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Industrial Clusters and High-Quality Development of Foreign Trade under New Trade Protection

Yufan Huang
Finance Department, China Construction Technology Group Co., Ltd, Beijing, China
872215446@qq.com

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Abstract: Based on panel data covering 30 Chinese provincial-level regions during 2001-2021, this study applies a heterogeneous industrial dynamics framework to investigate how industrial clusters shape the upgrading of foreign trade. The analytical approach identifies three operational mechanisms—cost reduction, transaction efficiency gains, and knowledge spillovers—through which agglomeration fosters trade quality improvement. The empirical evidence indicates that: (1) Industrial agglomeration exerts a statistically significant positive effect on trade development quality, with areas exhibiting stronger clustering tendencies achieving more substantial advances in trade upgrading. (2) The magnitude of this effect displays marked regional variation, being most pronounced in eastern China, comparatively moderate in the western China, and least evident in central China. (3) Cluster-induced trade upgrading operates principally through three mediating pathways: reduced transaction costs, enhanced transaction efficiency, and intensified knowledge diffusion.

1. Introduction

Since 2017, the Trump administration in the United States has implemented new trade protectionism, which is the trade shock discussed in this paper, using tariff barriers as the primary means. Various trade barriers such as technical barriers (restricting China's development of high technology), green barriers, intellectual property barriers, and even "human rights" barriers have been constantly innovated and gradually expanded to advantageous industries and strategic industries [1]. In addition to directly disrupting China's export orders, these policies compound detrimental effects on domestic industrial ecosystems. This context has catalyzed the rise of industrial agglomeration—geographic concentrations of interconnected firms, suppliers, and institutions—as a critical mechanism for transforming the export structure. Through pooled resources, shared technology, and collective market insights, such clusters drive down costs, streamline transactions, and foster knowledge exchange, ultimately enhancing export quality. This paper constructs a theoretical model to delineate the specific pathways by which industrial clusters facilitate foreign trade upgrading. Grounded in this framework, we empirically evaluate the tangible impacts of clustering using panel data from 30 Chinese provinces [2]. The findings confirm that intensified industrial agglomeration is a significant driver of foreign trade transformation, with the strength of this effect varying markedly by area: it is most substantial in eastern China and comparatively weaker in central and western areas [3].

2. Models, Variables and Data

2.1. Model construction

To empirically test the significant impact of industrial clusters on trade upgrading, we establish the following baseline model based on the preceding theoretical and empirical groundwork.

$$TU_{\mathrm{it}} = \partial_0 + \partial_1 IC_{it} + \mu_i + \nu_t + \varepsilon_{it} \quad (1)$$

In Eq. (1), TU indicates the degree of trade upgrading, IC denotes the degree of industrial clustering, i stands for areas, and t indicates the year [4]. Furthermore, to account for the potential influence of other factors on quality-driven trade growth, we incorporate a set of control variables, which leads to the following final model specification.

$$TU_{\mathrm{it}} = \beta_0 + \beta_1 IC_{it} + \beta_2 CX_{it} + \beta_3 \mathrm{HUM}_{it} + \beta_4 FDI_{it} + \beta_5 GOV_{it} + \beta_6 INF_{it} + \mu_i + \nu_t + \varepsilon_{it} \quad (2)$$

Here, TU denotes quality-driven trade growth, IC represents the degree of regional industrial clustering, CX indicates technological innovation level, HUM stands for human capital accumulation, FDI signifies foreign direct investment, GOV refers to government expenditure, INF indicates infrastructure [5]. Besides, i stands for area, t represents year, ν μ are respectively regional effects and time effects, and ε is stochastic disturbance term.

2.2. Variable selection

2.2.1. The explained variable: quality of foreign trade development(TU)

The dependent variable of this paper, quality of foreign trade development(*TU*), is gauged using the contribution share of foreign trade to national output [6]. This metric is predicated on the rationale that the contribution rate is positively correlated with development quality; thus, a higher value denotes more advanced trade development.

