



Prediction of data-driven global value chain reconstruction path: from the perspective of new structural economics

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SUMMARY: *In response to the problem of the global value chain (GVC) reconstruction path of emerging economy enterprises, this study is based on the perspective of new structural economics, revealing the internal mechanism and transmission path of data driven global value chain reconstruction. The aim is to crack the synergy between digital elements and industrial structure and division of labor structure, and promote the dual reconstruction of GVC in terms of division of labor form and spatial layout. This study constructed a dual model empirical framework consisting of a benchmark nonlinear driving model and a structural adaptation adjustment model. Case data from 66 Chinese manufacturing enterprises were selected to conduct quantitative tests on variables such as digital factor input, GVC production length, geographic concentration, and structural adaptation. The driving mechanism was validated through component regression and interaction effects. Case analysis shows that digital factor input has a significant inverted U-shaped direct driving effect on GVC reconstruction, with positive moderating effects on demand income elasticity, industry correlation, industry scale, and global regional value chain embedding level. High digital factor input enterprises have significantly better GVC extension and spatial agglomeration performance than low input enterprises. Research has shown that the coupling of data-driven and structural adaptation is the core mechanism of GVC reconstruction, and enterprises should enhance their structural adaptation capabilities to achieve efficient value chain upgrading.*

KEYWORDS: *Data-driven; Global value chain; Path reconstruction; New Structural Economics; Dual model*

1 Introduction

Emerging economy enterprises have grown into emerging entities in the global economic landscape, continuously driving structural changes in the international division of labor system [1]. As the world's largest emerging economy, China's local enterprises have shown particularly outstanding performance in global competition. For example, Huawei has successfully established a global supply chain system for its own brand smartphones, and its global sales of smartphones once surpassed Samsung and Apple. For example, in the global video surveillance field, Hikvision has a global market share of 40% and has consistently ranked first in global sales for nine consecutive years [2]. This type of enterprise has achieved a leapfrog climb from the mid to low end to the high-end segment in the Global Value Chains (GVC), growing into a global industry leader in various sub sectors, breaking through the traditional perception that Chinese enterprises have long been locked in the mid to low end segment of GVC and passively constrained by flagship enterprises on the chain [3].

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The phenomenon of GVC structural reconstruction caused by the rise of emerging economy enterprises has received widespread attention from the academic community. The academic community has conducted extensive discussions on the driving forces, strategic models, and influencing factors of the leapfrog development of emerging economy enterprises, but related research is mostly limited to a single research category of enterprise GVC upgrading [4]. There is still a lack of systematic research on the status transition, governance power evolution, and value chain restructuring of enterprises in GVC after upgrading. This phenomenon should be conceptually distinguished from conventional enterprise GVC upgrading, and theoretical connections between enterprise upgrading and GVC governance can be attempted. At present, the restructuring of enterprise GVC, as a cutting-edge research topic in the global economic situation and management, is still in the initial stage of theoretical development. Existing achievements mainly focus on conceptual definition, quantitative measurement, and theoretical framework construction. There is still a lack of systematic exploration on the implementation path and core supporting capabilities of enterprise GVC restructuring [5].

This article is based on the perspective of new structural economic theory, taking data elements as the core driving variables and incorporating structural characteristic variables such as demand income elasticity, industry correlation, industry scale, and global regional value chain division of labor. It constructs an analytical framework for the linkage between benchmark nonlinear driving models and structural adaptation adjustment models. On this basis, empirical tests and quantitative analysis were conducted using case data from 66 manufacturing enterprises in China to verify the dual impact of digital factor input on the production length and geographical concentration of the global value chain, as well as the moderating effect of structural adaptation conditions. This provides theoretical basis and practical reference for emerging economy enterprises to rely on digital transformation to achieve value chain ascent, participation, and even leadership in global value chain reconstruction.

2 Related research

2.1 Connotation of Global Value Chain Restructuring

The Value Chain theory holds that the enterprise value system is composed of upstream value at the supplier end, channel value at the distribution stage, and customer value at the consumer end. The essence of enterprise competition is a comprehensive game of the overall value system. Nyagadza et al. [6] proposed Global Value Chains (GVCs), which not only focus on the trade of final products, but also on deep issues such as the flow of intermediate goods and value distribution. They systematically depict the value and profit patterns of all participants in the production, circulation, transportation, consumption, and after-sales chains. Coveri et al. [7] pointed out that enterprises tend to allocate core elements such as labor, capital, and technology to production links with comparative advantages. Compared with the value chain from a single enterprise perspective, the value-added chain focuses on the value creation and value-added process in cross enterprise and cross industry production activities, emphasizing the vertical division of labor layout and factor reconfiguration logic of the product production system. After the 2008 international financial crisis, the process of economic globalization slowed down, and Restructuring the Global Value Chains (RGVC) gradually became a research hotspot. Since then, multiple external shocks such as Brexit, economic and trade frictions, the COVID-19, and geopolitical conflicts have triggered a break in the supply chain of the global industry chain. Economic security and sustainable development have become the core demands of all countries, accelerating the process of restructuring the global value chain. Almazán-Gómez et al. [8] believes that the restructuring of the global value chain is a re adjustment and combination of

