Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 6, 2168-2183
2025
Publisher: Learning Gate
DOI: 10.55214/25768484.v9i6.8329

How to achieve economic growth through industrial synergy and agglomeration: Evidence from China

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Abstract: Against the intertwined backdrop of deglobalization and the digital technology revolution, industrial collaborative agglomeration, as a crucial spatial organizational form for optimizing resource allocation, demands in-depth exploration of its mechanism of action on regional economic growth. This paper constructs a revised E-G index based on the panel data of 31 provinces in China from 2011 to 2023 to measure the level of industrial collaborative agglomeration. By employing fixed-effect models, mediating effect tests, and heterogeneity analysis, it systematically investigates the impact pathways of industrial collaborative agglomeration on economic growth and regional disparities. The study reveals that industrial collaborative agglomeration has a positive promoting effect on regional economic growth, and this conclusion remains robust in variable substitution and lag tests. Mechanism analysis shows that industrial collaborative agglomeration indirectly drives economic growth by enhancing social consumption levels. Heterogeneity analysis finds that the economic promotion effect of industrial collaborative agglomeration is significant in provinces with low urbanization rates and low tax burdens; conversely, the results are insignificant in provinces with high urbanization rates and high-tax environments. This research expands the theoretical framework of industrial collaborative agglomeration, confirms the transmission mechanism driven by consumption, and reveals the role of regional development stages and policy environments in agglomeration effects, providing theoretical support and practical guidance for promoting high-quality economic development.

Keywords: *Agglomeration, Economic growth, Industrial synergy, Regional economies.*

1. Introduction

Against the intricate backdrop of the resurgence of anti-globalization sentiments and the revolutionary wave of digital technologies, the global economy is undergoing profound structural adjustments. Geopolitical conflicts have exacerbated supply chain risks, while climate change has spurred the imperative for green transformation [1]. Meanwhile, breakthroughs in emerging technologies such as artificial intelligence and big data have not only presented new opportunities for industrial transformation but have also intensified regional development disparities. In this context, how to break free from the shackles of traditional growth models and nurture new drivers of economic growth that align with the demands of the new era has emerged as a formidable challenge faced by nations and regional economies worldwide [2]. As a pivotal spatial organizational form for optimizing resource allocation and stimulating innovation vitality, industrial synergistic agglomeration is reshaping the regional economic landscape at an unprecedented pace. From Silicon Valley in the United States, which has fostered a global hub for technological innovation through the synergistic agglomeration of information technology and venture capital, to the Yangtze River Delta region in China, which has constructed world-class industrial clusters through the deep integration of advanced manufacturing and producer services, empirical evidence consistently underscores that the

History: Received: 19 March 2025; Revised: 20 May 2025; Accepted: 23 May 2025; Published: 24 June 2025
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agglomeration effects of inter-industrial factor sharing, technological synergy, and market complementarity can significantly enhance production efficiency, reduce transaction costs, and generate sustained economic growth momentum through the construction of knowledge spillovers and innovation networks.

Despite the widespread recognition of the economic value of industrial synergistic agglomeration, notable gaps persist in both theoretical research and practical applications. At the theoretical level, existing literature predominantly analyzes industrial agglomeration effects from singular perspectives such as Marshall's externalities and Porter's competitive advantage theory, with systematic research on the dynamic synergistic mechanisms among multiple industries, the network effects of factor mobility, and innovation diffusion pathways remaining relatively weak [3]. The depiction of spatial heterogeneity and nonlinear relationships in econometric models also requires further refinement. In the realm of practice, some regions blindly emulate the industrial policies of advanced regions, neglecting their local resource endowments and industrial foundations, leading to widespread phenomena of "emphasizing quantity over quality" and "prioritizing agglomeration over synergy." Although some industrial parks have achieved spatial agglomeration of enterprises, the inter-industrial correlation remains low, lacking effective technological exchanges and division of labor collaboration [4]. Certain emerging industrial clusters excessively rely on policy subsidies and have yet to form a market-oriented collaborative innovation ecosystem. Furthermore, issues such as regional administrative barriers, obstacles to the circulation of data elements, and inadequate intellectual property protection severely constrain the full realization of the efficacy of industrial synergistic agglomeration.

In practical domains, delving into the theoretical mechanisms and implementation pathways through which industrial synergistic agglomeration promotes economic growth has become a significant concern shared by academia and policymakers. This research not only enriches the theoretical frameworks of industrial economics and regional economics by elucidating the inherent laws of multi-industrial synergistic development but also provides a scientific basis for local governments to formulate differentiated industrial policies and optimize regional economic layouts. By dissecting the formation mechanisms, influencing factors, and evolutionary pathways of industrial synergistic agglomeration, this study will offer crucial theoretical support and practical guidance for addressing regional development imbalances, promoting industrial transformation and upgrading, and constructing a modernized economic system. It holds irreplaceable significance for achieving high-quality economic development and enhancing global economic competitiveness.

2. Literature Review

Industrial Co-agglomeration refers to the spatial proximity and functional complementarity among different industries, fostering an economic ecosystem characterized by enhanced innovation and competitiveness through knowledge spillovers, resource sharing, technological interactions, and industrial chain integration [5]. This phenomenon not only reshapes the regional industrial landscape but also offers a new avenue for achieving high-quality economic development. In terms of measurement, scholars predominantly employ methods such as location quotient and spatial Gini coefficient to gauge the degree of industrial co-agglomeration. For instance, the location quotient is utilized to reflect the relative extent of industrial co-agglomeration in a specific region compared to the national average [6]. By calculating the ratio of the employment or output share of a particular industry in the region to its corresponding national share, the level of industrial co-agglomeration is delineated.