2.2.2. Key independent variable: Industrial Clusters (IC)

This paper examines the key independent variable, Industrial clusters (*IC*). Various measurement methods exist and guided by research objectives and referencing Liu Yan and Deng Ruobing's 2017 study framework, we employ the location quotient to quantify the degree of industrial clustering. The location entropy calculated as: $E_{ij} = \dfrac{Y_{ij}/Y_i}{Y_j/Y}$,where Yij denotes the gross output of industry j (j = 1, 2, 3) in area i, Yi is the gross regional product of area i, Yj is the national gross output of industry j and Y represents national output [7]. A higher Eij value indicates stronger industrial agglomeration. Specifically: When Eij > 1, it indicates that industry j has a significant level of agglomeration in area i. When Eij < 1, it suggests the dispersion of industry j in area i is below the national average. When Eij = 1, it implies the dispersion of industry j in area i is on par with the national level [8].

2.2.3. Additional control variables

A set of additional control variables is incorporated: (1) Technological Innovation (*CX*). It is widely recognized that the greater the number of patent applications and authorizations, the greater the level of technological innovation [9]. We use the per-capita patent grants area as the indicator. (2) Human Capital (*HUM*). Adopting Peng Guohua's (2005) research methodology, we use the log of human capital stock as an indicator. The human capital stock is calculated as follows: $Y = \exp(\ln(h)) * L$, where Y represents HUM, ln(h) denotes average human capital across areas (calculated using education return rates and average years of labor force education), and L indicates the employed population in each area [10]. (3) Foreign Direct Investment (*FDI*). We measure this by the share of actual FDI in regional output. (4) Government Expenditure (*GOV*). Following most scholars' approaches, we assess this using the share of total government expenditure relative to regional output. (5) Infrastructure (*INF*). Referencing Bai Junhong et al. (2016), we employ per capita length of long-distance optical cable lines in each area as an indicator [11].

2.3. Data sources

This study employs panel data from 30 provincial-level units in China covering the period 2001-2021 to empirically investigate the effects of industrial clusters on the quality of foreign trade development [12]. During the research process, Xizang was excluded from the study due to severe data gaps in Xizang. Additionally, the variable data used were smoothed, with interpolation methods employed to supplement missing data. The original data used in this study primarily originate from statistical yearbooks from various provinces and autonomous areas over the years, and the China Economic and Social Development Statistical Database, among others.

3. Empirical Results and Analysis

3.1. Benchmark regression results

Table 1 demonstrates a significantly beneficial effect of industrial clusters on trade upgrading at the national level. Model 2 shows that a 10% increase in industrial agglomeration improves China's foreign trade quality by 14.47% (coefficient=1.447, significant at 1% level), supporting Hypothesis [13]. This confirms that industrial clusters promote trade upgrading by reducing business costs and improving transaction efficiency. At low-medium agglomeration levels, scale economies outweigh excessive competition effects, thereby enhancing firms' export product quality and driving foreign trade upgrading.

