



How does the flow of Data Elements Reshape the Division of Labor Between Urban and Rural Industries? — A case Study Based on the Digitalization of Enterprise Supply Chains

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Abstract. This study explores how data elements influence the urban-rural industrial division of labor by reshaping the digitalization process of enterprise supply chains. Based on the analysis of typical cases such as intelligent manufacturing and agricultural e-commerce, this paper proposes a theoretical framework of "data-driven spatial restructuring of value chains," pointing out that data flow enables the spatial decoupling of the management and coordination functions and physical execution functions of the value chain, thereby guiding high-data-density links to cluster in cities and standardized links to diffuse to counties. The study finds that different data flow patterns will give rise to differentiated urban-rural division of labor. The research conclusions provide a new theoretical perspective and policy implications for understanding the urban-rural integration development in the digital economy era.

Keywords: Data flow; urban-rural industrial division of labor; supply chain digitalization; value chain spatial restructuring; digital economy; case studies

1 Introduction

Against the backdrop of the deepening development of the digital economy, data has become a key production factor driving economic growth. Statistics show that my country's digital economy exceeded 50 trillion yuan in 2022, but the urban-rural digital divide remains significant: the internet penetration rate in rural areas is 61.9%, nearly 15 percentage points lower than in urban areas. Currently, urban-rural industrial cooperation is largely limited to the transfer of labor based on geographical proximity. However, platforms like Haier COSMOPlat, through real-time data flow, have achieved a new division of labor where intelligent decision-making remains in cities while standardized production is implemented in rural areas. In the process of supply chain digitalization, data elements, through specific flow patterns, systematically drive the reconfiguration of value chain links in urban and rural spaces.

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2 Research Theory

This research's theoretical framework is based on a critical integration of traditional urban-rural division of labor theory, global value chain theory, and emerging data economy geography. To address the gaps in existing theories, this study proposes an analytical framework of "data-driven spatial restructuring of the value chain." Its core logic is that digitalization spatially decouples the "management and coordination functions" (via data flow) and "physical execution functions" (via logistics) of the value chain. Enterprises allocate resources to locations with the greatest comparative advantage based on the "data endowment differences" of each link.[1] High-data-density links cluster in cities, forming "decision-making centers," while medium-to-low data-density but highly standardized links diffuse to counties, forming "digital workshops."

3 Research Methods

This study employs an exploratory multi-case study approach, selecting three typical enterprise cases: intelligent manufacturing, agricultural e-commerce, and digital services[2]. Through in-depth interviews, participant observation, and triangulation using multi-source secondary data, a complete narrative chain of "digital transformation - data flow - spatial restructuring" is constructed[3]. Cross-case comparisons are then conducted to identify key patterns of data flow and their systemic impact on the urban-rural industrial division of labor.

4 Case Analysis

This study, through comparative analysis of multiple cases, systematically reveals the inherent mechanisms and complex effects of data element flow reshaping the urban-rural industrial division of labor.

Haier Smart Home's digital transformation practice provides a typical example for understanding the value chain spatial restructuring driven by the Industrial Internet. Based on its self-developed COSMOplat platform, as shown in Figure 1, Haier has constructed a collaborative ecosystem connecting the city's "intelligent decision-making center" with the county-level "flexible production network." This platform processes over 1 billion user interaction data points daily, transforming unstructured market demands into structured product parameters and production instructions through natural language processing and machine learning algorithms[4]. The headquarters data center hosts the platform's core data aggregation, model training, and global optimization functions, forming a "digital brain." Meanwhile, 15 interconnected county-level factories distributed across the country act as "flexible limbs," uploading production status data in real time via 5G private networks and IoT devices, and receiving precise operational instructions from the platform[5]. Figure 2 compares the key performance changes of a typical connected factory before and after connecting to

the COSMOPlat platform, showing a significant improvement in its ability to respond to market changes and operational quality.