Subsequently, with the deepening of economic globalization and regional integration, the impacts of industrial co-agglomeration on economic growth, innovation, and green development have become increasingly pronounced [7]. Numerous studies have demonstrated the positive role of industrial co-agglomeration in promoting economic growth. Some scholars have found that industrial co-agglomeration can enhance production efficiency by facilitating factor mobility, technological innovation, and specialized division of labor, thereby driving regional economic growth [8]. For example, research on the Yangtze River Delta urban agglomeration reveals that the co-agglomeration

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 6: 2168-2183, 2025
DOI: 10.55214/25768484.v9i6.8329

of manufacturing and producer services optimizes resource allocation and spurs regional economic growth [9]. Meanwhile, there exists a close nexus between industrial co-agglomeration and innovation. On the one hand, industrial co-agglomeration promotes knowledge spillovers and technological exchanges, with frequent interactions and collaborations among firms accelerating the dissemination and application of new technologies and ideas. On the other hand, the competitive pressures engendered by agglomeration incentivize firms to increase R&D investment and enhance their innovative capabilities. Furthermore, against the backdrop of green development emerging as a crucial orientation for economic advancement, the impacts of industrial co-agglomeration on green economic efficiency and green innovation efficiency have garnered attention. Some studies, utilizing methods such as the spatial Durbin model, have found that the co-agglomeration of producer services and manufacturing has a direct effect on green economic efficiency, exhibiting spatial-temporal heterogeneity [10]. Meanwhile, industrial co-agglomeration also influences green innovation efficiency, with the co-agglomeration of high-end producer services and manufacturing significantly enhancing local green innovation efficiency. However, as uncertainties in the global industrial chain escalate, the impact of industrial co-agglomeration on industrial chain resilience has become a research hotspot. Scholars have constructed relevant models to analyze how industrial co-agglomeration enhances industrial chain resilience by strengthening inter-industry linkages and improving the capacity to withstand external shocks [11]. Studies have revealed that industrial co-agglomeration can significantly enhance industrial chain resilience, with artificial intelligence and green technological innovation playing pivotal roles. Moreover, industrial co-agglomeration exhibits notable synchronous and chain-like intermediate effects in the process of influencing industrial chain resilience.

Economic growth has consistently been a core research topic within the field of economics. With the dynamic evolution of economic environments and the continuous innovation of research methodologies, numerous scholars have conducted studies on economic growth from diverse perspectives, aiming to unveil its underlying mechanisms and influencing factors, thereby providing theoretical support for economic policy formulation and regional development [12].

Firstly, regarding policy and institutional factors, governments play a pivotal role in economic growth. Scholars have found that the specialization of government economic governance can lead to unexpected economic growth, which is associated with the efficient allocation of resource elements and incentive factors like the "promotion tournament" [13]. However, as the performance evaluation system for local governments undergoes transformations, the extent of this impact has diminished. The targeted reserve requirement ratio reduction policy also exerts a significant influence on the macroeconomic performance of counties, primarily manifesting in stimulating fixed asset investment and promoting the growth of the secondary industry. Environmental taxation policy, as a crucial component of taxation policies, significantly reduces pollution emissions but has a negative impact on economic growth [14]. Nevertheless, when energy intensity, technological innovation investment, and marketization levels surpass certain threshold values, environmental taxation can simultaneously reduce pollution emissions and foster economic growth.

Secondly, industrial and structural factors are of paramount importance to economic growth. Numerous studies have demonstrated that industrial co-agglomeration, particularly the synergy between manufacturing and producer services, positively promotes economic growth by facilitating factor mobility, technological innovation, and specialized division of labor, thereby enhancing production efficiency and driving regional economic growth [15]. Moreover, the digitization of the cultural industry has emerged as a new paradigm for promoting economic growth. The digitization of cultural relics not only effectively preserves cultural heritage but also injects new vitality into the cultural industry by innovating display methods, enriching cultural product offerings, and expanding consumer markets, thus propelling high-quality economic development.

Thirdly, factor inputs and mobility significantly impact economic growth. New-quality productivity has become a crucial engine for urban economic growth, driving it through three mechanisms: "high-tech" leadership, "high-efficiency" allocation, and "high-quality" supply [16]. The development of data

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ISSN: 2576-8484
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elements also significantly promotes regional economic growth, with regions possessing stronger digital service supply capabilities and higher government attention to the digital economy achieving greater economic growth. Additionally, the flow of digital knowledge can facilitate regional coordinated development, with digital knowledge flowing from developed to underdeveloped regions contributing to this process [17].

In conclusion, industrial co-agglomeration has a profound impact on economic growth, innovation, green development, and industrial chain resilience. The study of economic growth encompasses multiple factors, including policy and institutional frameworks, industrial structures, factor inputs and mobility, as well as infrastructure and public services. The marginal contributions of this paper are as follows: Firstly, it systematically reviews theories related to industrial co-agglomeration and economic growth, integrating research findings from multiple fields to provide a more comprehensive theoretical framework for subsequent studies. Unlike existing research that often focuses on a single domain, this paper synthesizes the relationship between the two, thereby expanding the theoretical boundaries. Secondly, it comprehensively analyzes the impact of industrial co-agglomeration on economic growth from multiple dimensions, covering aspects such as economic growth, innovation, green development, and industrial chain resilience, as well as various influencing factors of economic growth. This enriches the research perspectives and compensates for the shortcomings of previous studies that tended to focus on a single dimension. Thirdly, it offers a comprehensive reference for economic policy formulation. Previous research findings have been relatively fragmented in terms of policy implications. This paper integrates these findings to provide systematic insights for governments in formulating industrial policies, regional development policies, etc., thereby assisting in the realization of high-quality economic development.

3. Theoretical Hypothesis

From the perspective of externality theory, the spatial proximity of different industries can give rise to knowledge spillover effects. Specifically, the co-location of producer services and manufacturing industries enables service segments such as design, R&D, and logistics to be deeply embedded in the manufacturing process [18]. Informal exchanges among firms accelerate technology diffusion and the sharing of management experiences, while the deepening of specialized division of labor allows firms to focus on core activities, thereby reducing transaction costs and enhancing economies of scale and scope. Meanwhile, the industrial linkage theory posits that industrial co-agglomeration activates the efficiency of industrial chains by strengthening forward and backward linkages [19]. The synergy between high-end manufacturing and R&D service industries can elevate the level of self-reliance in key components, driving innovation in downstream application scenarios through forward linkages. The coupling of modern service industries with traditional industries, on the other hand, pulls the upgrading of upstream raw materials and equipment through backward linkages. Such linkage effects not only extend the length of industrial chains but also expand demand scale through the "home market effect," thereby promoting economic growth.