With respect to the control variables: (1) Technological Innovation (*CX*). The regression coefficient of 0.003 (significant at 10% level) confirms technological innovation's beneficial contribution to advanced foreign trade development. This finding aligns with existing literature positioning innovation as a key driver of trade upgrading [14]. Evidence shows technological advancement enhances factor allocation, production efficiency, and product sophistication. By facilitating factor concentration, accelerating product iteration, and increasing value-added ratios, innovation enables firms to develop competitive products and services, ultimately optimizing export commodity structure and market diversification for high-quality trade development. (2) Human Capital (*HUM*). HUM demonstrates a significantly positive impact on trade development quality (coefficient=0.046, significant at 5% level). As the fundamental carrier of trade activities, HUM directly determines regional trade development efficiency [15]. To achieve trade upgrading, it is essential to establish human capital's dominant role through strengthened investment and improved human resource systems to build core competitiveness. (3) Foreign Direct Investment (*FDI*). FDI shows a significantly positive coefficient of 0.051 (significant at 1% level), confirming its role in enhancing trade development quality [16]. The mechanisms operate through two channels: first, FDI introduces advanced equipment and management expertise that improve production efficiency and product quality, creating differentiated competitive advantages; second, FDI facilitates international technology diffusion through spillover effects, elevating the technical level of foreign trade industries and providing technical support for high-quality development [17]. (4) Government Expenditure (*GOV*). Government expenditure demonstrates a significantly negative impact on trade development quality. Theoretically, fiscal expansion could improve market conditions through public goods provision, reduce transaction costs, and enhance factor allocation efficiency. However, empirical results suggest excessive government intervention may create crowding-out effects: increased fiscal spending expands government procurement while reducing private investment, ultimately undermining foreign trade quality through diminished market efficiency. (5) Infrastructure (*INF*). Infrastructure significantly enhances trade development quality (coefficient=0.008, significant at 1% level). Convenient infrastructure will help businesses expand their product sales markets, reduce costs, minimize inventory buildup, and accelerate capital turnover. Moreover, infrastructure development not only effectively drives regional economic activities and facilitates trade circulation, but also promotes specialization of labor division and enhances the efficiency of production factor allocation, thereby fostering high-quality growth in foreign trade [18].

Table 1: Results of benchmark regression

Variable	Model 1	Model 2
Industrial Cluster (IC)	1.526*** (0.073)	1.447*** (0.080)
Technical Innovation (CX)		0.003* (0.002)
Human Capital (HUM)		0.046** (0.021)
Foreign Direct Investment (FDI)		0.051*** (0.006)
Government Expenditure (GOV)		-0.805** (0.167)
Infrastructure (INF)		0.008*** (0.005)
Constant term	-1.615*** (0.069)	-1.583*** (0.303)
Regional effects	Yes	Yes
Time effects	Yes	Yes
R2	0.508	0.515
Observations	630	630

Note: ***p<0.01, **p<0.05, *p<0.1. Robust standard errors are reported in parentheses. This convention applies to all subsequent tables.

3.2. Robustness test

To verify the robustness of the empirical findings, we substitute the core explanatory variable with the location quotient of the secondary sector (IC2) and conduct renewed estimations using both the full sample and regional subsamples (eastern, central, and western China). Table 2 presents the complete robustness check results. The estimates demonstrate that both the coefficient signs and significance levels of IC2 remain highly consistent with the baseline regression results across all sampling configurations, confirming the strong robustness of the conclusion that industrial clusters promote high-quality development of foreign trade [19].

Table 2: Results of robustness test

Variable	Overall	Eastern China	Central China	Western China
	Model 14	Model 15	Model 16	Model 17
Industrial Cluster (IC2)	0.332*** (0.117)	0.585*** (0.249)	0.045* (0.123)	0.010* (0.045)
Technical Innovation (CX)	0.016** (0.002)	0.007** (0.004)	0.005* (0.011)	0.009*** (0.002)
Human Capital (HUM)	0.033** (0.025)	0.151** (0.077)	0.062* (0.043)	0.018*** (0.008)
Foreign Direct Investment (FDI)	0.072*** (0.010)	0.078** (0.017)	0.044** (0.019)	-0.005* (0.005)
Government Expenditure (GOV)	-0.825** (0.290)	-0.566 (0.831)	-1.122** (0.557)	-0.190*** (0.078)
Infrastructure (INF)	0.003 (0.002)	-0.056** (0.027)	0.015 (0.011)	-0.003* (0.002)
Constant term	1.241*** (0.258)	-0.197 (0.682)	0.709* (0.556)	0.321*** (0.092)
Regional effects	Yes	Yes	Yes	Yes
Time effects	Yes	Yes	Yes	Yes
R2	0.405	0.218	0.254	0.233
Observations	630	231	168	231

3.3. Further research: analysis of pre- and post-trade shock regression results

Given the intensification of trade protectionism and disputes since 2017, this section divides the sample into two periods, 2001-2016 and 2017-2021, for separate regression analyses. This methodology facilitates a contrast in the trade quality enhancement effect of industrial clusters pre- and post-trade shock. Table 3 reports the regression results before and after the 2017 trade shock [20].