the value distribution structure of the global product production system, reflected in the shrinkage of the scale of each link in the value chain, the transformation of business formats, and the transfer of space to other places. Giovannetti et al. [9] believes that value chain restructuring is a dynamic process in which enterprises rely on information technology to empower value chain collaboration capabilities and achieve a rising position in division of labor. Islam [10] portrayed the realistic characteristics of cross link resource integration in multinational enterprises, laying the conceptual foundation for the reconstruction of the global value chain. Capello et al. [11] were the first to construct an analytical framework for vertical and horizontal restructuring of global value chains, which improved and expanded the theoretical system of global value chain restructuring and led to a structural change in the global competitive landscape.

2.2 Driving factors for global value chain restructuring

Further focus on the driving factors related to the connotation and quantitative measurement methods of global value chain reconstruction. For example, Debellis et al. [12] found that the global value chain has undergone two significant restructuring cycles so far: (1) the 2008 international financial crisis triggered the first round of restructuring, with unilateralism rising and international trade frictions intensifying; (2) In 2020, under the double impact of economic and trade games and the global spread of COVID-19, the global value chain suffered a second disturbance. The overall restructuring of the global value chain in this round presents regional and localized evolution characteristics. The original decentralized production model is gradually shifting towards a regional agglomeration model. Multinational enterprises tend to internalize most production processes, and intangible assets such as innovative resources, big data elements, brand assets, and high-end talents are increasingly empowering the evolution and layout adjustment of the global value chain. There is significant heterogeneity in the paths of different industries participating in the reconstruction of the global value chain, which can be summarized into three paradigms [13]: (1) manufacturing industries such as chemical products, metal products, electrical, electronic and computer equipment, textiles and leather, paper products, and printing, which mainly dominate the layout of regional value chains; (2) The pharmaceutical manufacturing, food manufacturing, and tobacco manufacturing industries primarily focus on building a national value chain; (3) The transportation equipment manufacturing industry is choosing between the path of restructuring the national value chain or deeply embedding into the global value chain.

The reconstruction of the global value chain is mainly driven by four core factors [14]: (1) technological progress characterized by digitization and automation plays a decisive role in adjusting the direction of the global value chain; (2) Automation technology replaces some manual labor, promoting cross-border industrial relocation and supply chain layout adjustment. (3) The technological revolution continues to reshape the comparative advantage of traditional factor endowments, the contribution of low skilled labor is gradually weakening, and the ability to control and allocate capital factors continues to increase; (4) The global digital wave has generated incremental consumer demand, and the market size continues to expand, creating favorable conditions for the economy to achieve a higher position in the value chain. (5) Frequent trade protectionism measures have pushed up the cost of cross-border trade, and their chain reaction has further driven the evolution of the global value chain towards localization and regionalization. Figure 1 shows a driving factor diagram for the restructuring of the global value chain.