Furthermore, within the theoretical framework of innovation systems, industrial co-agglomeration is essentially the construction of an innovation ecosystem characterized by interactions among multiple actors [20]. The spatial agglomeration of firms, universities, research institutions, and governments enhances the efficiency of industry-university-research collaboration. For instance, information technology firms and venture capital institutions in Silicon Valley achieve rapid iterations in technology commercialization through geographical proximity. Based on the above analysis, the following hypothesis is proposed:

Hypothesis 1: Industrial co-agglomeration has a significant positive effect on regional economic growth.

On the one hand, industrial co-agglomeration drives the spatial concentration of enterprises from diverse industries, fostering the formation of a more complete industrial chain and consequently creating a greater number of job opportunities. Subsequently, through knowledge spillovers and

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technological complementarity, industrial co-agglomeration enhances labor productivity, propels the development of high value-added industries, and thereby increases workers' incomes. As residents' disposable incomes grow, consumer demand, particularly for services and high-quality goods, expands directly [21]. In essence, industrial co-agglomeration boosts residents' consumption capacity by expanding employment and wage growth.

On the other hand, industrial co-agglomeration reduces transportation and transaction costs for intermediate goods, leading to lower prices for final consumer goods. Moreover, the synergy among different industries facilitates the innovation of new products and services, catering to consumers' differentiated needs. In this context, enterprises enhance supply efficiency by sharing infrastructure and market information, enabling consumers to access higher-quality goods at lower prices. In other words, industrial co-agglomeration promotes social consumption levels by enriching consumption choices and optimizing consumption supply. Consumption is one of the "three carriages" driving economic growth [22]. As a core component of aggregate social demand, its enhancement directly amplifies the total economic output through the Keynesian multiplier effect. According to Keynesian theory, an increase in consumption expenditure triggers a chain reaction through the cycle of "consumption—income—re-consumption." Specifically, data from the National Bureau of Statistics indicate that in 2023, the contribution rate of final consumption expenditure to China's GDP growth reached 82.5%, far surpassing that of investment and exports, underscoring consumption's role as the "ballast stone" for economic growth. Therefore, this paper proposes the following hypothesis:

Hypothesis 2: Industrial co-agglomeration promotes economic growth by enhancing social consumption levels.

4. Model Design

4.1. Data Sources

Based on the data spanning from 2011 to 2023 across 31 provinces, municipalities, and autonomous regions in China, this paper empirically analyzes the relationship between industrial co-agglomeration and the level of economic development. The research data primarily originate from the "China Statistical Yearbook," "China City Statistical Yearbook," the National Bureau of Statistics, as well as statistical yearbooks of various provinces, municipalities, and autonomous regions. In alignment with the research theme, this study processes the data. Apart from directly utilizing the indicator data provided in the yearbooks, linear interpolation is employed to fill in some missing data. Additionally, logarithmic transformations are applied to certain variables to mitigate the potential impact of heteroscedasticity on the empirical analysis. After excluding samples with excessive missing values, a final valid sample size of 403 is obtained.

4.2. Variable Description

The level of economic development is the dependent variable in this article, sourced from the National Bureau of Statistics and expressed as the logarithm of per capita GDP.

The Industrial Synergy Agglomeration Index (Cai) is the explanatory variable in this article, which represents the degree of spatial synergy between productive service industries and manufacturing industries in various provincial administrative regions. The commonly used measurement methods currently include the D-0 index constructed by DURANTON and the E-G index constructed by ELLION. Among them, the D-0 index is greatly limited by data and has low applicability; The revised E-G index is more in line with the actual situation in China compared to the original E-G index. Therefore, this study uses the modified E-G index to calculate the synergistic agglomeration index of the two, and the calculation formula is as follows:

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$$\begin{cases} SA_{is} = (\frac{L_{is}}{L_i})/(\frac{L_s}{L}) \\ HA_{ih} = (\frac{L_{ih}}{L_i})/(\frac{L_h}{L}) \end{cases}$$

In the formula, SA_{is}, HA_{ih} respectively represent the location quotient of the productive service industry (s) and manufacturing industry (h) in region i; L_{is}, L_{ih} represents the number of employees in the productive service industry and manufacturing industry in region i; L_s, L_h respectively represent the number of employees in the national productive service industry and manufacturing industry; L_i, L respectively represent the total number of employees in each region and across the country. Furthermore, the construction of the collaborative agglomeration index between productive service industries and manufacturing industries is as follows:

$$Cai = [1 - |SA - HA|/(SA + HA)] + |SA + HA|$$

Existing literature has found that certain potential factors can cause model changes. In order to avoid the impact of omitted variables, this study controls for the variables shown in the table below.

Table 1.
Variable Definition.

Variable type	Variable meaning	Variable Symbol	Variable Declaration
Explained Variable	Economic development level	Eco	Logarithmic calculation of per capita GDP
Explanatory variable	Industrial synergy agglomeration index	Cai	Addition of collaborative agglomeration index between productive service industry and manufacturing industry
Control variables	Tax burden level	Tl	Tax revenue/GDP
	Financial support intensity	Csl	General budget expenditure/GDP
	Industrial structure	Ig	Value added of the tertiary industry/GDP
	Urbanization rate	Cl	The urbanization level of each province in that year
	Income gap between urban and rural residents	Ccg	The logarithm of (urban resident income - rural resident income)
	Urban financial level	Fin	The proportion of the sum of deposits and loans of financial institutions to GDP

4.3. Model Construction

Based on the previous analysis, construct the following benchmark regression model:

$$Eco_{it} = \alpha + \beta_1 Cai_{it} + \beta_2 X_{it} + \mu_i + \theta_t + \varepsilon_{it} \quad (1)$$

Among them, Eco is the level of economic development, Cai is the index of industrial synergy agglomeration, and X is the control variable, including tax burden level (Tl), fiscal support level (Csl), industrial structure (Ig), urbanization rate (Cl), urban-rural income gap (Ccg), and urban financial level (Fin). α is a constant term, μ_i is the fixed effect of the province, controlling for the influence of unobservable factors that do not change over time on individuals in the province, θ_t is the fixed effect over time, ε is the error term, and i, t are different provinces and times in China.