Model 12 shows that during the pre-trade shock period (2001-2016), the industrial cluster coefficient is 1.476 (significant at the 1% level), indicating that a 10% increase in industrial agglomeration leads to a 14.76% improvement in China's foreign trade development quality. Model 13 presents the post-trade shock results (2017-2021), with an industrial cluster coefficient of 0.631 (significant at the 1% level), implying that a 10% increase in industrial agglomeration improves China's foreign trade quality by 6.31%. In summary, whether in the periods from 2001-2016 or 2017-2021, the coefficient of industrial clusters remained positive across both time frames, demonstrating that industrial clusters significantly promote advanced evolution of foreign trade before and after the trade shock. Moreover, the promoting effect of industrial clusters on foreign trade development quality was more pronounced during 2001-2016 than in 2017-2021, indicating that under rising trade protectionism, the contribution and function of industrial clusters in enhancing foreign trade development quality has diminished. This may be attributed to the fact that since the implementation of the trade shock in 2017, the industrial logic of foreign trade development has shifted more toward optimizing industrial structures and industrial integration, with entrepreneurial clusters exerting relatively weaker influence. Additionally, after the trade shock, the contribution of technological innovation to foreign trade multidimensional upgrading has significantly increased, making efforts to enhance technological innovation levels a foundational element for achieving trade upgrading in China [21].

Table 3: Regression results before and after trade shock

Variable	2001-2016	2017-2021
	Model 12	Model 13
Industrial Cluster (IC)	1.476*** (0.089)	0.631*** (0.180)
Technical Innovation (CX)	0.005** (0.002)	0.015*** (0.005)
Human Capital (HUM)	0.076*** (0.020)	0.023* (0.042)
Foreign Direct Investment (FDI)	0.063*** (0.006)	-0.002 (0.007)
Government Expenditure (GOV)	-0.777*** (0.211)	0.033 (0.396)
Infrastructure (INF)	0.009*** (0.002)	-0.002 (0.006)
Constant term	-1.824*** (0.248)	-0.654* (0.417)
Regional effects	Yes	Yes
Time effects	Yes	Yes
R2	0.639	0.715
Observations	480	150

3.4. Heterogeneity analysis

Table 4 Regional heterogeneity test results

Variable	Eastern China	Central China	Western China
	Model 3	Model 4	Model 5
Industrial Cluster (IC)	1.747*** (0.129)	0.023* (0.215)	0.183*** (0.056)
Technical Innovation (CX)	0.007*** (0.003)	0.004* (0.008)	0.011*** (0.002)
Human Capital (HUM)	0.140*** (0.042)	0.068* (0.050)	0.023*** (0.007)
Foreign Direct Investment (FDI)	0.059*** (0.015)	0.037** (0.013)	-0.005* (0.006)
Government Expenditure (GOV)	-1.582*** (0.570)	-1.119** (0.524)	-0.143** (0.061)
Infrastructure (INF)	0.0243* (0.019)	0.012 (0.010)	-0.002*** (0.001)
Constant term	-2.673*** (0.466)	0.901* (0.520)	0.530*** (0.088)
Regional effects	Yes	Yes	Yes
Time effects	Yes	Yes	Yes
R2	0.604	0.577	0.231
Observations	231	168	231

Regional regression results in Table 4 indicate that industrial clusters significantly promote foreign trade quality in eastern, central, and western China. Specifically, the coefficients are 1.747 (significant at 1%) for the eastern China, 0.023 (significant at 10%) for the central China, and 0.183 (significant at 1%) for the western China. These results reveal clear regional heterogeneity: the promoting effect is strongest in eastern China, followed by the western China, while the central

China shows the smallest impact [22].

