooth integration of rationalizing and upgrading industrial structure with regional economic development. It is essential to enhance central-level planning and create a national strategy for industry restructuring. This plan should include specific guidance and priorities for industry development in different regions, focusing on supporting high-tech and strategic emerging industries. We must steadfastly advance the transformation and upgrading of the industrial structure, boost the inherent motivation for optimizing and adjusting the industrial structure, and enhance support for high-tech industries, technology-intensive industries, and strategic emerging industries through measures such as tax incentives, R&D subsidies, and talent introduction policies. Enhance the modernization of traditional industries by promoting the use of innovative technology and equipment, optimizing production processes, and increasing product quality and value. It is essential to seize the new opportunities arising from the technological advancements of the new generation, establish technological innovation centers and incubators, boost innovation's vitality and potential, and expedite the market adoption of new technologies and products. Encourage the extensive integration of production and service sectors, like manufacturing combined with the Internet, to broaden the industrial chain and enhance industrial value. Encourage the growth of the service sector, particularly the modern service sector, and back the advancement of financial services, information services, technical services, and other areas to stimulate the enhancement of the manufacturing industry through service industry innovation. It is important to enhance the industrial structure policy in the new era by establishing a robust incentive mechanism, which includes rewarding significant projects and technological breakthroughs, as well as promoting creative applications with demonstrative impacts.

This study is significant for uncovering the influence of geographical imbalance in industry structural changes on the wealth gap. The analysis offers a fresh viewpoint and detailed examination of how changes in industry structure relate to reducing the wealth divide. Nevertheless, the research also has certain constraints. The research findings are derived from data particular to China. While the results have been thoroughly evaluated and align with China's specific circumstances, variations in different regions may hinder the generalizability of our findings beyond China. Future research could broaden its scope by comparing data from various countries and taking into account the distinctiveness of each location.

Ethics statement

This study did not require ethics committee review and/or approval because it did not involve human or animal participation or the collection of sensitive personal information.

Informed consent is not required for this study because this study typically uses publicly available secondary data, such as published statistics, data from public databases, etc. These data are anonymized and are fully disclosed and shared.

Data availability statement

Data will be made available on request.

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CRediT authorship contribution statement

Xinbao Tian: Writing – review & editing. **Xiaomin Liu:** Writing – original draft.

Declaration of competing interest

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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References