This study used a two-step method to test the mediation effect and constructed the following mediation regression model:

$$Eco_{it} = \alpha + \beta_1 Cai_{it} + \beta_2 X_{it} + \mu_i + \theta_t + \varepsilon_{it} \quad (2)$$

$$Scl_{it} = \alpha + \beta_1 Cai_{it} + \beta_2 X_{it} + \mu_i + \theta_t + \varepsilon_{it} \quad (3)$$

Among them, Scl is the consumption level of social consumer goods,Eco is the level of economic development, Cai is the index of industrial synergy agglomeration, and X is the control variable, including tax burden level (Tl), fiscal support level (Csl), industrial structure (Ig), urbanization rate (Cl), urban-rural income gap (Ccg), and urban financial level (Fin). α is a constant term, μ_i is the fixed effect of the province, controlling for the influence of unobservable factors that do not change over time on

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 6: 2168-2183, 2025
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individuals in the province, θ_t is the fixed effect over time, ε is the error term, and i, t are different provinces and times in China.

4.4. Descriptive Statistics

The descriptive statistical results of the main variables in this article are shown in Table 1. The average value of the dependent variable economic development level is 10.8915, with a standard deviation of 0.4715, a minimum value of 9.6818, and a maximum value of 12.2075. This indicates that there is not much difference in the level of economic development in China. The average value of the industrial synergy agglomeration index is 1.6691, with a standard deviation of 0.6920, indicating that the current level of industrial synergy agglomeration in various provinces of China is relatively low. The average urbanization rate is 58.97%, but the standard deviation is 0.1410, indicating that China's urbanization development is rapid but uneven. The dispersion and difference levels of the remaining control variables are distributed within a reasonable range and consistent with existing literature.

Table 2.
Descriptive Statistics.

Variable	Obs.	Mean	Std. dev.	Min.	Max.
Eco	403	10.8915	0.4715	9.6818	12.2075
Cai	403	1.6691	0.6920	0.6747	4.7092
Tl	403	0.0825	0.0282	0.03553	0.1882
Csl	403	0.2889	0.2044	0.1050	1.3538
Ig	403	1.3836	0.7506	0.5271	5.6898
Cl	403	0.5897	0.1410	0	0.8958
Ccg	403	2.5301	0.3903	1.7180	3.6716
Fin	403	3.5410	1.1394	1.6879	8.1641

5. Empirical analysis

5.1. Correlation Test

The correlation test analysis primarily aims to measure the interrelationships among the selected variables. As can be observed from the table, variables such as the level of economic development (Eco), industrial co-agglomeration (Cai), tax burden level (Tl), fiscal support intensity (Csl), industrial structure (Ig), urbanization rate (Cl), urban-rural income gap (Ccg), and urban financial level (Fin) all exhibit significant correlations. This is evidenced by their relatively large correlation coefficients (typically, three stars indicate a correlation coefficient close to 1, signifying a strong correlation). The statistical significance of these correlation coefficients implies a robust interrelationship among the research variables chosen, which further suggests that the selected data are appropriate for the study.

Table 3.
Correlation Test.

	Eco	Cai	Tl	CSL	Ig	Cl	CCG	Fin
Eco	1							
Cai	0.604***	1						
Tl	0.262***	0.408***	1					
Csl	-0.357***	-0.431***	0.047	1				
Ig	0.461***	0.291***	0.533***	0.062	1			
Cl	0.695***	0.573***	0.434***	-0.437***	0.384***	1		
Ccg	-0.602***	-0.359***	-0.014	0.422***	-0.115**	-0.483***	1	
Fin	0.453***	0.270***	0.594***	0.327***	0.748***	0.393***	-0.082*	1

5.2. Multicollinearity Test

To prevent the issue of multicollinearity among the variables selected in this study, the variance inflation factor (VIF) was calculated for examination. Generally speaking, when the VIF is less than 10, it can be considered that there is no multicollinearity problem among the variables. As shown in Table

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 6: 2168-2183, 2025
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4, the VIF values of all variables are less than 10. Therefore, there is no multicollinearity problem among the variables chosen in this study.

Table 4.
Multicollinearity Test.

Variable	VIF	1/VIF
Fin	4.03	0.24813
Ig	2.54	0.393227
Csl	2.49	0.401594
Cl	2.45	0.408628
Tl	1.89	0.528629
Cai	1.82	0.549862
Ccg	1.49	0.669654
Mean VIF	2.39	

5.3. Benchmark Regression

This study employs a fixed-effects model to regress the dependent variable Cai. Based on the sample data, fixed effects and control variables are gradually incorporated into the regression analysis, with the results presented in Table 5. Column (1) of Table 5 indicates that, in the absence of fixed effects and control variables, the regression coefficient of the explanatory variable is 0.4116, which is significantly positive at the 1% statistical level, suggesting that industrial co-agglomeration can enhance the level of economic development. Column (2) of Table 5 incorporates fixed effects, and the value of the explanatory variable is 0.0619, which remains significantly positive at the 1% statistical level. Column (3) of Table 5 includes all control variables, and the explanatory variable Cai is significantly positive at the 5% statistical level, with a coefficient of 0.0355. This implies that industrial co-agglomeration has a positive impact on the level of economic development.

The goodness-of-fit of the model reflects its explanatory power for the data. The R-squared value represents the proportion of the total sample variance explained by the model, with values closer to 1 indicating a better fit. In the regression results presented in Column (3) of Table 5, the R-squared value is 0.991, indicating that the model explains 99.1% of the sample variance, suggesting a relatively good fit of the model.Overall, the direction of influence and the significance level of the explanatory variable do not exhibit significant changes across the columns, indicating robust model estimation. This further substantiates that industrial co-agglomeration can enhance the level of economic development.

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ISSN: 2576-8484
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Table 5.
Benchmark Regression.