The control variables exhibit distinct regional heterogeneity in their effects on foreign trade quality. Both technological innovation (*CX*) and human capital (*HUM*) show significantly positive effects across all three regions, indicating their universal role as drivers of regional foreign trade upgrading. Government expenditure (*GOV*) demonstrates constraining effects in all areas, suggesting structural limitations in fostering trade quality. Foreign direct investment (*FDI*) and infrastructure (*INF*) display divergent impacts: while beneficial in eastern and central areas, they exhibit negative effects in western China. The adverse impacts in the western China may be attributed to contextual constraints: FDI's effectiveness is moderated by institutional and industrial conditions, while excessive infrastructure investment could lead to overcapacity and resource misallocation, crowding out more productive investments [23].

3.5. Research Conclusions and Insights

This study systematically examines the mechanisms and effects of industrial clusters on trade upgrading through theoretical and empirical analysis. Theoretical research reveals that industrial clusters promote trade quality upgrading through pathways such as reducing enterprise costs, optimizing transaction processes, and enhancing knowledge-technology spillovers. Empirical results based on panel data from 30 Chinese provinces and municipalities from 2001 to 2021 demonstrate the following: First, industrial clusters significantly improve foreign trade quality at both the national and regional levels, indicating a positive correlation between the degree of industrial agglomeration and trade quality enhancement [24]. Second, the promoting effect of industrial clusters exhibits regional heterogeneity, with a more pronounced impact in the eastern China compared to the central and western China, reflecting the prominent role of cluster development in trade quality upgrading in more developed areas. Third, despite the trade shock after 2017 marginally attenuating the contribution of industrial clusters, their fundamental effect on advanced evolution of foreign trade remains significant. Meanwhile, the driving role of technological innovation has been further strengthened under trade shocks, highlighting the necessity of synergistic efforts between industrial policy and innovation-driven strategies [25].

This study proposes three policy recommendations based on the findings: (1) Enhance innovation leadership to accelerate product iteration and value-added upgrading. Particularly in the context of trade shocks, the driving role of technological innovation has become increasingly prominent, making enhanced innovation capability a core task for advancing trade upgrading. (2) Establish a human-capital-led strategy, increase investment in human capital, and improve the modern human resource system [26]. (3) Promote infrastructure development aligned with regional needs to effectively stimulate regional economic vitality, facilitate trade circulation, and support high-quality foreign trade through specialized division of labor and optimized factor allocation.

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References

[1] Greenaway D, Kneller R. Industry differences in the effect of export entry: Learning by exporting[J]. Review of World Economics, 2007, 143(3): 416-432.

[2] Clemente Ruiz Duran. The future of industrial policies in the world: towards a new manufacturing narrative[M]. Edward Elgar Publishing, 2019.

[3] Melitz M J. The impact of trade industry real locations and aggregate industry productivity[J]. Econometrica, 2003,