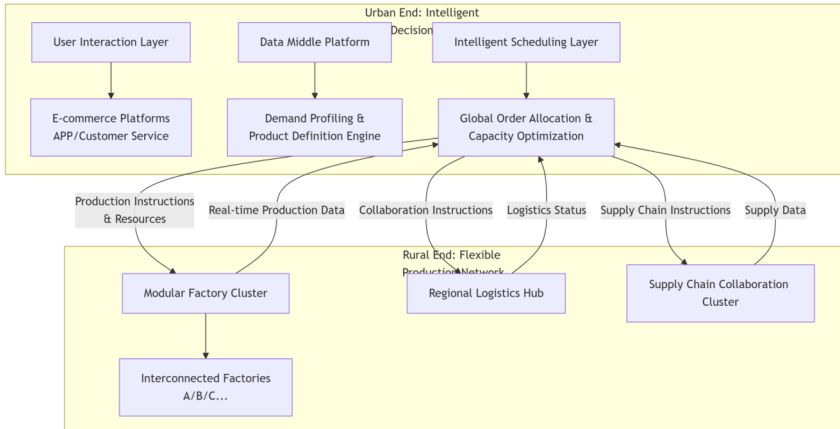


Fig. 1. Haier COSMOPlat Platform Urban-Rural Bidirectional Data Flow Architecture

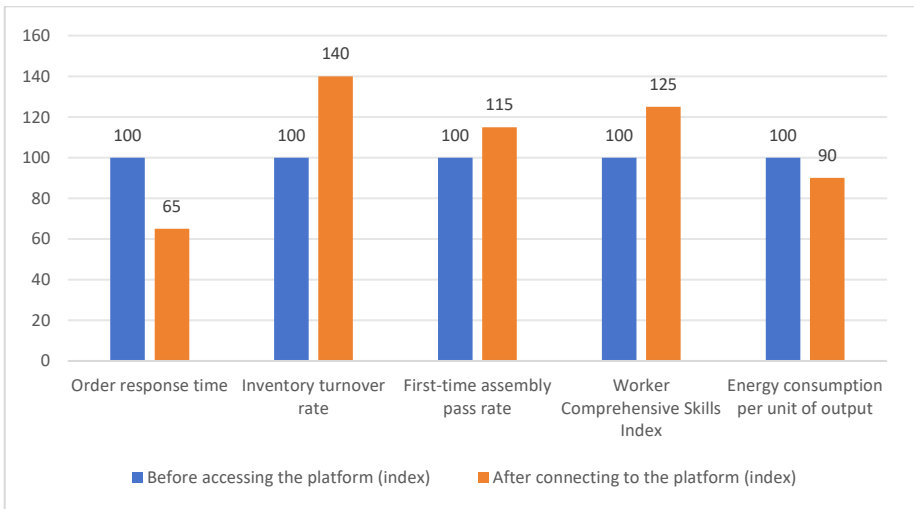


Fig. 2. Comparison of Key Indicators of a Haier County-Level Interconnected Factory Before and After Connecting to the COSMOPlat Platform (Note: The baseline value is assumed to be the level before access, set at 100)

The "centralized radiation" model has produced a significant spatial restructuring effect. Performance comparison data in Table 1 shows that after connecting to the platform, the average order response cycle for county-level factories decreased from 15.2 days to 9.8 days (a reduction of 35.5%), and inventory turnover increased from an average of 6.3 times per year to 8.9 times (an increase of 41.3%). However, this efficiency improvement has been accompanied by a reshaping of the power structure: the proportion of instructions automatically generated by the platform has increased from

65% initially to the current 83%, correspondingly compressing the local decision-making space of county-level factories in areas such as process parameter adjustments and production scheduling optimization, with their technical decision-making weight decreasing from 45% to 28%.

Table 1. Changes in Key Performance Indicators and Decision-Making Power Before and After County-Level Interconnected Factories Connected to the COSMOplat Platform

Metrics and Dimensions	Specific Indicators	Before connection	After connection	Amount of change
Operational Efficiency	Average Order Response Time (days)	15.2	9.8	Shortened by 35.5%
	Inventory Turnover Rate (times/year)	6.3	8.9	Increased by 41.3%
Decision-Making Structure	Percentage of Orders Automatically Generated by the Platform	65%	83%	Increased by 18 percentage points
	Weight of Local Technology Decisions	45%	28%	Decreased by 17 percentage points

It is worth noting that the increased reliance on data has had a dual impact on county-level innovation capabilities. On the one hand, factories have reduced operational complexity by implementing standardized instructions, with the proportion of frontline operators directly handling non-routine operating conditions decreasing from 32% to 15%. On the other hand, the number of process improvement proposals from county-level factories has decreased by 42% year-on-year, and local technical teams' independent R&D investment in predictive maintenance, energy efficiency optimization, and other areas has shown a downward trend. This "efficiency-innovation" trade-off reveals that in a data-driven industrial division of labor system, rural nodes, while gaining access value, may also face potential limitations in their capability development paths.