Variables	(1)	(2)	(3)
	Eco	Eco	Eco
Cai	0.4116***	0.0619***	0.0355**
	(0.0435)	(0.0185)	(0.0143)
Tl			1.0855**
			(0.4979)
Csl			-0.6598***
			(0.2062)
Ig			-0.0486**
			(0.0189)
Cl			0.0159
			(0.0298)
Ccg			-0.1642***
			(0.0539)
Fin			-0.0298*
			(0.0153)
Province fixed effect	No	Yes	Yes
Time fixed effect	No	Yes	Yes
Constant	10.2044***	10.7881***	11.5120***
	(0.0696)	(0.0310)	(0.1399)
Observations	403	403	403
R-squared	0.365	0.987	0.991

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

5.4. Robustness Tests

5.4.1. Changing the Explained Variable

To verify the robustness of the benchmark regression, this study replaces the dependent variable. GDP growth rate is employed as a proxy variable, denoted as "Egp," while maintaining consistency in other regression steps. The regression results are significantly positive at the 1% statistical level, as detailed in Table 6, Column (1), indicating robust estimation outcomes.

5.4.2. Changing the Explanatory Variable

To further assess the credibility of the regression results, this study conducts a robustness test by substituting the explanatory variable. The specific results are presented in Table 6, Column (2). The original explanatory variable "Cai" is replaced with the industrial agglomeration level "Cxt," which is calculated as [(Industrial Added Value of Each Province / Total Industrial Added Value) / (GDP of Each Province / National GDP)]. The regression procedure remains unchanged, and the results are significant at the 5% statistical level, largely consistent with the preceding analysis. This suggests that the estimation results are robust.

5.4.3. Lagging the Explanatory Variable by One Period

Table 6, Column (3), presents the regression results after extending the observation window for the explanatory variable by one period. The regression results indicate that, even after lagging the explanatory variable, its coefficient remains significantly positive at the 5% statistical level. This implies that industrial co-agglomeration has an impact on provincial economic growth one year later, and the conclusions of this study remain substantially unchanged. The regression results continue to be robust.

Table 6.
Robustness Tests.

Variables	(1)	(2)	(3)
	Egp	Eco	Eco
Cai	1.2029***		
	(0.4214)		
Cxt		0.0306**	
		(0.0135)	
Cai_L			0.0274**
			(0.0133)
Tl	-13.2509	1.0862**	1.0467**
	(14.6720)	(0.4958)	(0.4998)
Csl	18.6186***	-0.6524***	-0.5469***
	(6.3211)	(0.2020)	(0.1898)
Ig	6.1474***	-0.0463**	-0.0521**
	(1.2159)	(0.0188)	(0.0220)
Cl	2.5465**	0.0147	0.0126
	(1.0988)	(0.0302)	(0.0279)
Ccg	7.8686***	-0.1567***	-0.1036*
	(1.7101)	(0.0539)	(0.0577)
Fin	1.2760**	-0.0277*	-0.0357**
	(0.5907)	(0.0153)	(0.0167)
Province fixed effect	Yes	Yes	Yes
Time fixed effect	Yes	Yes	Yes
Constant	9.2087**	11.4703***	11.4127***
	(4.0706)	(0.1432)	(0.1441)
Observations	403	403	372
R-squared	0.967	0.991	0.992

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

6. Heterogeneity Test

6.1. Urbanization Rate

Driven by the wave of globalization and integration, industrial co-agglomeration, as a crucial driver of regional economic development, exhibits significant differences in its effects across provinces with varying levels of urbanization. This section categorizes regions into high and low urbanization rate groups using the median as the demarcation point, with areas having an urbanization rate greater than 50% classified as high urbanization rate regions and those below 50% as low urbanization rate regions. The regression results are presented in Table 7, Columns (1) and (2). The explanatory variable is significantly positive at the 10% statistical level in provinces with low urbanization rates, indicating that higher industrial co-agglomeration is associated with better economic development in these regions.

Specifically, in provinces with relatively low urbanization rates, industrial co-agglomeration significantly promotes regional economic development by enhancing resource sharing, optimizing resource allocation efficiency, and facilitating technology spillovers. This effect is less pronounced in provinces with higher urbanization rates. The significant positive correlation between industrial co-agglomeration and regional economic development in low urbanization rate provinces can be explained from multiple dimensions.

On the one hand, provinces with low urbanization rates are typically in the accelerated industrialization phase. Industrial co-agglomeration effectively integrates scattered production factors within the region, reducing transaction costs for enterprises through mechanisms such as infrastructure sharing, technology spillovers, and knowledge diffusion. This leads to the formation of economies of scale and scope, thereby breaking through resource bottlenecks in traditional industrial development and directly driving the growth of regional GDP and the optimization of industrial structure.

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ISSN: 2576-8484
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DOI: 10.55214/25768484.v9i6.8329

On the other hand, these regions often possess significant element price depressions and policy dividend spaces. Industrial co-agglomeration can accelerate the transfer of rural surplus labor to non-agricultural industries, improving the efficiency of labor factor allocation. Additionally, through industrial linkage effects, it drives the development of upstream and downstream supporting enterprises, forming a virtuous cycle of "industry-driven urbanization."However, in provinces with higher urbanization rates, the marginal effect of industrial co-agglomeration on economic development tends to weaken, primarily due to the following reasons: First, high urbanization areas have already formed relatively mature industrial division systems and spatial layouts, with diminishing marginal returns on industrial co-agglomeration as agglomeration density increases. Second, these regions generally face upward pressure on factor costs such as land and labor, offsetting the economies of scale effects of industrial co-agglomeration. Third, high urbanization areas rely more on innovation-driven and high-end factor agglomeration, making it difficult for traditional industrial co-agglomeration models to effectively translate into total factor productivity improvements, resulting in statistically insignificant correlations between industrial co-agglomeration and economic development levels.This regional disparity essentially reflects the dynamic adaptation law between economic development stages and industrial upgrading paths, suggesting that the effectiveness of industrial co-agglomeration needs to align with the factor endowment structure, institutional environment, and development needs under specific spatial and temporal conditions.