71(6): 695-725.
[4] Tan Hongbo and Xia Jiechang. Digital Trade Reshapes Industrial Agglomeration Theories and Models—— From Geographical Agglomeration to Online Agglomeration [J]. Review of Finance and Economics, 2022(06):43-52.
[5] Li Fang, Yang Lihua, and Liang Hanyue. Research on the Mechanism and Pathways of Cross-border E-commerce and Industrial Cluster Synergy Development in China [J]. International Trade Issues, 2019(02):68-82.
[6] Zhang Jiawang, Li Boyang, Peng Hui. "The 'Cluster-Promoting Development' Policy in National High-Tech Zones: Enhancing Urban Innovation Capacity ——and Exploring the Technical Complementarity of Central-Peripheral Structures in Innovation Clusters" [J]. Journal of Economics, 2023, (11):79-88.
[7] Shao Chao, Su Danin. Industrial Agglomeration and Domestic Value-added Exports: A Localization Path for Global Value Chain (GVC) Upgrading [J]. Management World, 2019,35(08):9-29.
[8] Ren Wanwan, Liang Qihui. Virtual Agglomeration and Domestic Value Added Rate of Enterprise Exports —— From the Perspective of Upstream-Downstream Linkages [J]. International Trade Issues, 2022(11):53-68.
[9] Liu Zhibiao, Wu Fuxiang. Dual Embedding of Global Value Chains under the Belt and Road Initiative [J]. China Social Sciences, 2018(08):17-32.
[10] Yang Danping, Mao Jiangnan. Research on the Correlation Between Industrial Agglomeration and International Competitiveness in Foreign Trade—— An Empirical Analysis Based on 15 Manufacturing Variable-Coefficient Panel Data from China [J]. International Trade Issues, 2011(01):20-28.
[11] Yang Rudai and Zhu Shi' e. The Relationship between Agglomeration, Productivity and Export Decisions of Enterprises [J]. Reform, 2018(07):84-95.
[12] Sudan Ni, Sheng Bin. Industrial Agglomeration, Agglomeration Externalities and Corporate Emission Reductions —— New Microeconomic Evidence from China [J]. Economics (Quarterly), 2021,21(05):1793-1816.
[13] Mi, M., Jin, C and Zhao Zhongxiu. Industrial Clusters and Corporate Carbon Decoupling [J]. International Trade Issues, 2022(09):17-34.
[14] Chang Luan, Qian Chen, and Pan Weikang. Mechanisms, Models, and Pathways for the International Development of Manufacturing Industrial Clusters: A Case Study Based on Zhejiang [M]. Hangzhou: Zhejiang Gongshang University Press, 2016.
[15] Wang Shiyin, ed. Industrial Clusters: Urban Development Pathways and Implications in the Yangtze River Delta Region [M]. Shanghai: Tongji University Press, 2015.
[16] Wang Xingpeng. Research on Technological Innovation in Industrial Clusters Based on Knowledge Management [M]. Shijiazhuang: Hebei Science and Technology Publishing House, 2014.
[17] Wang Lei. Research on Technological Innovation Models in Industrial Clusters Under Foreign Capital Dominance [M].Shanghai: Shanghai Far East Publishers, 2013.
[18] Liu Yan & Deng Ruobing. The Impact of Financial Agglomeration on Real Estate Prices: An Analysis Using Static and Dynamic Panel Data [J]. Economic Issues Exploration, 2017(09):126-134.
[19] Liu Jun, Li Lianshui, and Wang Zhong. The Impact of Industrial Clusters on Regional Innovation Capabilities and Industry Variations [J]. Research Management, 2010,31(06):191-198.
[20] Peng Guohua. Analysis of Income Disparity, Total Factor Productivity and Their Convergence in China [J]. Economic Research, 2005, (09):19-29.
[21] Bai Junhong, Bian Yuanchao. Distortions in Factor Markets and Efficiency Losses in China's Innovative Production [J]. China Industrial Economics, 2016, (11):39-55.
[22] Wen Zhonglin, Zhang Lei, Hou Jetai et al. The test procedure and application of the mediation effect [J]. Journal of Psychology, 2004(05):614-620.
[23] Huang Jiuli and Li Kunwang. Export Opening, Regional Market Size and Economic Growth [J]. Economic Research, 2006(06):27-38.
[24] Yao Yangyang, Li Wenxiu, and Zhang Shaohua. Research on the Impact of Transaction Efficiency on the Development of Production Services—— An Empirical Analysis Based on Panel Data from 28 Developed Countries [J]. China Soft Science, 2015, (05):184-192.
[25] Zeng Shihong and Liu Yingdi. Internet Technology, Transaction Efficiency, and Service Industry Development——: A Discussion on the Foundational Role of Service Consumption in High-Quality Development [J]. Industrial and Economic Review, 2020,11(03):16-31.
[26] Yu Jie and Dong Jing. Regulation and Threshold Effects of Knowledge Spillover in the Introduction of Venture Capital to High-Quality Industrial Development [J]. Science and Technology Progress and Countermeasures, 2021,38(14):62-71.