Haier's case demonstrates that industrial internet platforms, by establishing real-time and precise data flow channels, can indeed overcome geographical constraints and achieve optimal allocation of urban and rural production capacity[6]. However, the "center-node" network structure it constructs is also subtly reshaping the knowledge power relationship between urban and rural areas.

To deepen the comparative analysis, this study introduces the cases of Pinduoduo's "Farmland Cloud Group Buying" and Sany Heavy Industry's "Root Cloud Platform."

Pinduoduo achieves "production based on sales" by aggregating consumer data[7]. Table 2 reveals that the platform possesses complete consumer data, while production sites can only access partial production data, resulting in the platform capturing 68% of the digital service revenue in value distribution. The case of Sany Heavy Industry shows that equipment operating data improves service efficiency in county-level areas, but it also leads to a structural shift in the core skills required of technical service personnel.

Table 2. Key Indicators and Data Rights Changes Before and After Core Production Areas Join the Platform under Pinduoduo's "Farmland Cloud Group Buying" Model

Metrics and Dimensions	Specific Indicators	Before connection	After connection	Amount of change
Operational efficiency and effectiveness	Average Order Response Time (days)	7.5	4.5	Shortened by 40.0%
	Product premium rate (%)	100 (Benchmark)	125	Increased by 41.3%
	Data completeness held by the platform (%)	-	98	Dominant
Data control and value distribution	Data completeness accessible at the production site (%)	-	30	Severely restricted
	Revenue sharing percentage of digital services at the production site (%)	0	22	In a weak position

These cases collectively reveal three-dimensional obstacles to building rural data capabilities. At the infrastructure level, 5G coverage in counties is only 62% of that in urban areas; at the human capital level, less than 4% of the workforce possesses data analysis skills; and at the institutional level, the definition of agricultural data property rights remains a blank. Based on this, this study constructs a four-tiered governance framework: national-provincial-county-enterprise. At the national level, an agricultural data asset registration system should be established; at the provincial level, access costs can be reduced through a 30% special subsidy; at the county level, the "data cooperative" model can be promoted; and at the enterprise level, a data revenue return mechanism needs to be established (e.g., 5-8% of platform optimization revenue should be returned to the production area). This framework aims to shift the urban-rural data relationship from technology dependence to capability co-construction, providing a new path for coordinated regional development in the digital age.

At the national level, the establishment of "urban-rural data element reform pilot zones" should be promoted to pilot an agricultural data asset registration and valuation system. At the provincial level, special subsidies can reduce the cost of digital transformation in counties; Guangdong's practice shows that a 30% subsidy can increase platform access rates by 40%. At the county level, local digital service providers should be cultivated. The "data cooperative" model in Lishui, Zhejiang, has increased tea farmers' data income by three times. At the enterprise level, a data revenue-sharing mechanism needs to be established. For example, Haier returns cost savings from platform optimization to its county-level factories for reinvestment. This multi-layered governance can propel urban-rural data flow from "technology empowerment" to a new stage of "capability building," providing a feasible path for integrated urban-rural development in the digital age.

5 Conclusions

This study reveals how enterprise supply chain digitalization systematically reshapes the urban-rural industrial division of labor by shaping specific data element flow patterns. The core conclusion indicates that this process is essentially a spatial reorganization of the value chain based on the "location sensitivity" of each link to data capabilities, thereby giving rise to a new urban-rural industrial pattern of "core-multi-node" networking. Its theoretical contribution lies in successfully operationalizing the abstract concept of "data elements" into a concrete process of data flow between enterprises, constructing a meso-level analytical framework of "data flow-value chain reconstruction-spatial reorganization," thus bridging the theoretical gap between macro-regional economics and micro-enterprise strategic research, and providing empirical support for the "flow space" theory based on the Chinese context.

6 Policy Implications and Research Prospects

The study's findings offer clear implications for regional policies: the policy focus of urban-rural integration should shift from a "supply-oriented" approach to hardware infrastructure to an "ecosystem-building" approach that cultivates data acquisition, analysis, and application capabilities. Specifically, rural areas need to focus on enhancing their data capabilities to consolidate their subjectivity in the new division of labor network; central cities should strengthen their data service and radiation functions, shifting from "resource extraction" to "value empowerment." Future research needs to verify the universality of the conclusions through large-sample quantitative analysis, and to explore in depth the moderating effects of situational factors such as industry characteristics, institutional environment and data property rights arrangements on data flow patterns and urban-rural integration paths, so as to promote the formation of a more inclusive and sustainable digital urban-rural development paradigm.

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