6.2. Tax Burden Level

In the process of regional economic pattern evolution and industrial upgrading, the role of industrial co-agglomeration in regional economic development has become increasingly prominent. The tax burden level, as a crucial policy variable, is intricately intertwined with regional economic development in terms of its effectiveness. This section categorizes regions into high and low tax burden levels using the median as the demarcation point, with areas having a tax burden level greater than 50% classified as high tax burden regions and those below 50% as low tax burden regions. The regression results are presented in Table 7, Columns (3) and (4). In regions with low tax burden levels, the explanatory variable is significant at the 5% statistical level, indicating that in areas with lower tax burdens, better industrial co-agglomeration is associated with higher levels of regional economic development. Conversely, in regions with high tax burden levels, the effect is not significant, and the economic development impact of industrial co-agglomeration tends to weaken.

A high tax burden environment directly increases enterprise operating costs, undermining the cost-saving advantages brought about by industrial co-agglomeration. Enterprises may reduce R&D investment, delay technological upgrades, or even choose to relocate some production processes to low-tax regions due to tax pressures, thereby weakening the regional industrial synergy effect. Meanwhile, high tax burdens may deter external capital inflows, limiting further expansion of the regional industrial scale and making it difficult for industrial co-agglomeration to form significant economies of scale. Consequently, in provinces with higher tax burden levels, the driving effect of industrial co-agglomeration on economic development is not significant and may even exhibit a negative correlation due to the crowding-out effect of high tax burdens.

In contrast, in provinces with lower tax burden levels, industrial co-agglomeration significantly promotes regional economic development by reducing enterprise operating costs, enhancing the efficiency of resource allocation, and facilitating technology spillover effects. Specifically, a low tax burden environment alleviates the tax burden on enterprises, allowing the economies of scale and scope effects brought about by industrial co-agglomeration to be more fully realized. Enterprises can share infrastructure, technology platforms, and market channels at lower costs, accelerating specialized division of labor and industrial chain integration, thereby improving overall production efficiency and innovation capabilities. Additionally, a low tax burden environment enhances the region's attractiveness to external capital and talent, further strengthening the positive cycle of industrial co-agglomeration.

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 6: 2168-2183, 2025
DOI: 10.55214/25768484.v9i6.8329

Table 7.
Heterogeneity Test.

Variables	(1)	(2)	(3)	(4)
	Low Urbanization Rate	High Urbanization Rate	Low Tax Burden Level	High Tax Burden Level
	Eco	Eco	Eco	Eco
Cai	0.0652*	-0.0183	0.0988**	-0.0109
	(0.0380)	(0.0115)	(0.0424)	(0.0109)
Tl	-1.1051*	1.8970***	-1.1373	1.1986**
	(0.6412)	(0.4271)	(0.6960)	(0.5852)
Csl	-0.4046*	-0.2244	-0.4307**	-0.8129***
	(0.2425)	(0.2416)	(0.2130)	(0.2748)
Ig	-0.1469***	0.0425	-0.1851***	-0.0265
	(0.0295)	(0.0270)	(0.0427)	(0.0214)
Cl	0.0865**	0.4878	0.0351*	0.0069
	(0.0389)	(0.2970)	(0.0191)	(0.0288)
Ccg	-0.2594***	0.0911	0.0516	-0.3455***
	(0.0729)	(0.0763)	(0.0699)	(0.0774)
Fin	-0.0095	-0.1116***	-0.0337*	-0.0088
	(0.0139)	(0.0142)	(0.0196)	(0.0176)
Province fixed effect	Yes	Yes	Yes	Yes
Time fixed effect	Yes	Yes	Yes	Yes
Constant	11.5713***	10.9410***	11.0917***	12.0176***
	(0.2259)	(0.2681)	(0.1330)	(0.1906)
Observations	200	203	202	201
R-squared	0.985	0.994	0.995	0.995

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

7. Mechanism Test

Driven by the dual forces of regional economic integration and industrial transformation and upgrading, industrial co-agglomeration, as a vital organizational form of modern economic development, is profoundly reshaping the regional economic landscape. It not only directly propels economic growth through optimizing resource allocation and fostering technological innovation but also exhibits remarkable efficacy in enhancing social consumer goods, thereby serving as a crucial indicator for measuring the vitality and potential of regional economic development. By constructing a tightly-knit industrial chain network and an industrial ecosystem, industrial co-agglomeration significantly elevates the level of social consumer goods in the regional economy, subsequently driving an upsurge in regional economic development.

From the demand side, co-agglomeration engenders economies of scale and specialized division of labor, reducing enterprise production costs and product prices, thereby enhancing residents' actual purchasing power. Simultaneously, through industrial linkage effects, it spawns new business formats and consumption scenarios (such as industrial tourism and industrial design experiences), directly stimulating the expansion of consumer demand. From the supply side, enterprise clusters accelerate technological innovation and product iteration, enriching the variety and quality tiers of commodity offerings to meet diversified consumer preferences, forming a virtuous cycle of "supply creating demand." Moreover, the employment absorption effect and wage level enhancement brought about by co-agglomeration further solidify the foundation of residents' consumption capacity, while the improvement of industrial supporting services (such as logistics and finance) reduces transaction costs and enhances consumption convenience.This transmission mechanism of "supply upgrading—demand expansion—economic growth" positions social consumer goods as a key mediating variable through which industrial co-agglomeration propels regional economic development. The growth amplitude of social consumer goods often exhibits a significant positive correlation with the degree of industrial co-agglomeration.

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 6: 2168-2183, 2025
DOI: 10.55214/25768484.v9i6.8329

In this study, the natural logarithm of total retail sales of social consumer goods is employed to characterize social consumer goods consumption. The regression results, as presented in Table 8, Column (2), indicate that the explanatory variable is significantly positive at the 5% statistical level, suggesting that industrial co-agglomeration can enhance economic development by increasing social consumer goods consumption. Industrial co-agglomeration facilitates close cooperation and resource integration among upstream and downstream enterprises in the industrial chain, forming economies of scale and scope, reducing production costs, and improving production efficiency. This, in turn, increases the diversity and competitiveness of market supply to meet the growing diversified demands of consumers. Simultaneously, by optimizing the industrial structure and enhancing product quality and service levels, industrial co-agglomeration directly bolsters consumers' willingness and ability to purchase, particularly through the brand influence and market radiation force formed by agglomeration effects, attracting more consumers and expanding the consumer market scale. Furthermore, industrial co-agglomeration promotes employment growth and resident income elevation, providing a solid economic foundation for the sustained prosperity of the consumer market. Therefore, industrial co-agglomeration collectively drives the growth of regional social consumer goods consumption by enhancing supply capacity, stimulating consumption potential, and elevating resident income levels, becoming a crucial driving force for high-quality regional economic development.