[1] X.F. Ma, R. Zhang, Y.F. Ruan, Evaluation of common prosperity level and regional difference based on the background of green development, Sustainability 14 (23) (2022) 15863.
[2] S. Yin, N. Zhang, K. Ullah, et al., Enhancing digital innovation for the sustainable transformation of manufacturing industry: a pressure-state-response system framework to perceptions of digital green innovation and its performance for green and intelligent manufacturing, Systems 10 (3) (2022) 72.
[3] M. Dunford, The Chinese path to common prosperity, Int. Crit. Thought 12 (1) (2022) 35–54.
[4] X. Yang, Q. Li, S. Luo, et al., How does labor mobility affect common prosperity?—an empirical study based on a panel of Chinese cities, Sustainability 15 (8) (2023) 6893.
[5] M. Zhang, B. Li, S. Yin, Configurational paths to regional innovation performance: the interplay of innovation elements based on a fuzzy-set qualitative comparative analysis approach, Technol. Anal. Strat. Manag. 32 (12) (2020) 1422–1435.
[6] B. Li, Y. Huo, S. Yin, Sustainable financing efficiency and environmental value in China's energy conservation and environmental protection industry under the double carbon target, Sustainability 14 (15) (2022) 9604.
[7] T. Xie, Y. Zhang, X. Song, Research on the spatiotemporal evolution and influencing factors of common prosperity in China, Environ. Dev. Sustain. 26 (1) (2024) 1851–1877.
[8] H. Wan, J. Chen, Theoretical connotation and quantitative measurement of common prosperity, China Finance and Economic Review 11 (2) (2023) 23–45.
[9] P. Schyns, Wealth of nations, individual income andlife satisfaction in 42 countries: a multilevel approach, Soc. Indicat. Res. 60 (1) (2002) 5–40.
[10] X. Zheng, X. Zhang, D. Fan, Digital transformation, industrial structure change, and economic growth motivation: an empirical analysis based on manufacturing industry in Yangtze River Delta, PLoS One 18 (5) (2023) e0284803.
[11] L. Han, Y. Peng, Q. Meng, Digital lnclusive finance, entrepreneurial activity and common wealth–an empirical study based on inter-provincial panel data in China, Soft Sci. 37 (3) (2023) 18–24.
[12] Jinlin Zhang, Xiaofan Dong, Jian Li, Can digital financial inclusion advance common wealth? –An empirical study based on micro household data[J/OL], Research on Finance and Economics 48 (7) (2022) 4–17+123.
[13] Shen Yun, Li Jingrong, Research on the evaluation indicator system of rural Residents' Wealthy living in China–Based on the perspective of comprehensively building a well-off society, J/OL]. Research World. (1) (2020) 42–50.
[14] X. Zhang, H. Liu, Heterogeneity perspective on the dynamic identification of low-income groups and quantitative decomposition of income increase: evidence from China, Sustainability 14 (15) (2022) 9367.
[15] D. Wu, L. Wu, Y. Ye, Industrial structure optimization, economic development factors and regional economic risk prevention in post COVID-19 period: empirical analysis based on panel data of Guangdong regional economy, J. Combin. Optim. 44 (5) (2022) 3735.
[16] F. Ye, J. Deng, B. Gong, et al., Economic policy uncertainty, resource endowments and industrial structure transformation, J. Asia Pac. Econ. 29 (1) (2024) 341–361.
[17] S. Zhao, X. He, K.U. Faxritdinovna, Does industrial structure changes matter in renewable energy development? Mediating role of green finance development, Renew. Energy 214 (2023) 350–358.
[18] Y. Liu, X. Dong, K. Dong, Pathway to prosperity? The impact of low-carbon energy transition on China's common prosperity, Energy Econ. 124 (2023) 106819.
[19] Z. Chen, S. Zhang, J. Qiu, Digital economy, industrial structure and common prosperity, Information Systems and Economics 4 (8) (2023) 113–120.
[20] K. Gerlach, Why growth rates differ. Postwar Experience in Nine Western Countries, 1971.
[21] Jr R.E. Lucas, Making a miracle, Econometrica: J. Econom. Soc. (1993) 251–272.
[22] C. Clark, The Conditions of Economic progress[J]. The Conditions of Economic Progress, 1967.
[23] A. Maddison, Growth and slowdown in advanced capitalist economies: techniques of quantitative assessment, J. Econ. Lit. 25 (2) (1987) 649–698.
[24] G.M. Grossman, E. Helpman, Innovation and Growth in the Global economy[M], MIT press, 1993.
[25] T. Kliestik, E. Nica, P. Durana, et al., Artificial intelligence-based predictive maintenance, time-sensitive networking, and big data-driven algorithmic decision-making in the economics of Industrial Internet of Things, Oeconomia Copernicana 14 (4) (2023) 1097–1138.
[26] H.B. Chenery, S. Robinson, M. Syrquin, et al., Industrialization and growth[M], Oxford University Press, New York, 1986.
[27] Zhenhua Zhou, Optimization of Industrial Structure [M], Shanghai People's Publishing House, 2014, p. 251.
[28] S. Yu, S. Zheng, X. Zhang, et al., Realizing China's goals on energy saving and pollution reduction: industrial structure multi-objective optimization approach, Energy Pol. 122 (2018) 300–312.
[29] J. Zhao, Q. Jiang, X. Dong, et al., How does industrial structure adjustment reduce CO2 emissions? Spatial and mediation effects analysis for China, Energy Econ. 105 (2022) 105704.

[30] X. Zhao, Y. Shang, M. Song, Industrial structure distortion and urban ecological efficiency from the perspective of green entrepreneurial ecosystems, Soc. Econ. Plann. Sci. 72 (2020) 100757.
[31] M.T. Majeed, M. Mazhar, I. Samreen, et al., Economic complexities and environmental degradation: evidence from OECD countries, Environ. Dev. Sustain. 24 (4) (2022) 5846–5866.
[32] Y.J. Zhang, Z. Liu, H. Zhang, et al., The impact of economic growth, industrial structure and urbanization on carbon emission intensity in China, Nat. Hazards 73 (2014) 579–595.
[33] X. Wei, Internet development, marketization degree and resource allocation efficiency, Journal of Southwest University for Nationalities (Humanities and Social Sciences Edition) 42 (9) (2021) 109–120.
[34] X. Zheng, X. Zhang, D. Fan, Digital transformation, industrial structure change, and economic growth motivation: an empirical analysis based on manufacturing industry in Yangtze River Delta, PLoS One 18 (5) (2023) e0284803.
[35] A.F. Shorrocks, The class of additively decomposable inequality measures, Econometrica: J. Econom. Soc. (1980) 613–625.
[36] D. Krackhardt, Predicting with networks: nonparametric multiple regression analysis of dyadic data, Soc. Network. 10 (4) (1988) 359–381.
[37] T.J. Zagenczyk, R.L. Purvis, M.K. Shoss, et al., Social influence and leader perceptions: multiplex social network ties and similarity in leader–member exchange, J. Bus. Psychol. 30 (2015) 105–117.
[38] C.H. Gan, R. Zheng, D. Yu, The impact of industrial structure change on economic growth and volatility in China, Econ. Res. 46 (2011) 4–16.