Table 8.
Mechanism Test.

Variables	**(1)**	**(2)**
	Eco	**Scl**
Cai	0.0355**	0.0466**
	(0.0143)	(0.0184)
Tl	1.0855**	0.9038**
	(0.4979)	(0.3962)
Csl	-0.6598***	-0.2517*
	(0.2062)	(0.1340)
Ig	-0.0486**	0.0445**
	(0.0189)	(0.0181)
Cl	0.0159	0.0274
	(0.0298)	(0.0338)
Ccg	-0.1642***	-0.0589
	(0.0539)	(0.0459)
Fin	-0.0298*	0.0011
	(0.0153)	(0.0087)
Province fixed effect	Yes	Yes
Time fixed effect	Yes	Yes
Constant	11.5120***	0.3776***
	(0.1399)	(0.1186)
Observations	403	403
R-squared	0.991	0.589

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

8. Conclusions and Policy Recommendations

8.1. Conclusions

In the current era of accelerated restructuring of the global economic landscape and deepening regional integration, breaking through the bottlenecks of economic growth and fostering new drivers for high-quality development have emerged as core challenges that countries and regions are urgently seeking to address. Drawing on provincial data from China spanning the period 2011-2023, this study systematically explores the intrinsic relationship between industrial co-agglomeration and economic growth, arriving at the following key conclusions:

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 6: 2168-2183, 2025
DOI: 10.55214/25768484.v9i6.8329

Firstly, the results of the benchmark regression indicate that for every one-unit increase in the industrial co-agglomeration index (Cai), there is a significant 0.0355-unit growth in the regional economy, statistically significant at the 5% level. This effect remains robust across alternative specifications of the dependent variable, different measures of the explanatory variable, and lagged-period tests. This finding corroborates Hypothesis 1, suggesting that knowledge spillovers, specialized division of labor, and industrial chain integration achieved through spatial proximity among industries can effectively enhance resource allocation and production efficiency, serving as a core driver of regional economic growth.

Secondly, the level of social consumption is identified as a crucial mediating pathway through which industrial co-agglomeration influences economic growth. Mechanism tests reveal that industrial co-agglomeration enhances the level of social consumption (Scl) through two pathways, thereby promoting economic growth. The mediation effect model demonstrates that for every one-unit increase in the industrial co-agglomeration index, there is a significant 0.0466-unit increase in the logarithm of total retail sales of social consumer goods ($p<0.05$), validating the transmission mechanism proposed in Hypothesis 2. This indicates that the dual activation of both the demand and supply sides is a vital channel through which industrial co-agglomeration releases its economic growth potential.

Thirdly, there exists significant regional heterogeneity in the effects of industrial co-agglomeration. In provinces with an urbanization rate below 50%, industrial co-agglomeration exhibits a pronounced positive effect on economic growth (coefficient 0.0652, $p<0.1$), whereas this effect is not significant in regions with high urbanization rates. This discrepancy arises because low-urbanization areas are in the accelerated phase of industrialization, where factor price depressions and policy dividends can foster economies of scale through industrial agglomeration, driving "industry-driven urbanization." In contrast, high-urbanization areas face rising factor costs and the imperative of innovation-driven transformation, leading to diminishing marginal returns from traditional industrial co-agglomeration models. Furthermore, in provinces with a tax burden level below the median, the economic promotion effect of industrial co-agglomeration is significant (coefficient 0.0988, $p<0.05$), whereas a high tax burden environment weakens this effect. Low tax burdens amplify the cost-saving and technology spillover effects of industrial agglomeration by reducing enterprise operating costs and enhancing capital attractiveness. Conversely, high tax burdens inhibit the formation of economies of scale in co-agglomeration by crowding out R&D investment and capital flows.

8.2. Policy Recommendations

Firstly, it is imperative to formulate a development plan for industrial co-agglomeration, delineating key development zones and leading industries, and guiding the concentrated layout of relevant industries in specific regions to foster industrial cluster effects. Simultaneously, infrastructure construction should be strengthened, and supporting services in industrial parks should be improved to reduce the coordination costs for enterprises, thereby creating a favorable hardware environment for industrial co-agglomeration. Additionally, a cross-departmental coordination mechanism should be established to break down administrative barriers, facilitate information sharing and resource integration among different industries, and promote the coordinated development of upstream and downstream sectors in the industrial chain.

Secondly, fiscal and tax incentives should be introduced, such as tax reductions or financial subsidies for enterprises participating in co-agglomeration, to incentivize them to actively integrate into industrial clusters. On the one hand, enterprises should be encouraged to innovate technologically, with support for industry-university-research collaboration and the establishment of industrial technology innovation alliances to enhance the overall technological level of co-agglomeration zones. On the other hand, efforts should be made to cultivate the consumer market by increasing residents' income levels and improving the social security system, thereby fully leveraging the pulling effect of consumption on economic growth.

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 6: 2168-2183, 2025
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Thirdly, the business environment should be optimized by simplifying administrative approval processes and protecting the legitimate rights and interests of enterprises, providing institutional guarantees for industrial co-agglomeration. Moreover, talent cultivation and introduction should be strengthened, and a talent system matching the co-agglomeration industries should be established to provide intellectual support for the development of industrial clusters.

Fourthly, a monitoring and evaluation mechanism should be established to regularly assess the economic and social benefits of industrial co-agglomeration and promptly adjust and improve relevant policies. Furthermore, regional coordinated development should be promoted to facilitate complementary cooperation in industrial co-agglomeration among different regions, forming a nationwide industrial co-agglomeration network.

8.3. Research Limitations and Prospects

This study still has the following limitations: Firstly, it solely focuses on the synergy between producer services and manufacturing industries, neglecting the synergy effects within the service sector itself (such as finance and logistics). Secondly, the analysis of the dynamic transmission mechanism (e.g., time-lag effects) of "industrial co-agglomeration - consumption - economic growth" is insufficient. Thirdly, the empowering role of digital technologies (e.g., big data, blockchain) in industrial co-agglomeration has not been thoroughly explored. Future research could expand to encompass the entire industrial spectrum, introduce dynamic spatial econometric models, and integrate the context of the digital economy to further unveil the cutting-edge evolutionary patterns of industrial co-agglomeration, providing more forward-looking theoretical support for high-quality economic development.

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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References

[1] D. Sheng and H. A. Montgomery, "Does herding and anti-herding reflect portfolio managers' abilities in emerging markets?," *Mathematics*, vol. 12, no. 8, p. 1220, 2024. https://doi.org/10.3390/math12081220

[2] Y. Liu and Z. He, "Synergistic industrial agglomeration, new quality productive forces and high-quality development of the manufacturing industry," *International Review of Economics & Finance*, vol. 94, p. 103373, 2024. https://doi.org/10.1016/j.iref.2024.103373

[3] L. Wang, H. Hu, X. Wang, X. Zhang, and Y. Wu, "Synergistic evolution of resilience and efficiency in the real estate industry: Evidence from 35 large and medium-sized cities in China," *Applied Economics Letters*, vol. 30, no. 19, pp. 2702-2710, 2023.

[4] Y. Wu, H. Huang, J. Hong, X. Wang, Y. Wu, and Y. Wu, "Transfer patterns and driving factors of China's energy use in trade: Evidence from multiregional input–output analysis and structural decomposition analysis," *Energy Reports*, vol. 8, pp. 10963-10975, 2022.

[5] Y. Ji, H. Cai, and Z. Wang, "Impact of industrial synergy on the efficiency of innovation resource allocation: Evidence from Chinese metropolitan areas," *Land*, vol. 12, no. 1, p. 177, 2023. https://doi.org/10.3390/land12010177

[6] Y. Geng, "Research on the impact of industrial synergy agglomeration on regional innovation and development," *Frontiers in Business, Economics and Management*, vol. 10, no. 1, pp. 50–57, 2023. https://doi.org/10.54097/fbem.v10i1.9860

[7] F. Dong and Y. Li, "How does industrial convergence affect regional high-quality development? Evidence from China," *Journal of the Asia Pacific Economy*, vol. 29, no. 3, pp. 1650-1683, 2024.

[8] Y. Chen, H. Nie, J. Chen, and L. Peng, "Regional industrial synergy: Potential and path crossing the "environmental mountain"," *Science of the Total Environment*, vol. 765, p. 142714, 2021.

[9] H. Sun, J. Chen, Y. Wu, and Y. Wu, "Land use tournaments and urban green total factor productivity: Evidence from the reform in China," *Economic Analysis and Policy*, vol. 86, pp. 794-811, 2025. https://doi.org/10.1016/j.eap.2025.04.002

[10] Y. Wu, Z. Kuang, H. Sun, K. Wang, and T. Zhang, "Cross border costs: Efficiency losses of manufacturing firms involved in housing," *Managerial and Decision Economics*, vol. 46, no. 3, pp. 1459-1477, 2025.

[11] H. Yin and W. Su, "Industrial synergy agglomeration, urban innovation capacity, and advanced manufacturing development," *Economies*, vol. 12, no. 5, p. 117, 2024. https://doi.org/10.3390/economies12050117

[12] Y. Zhang, X. Tang, and J. Yang, "Synergies of technological and institutional innovation driving manufacturing transformation: Insights from Northeast China," *Journal of the Knowledge Economy*, vol. 16, no. 1, pp. 1014-1048, 2024.

[13] J. Ding, B. Liu, and X. Shao, "Spatial effects of industrial synergistic agglomeration and regional green development efficiency: Evidence from China," *Energy Economics*, vol. 112, p. 106156, 2022.

[14] B. Lin and Y. Teng, "The effect of industrial synergy and division on energy intensity: From the perspective of industrial chain," *Energy*, vol. 283, p. 128487, 2023.

[15] Y. Wu, H. Sun, H. Sun, and C. Xie, "Impact of public environmental concerns on the digital transformation of heavily polluting enterprises," *International Journal of Environmental Research and Public Health*, vol. 20, no. 1, p. 203, 2022. https://doi.org/10.3390/ijerph20010203

[16] J. Hong, H. Huang, X. Wang, B. Dockerill, J. Ye, and S. Zhang, "Structural effects of provincial digital economy on carbon emissions within China: A multi-region input-output based structural decomposition analysis," *Science of The Total Environment*, vol. 934, p. 173140, 2024.

[17] J. Song, Z. Liu, and X. Leng, "The impact of the digital economy on provincial carbon emissions in China," *Applied Spatial Analysis and Policy*, vol. 17, no. 3, pp. 1209-1235, 2024.

[18] Z. Zhu, B. Liu, Z. Yu, and J. Cao, "Effects of the digital economy on carbon emissions: Evidence from China," *International Journal of Environmental Research and Public Health*, vol. 19, no. 15, p. 9450, 2022. https://doi.org/10.3390/ijerph19159450

[19] W. Xu and W. Wan, "Research on the carbon emissions reduction effects of China's digital economy: moderating role of the national big data comprehensive pilot zone policy," *Frontiers in Environmental Science*, vol. 13, p. 1523560, 2025.

[20] Y. Ni, P. Du, and H. Chen, "Enhancing blue: The resilience of blue economy and the efficiency of China's sea-land industrial synergy," *Technological Forecasting and Social Change*, vol. 198, p. 123007, 2024. https://doi.org/10.1016/j.techfore.2023.123007

[21] B. Liu, K. Zheng, M. Zhu, F. Wu, and X. Zhao, "Towards sustainability: The impact of industrial synergistic agglomeration on the efficiency of regional green development," *Environmental Science and Pollution Research*, vol. 30, no. 36, pp. 85415-85427, 2023.

[22] N. Yang, Q. Liu, and Y. Chen, "Does industrial agglomeration promote regional innovation convergence in China? Evidence from high-tech industries," *IEEE Transactions on Engineering Management*, vol. 70, no. 4, pp. 1416-1429, 2021.

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 6: 2168-2183, 2025
DOI: 10.55214/25768484.v9i6.8329