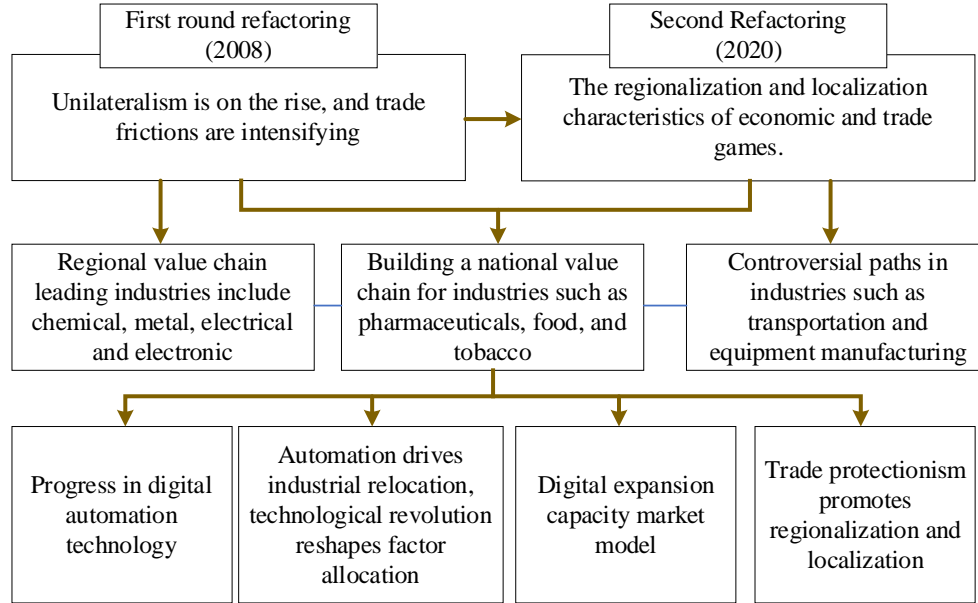


Figure 1: Driving factors of global value chain reconstruction

2.3 Digital elements drive the reconstruction of global value chains

Existing literature mostly explores the mechanism of digital elements in the reconstruction of global value chains from dimensions such as big data empowerment, digital industry penetration, digital technology iteration, and digital economy platform application. For example, Sanguineti et al. [15] empirically tested the correlation effect between digital factors and the change of global value chain status, and the study showed that digital factors can significantly enhance the global division of labor status of enterprises. The digital industry can optimize the allocation of innovative elements through three paths: (1) utilizing the cross regional flow of innovative elements to achieve rational planning of production capacity; (2) Promote the independent spillover and diffusion of innovative elements from upstream to downstream along the industrial chain; (3) Rely on Internet technology to accelerate the spatial integration of traditional trade and production links. At the same time, the digital industry relies on disruptive technological innovation to build a digital trade network, break down barriers to cross regional flow of production factors, and achieve a leap in the global value chain hierarchy. In addition, digital platforms can achieve collaborative operation and evolutionary upgrading of the global value chain and global production network through optimization of production capacity allocation, accumulation of monetary and non-monetary value, and reintegration of industrial chain rights and responsibilities, creating conditions for the integration of physical industries into the high-end value chain system.

The academic community also focuses on the intrinsic mechanism of digital elements driving the reconstruction of global value chains. For example, Boschma [16] research shows that the digital economy can extend the production length of the value chain through two channels: reducing trade costs and enhancing industrial linkages, promoting the replacement of offshore outsourcing with nearshore outsourcing, and accelerating the regional division of labor layout of the value chain. Herkenhoff et al. [17] explained the driving role of digital technology progress in the global value chain division of labor pattern, and believed that digital technology will drive the spatial layout of production links to shift towards regional agglomeration. Veiga et al. [18] proposed that under the background of the digital economy, the expansion of micro participants, the emergence of new business models, and the refinement of product division of labor will all promote the extension of value chain links. Ryan et al. [19] pointed out that data

elements have significant value chain regionalization driving characteristics and can generate indirect driving effects through resource allocation optimization, technological model innovation, and other paths.

3 From the perspective of new structural economics, dual model data-driven reconstruction of global value chains

3.1 Model Setting

To test the specific path of digital driven global value chain reconstruction, the following econometric model is constructed:

$$VRGVC_{it} = \alpha_0 + \alpha_1 Digital_{it} + \beta_1 Controls + V_i + V_t + \varepsilon_{it} \quad (1)$$

$$HRGVC_{it} = \alpha_0 + \alpha_1 Digital_{it} + \alpha_2 Digital_quared_{it} + \beta_1 Controls + V_i + V_t + \varepsilon_{it} \quad (2)$$

where, the subscripts i and t respectively represent the country and year. $RGVC_{it}$ represents the indicator of global value chain reconstruction. In formulas (1) and (2), logarithmic global value chain production length ($VRGVC_{it}$) and global value chain geographic concentration ($HRGVC_{it}$) are used as the dependent variables for empirical analysis; $Digital_{it}$ is the indicator of digital input, and $Digital_quared_{it}$ is the square term of digital input; Controls refers to the control variables from the perspective of new structural economics, including demand income elasticity index, industry correlation index, industry scale index, and global regional value chain evaluation index; V_i and V_t represent country fixed effects and year fixed effects, respectively, while ε_{it} is a random interference term.

The input of digital elements involves all industry sectors that apply data elements and digital technology, mainly reflected in the value-added input generated by the digital economy infrastructure sector to other sectors. Based on the previous text, this article selects the intermediate input of major digital economy basic sectors as the proxy variable for digital factor input, represented by Digital [20]. The main digital economy infrastructure sectors include: computer, electronic and optical product manufacturing, communication, information technology and other information service industries.

3.2 Controlling Variables from the Perspective of New Structural Economics

Under the global value chain, Pham & Jinjarak [21] used the production non integration index as an important tool to evaluate the degree of economic participation in the global value chain based on the impact of intra product division of labor on international division of labor and cooperation forms [22]. On the basis of the traditional leading industry indicator evaluation system, combined with the global value chain background, the indicators of "demand income elasticity", "industry correlation", "industry scale", and "global regional value chain" are included as components of the regional leading industry selection analysis framework.

(1) Income elasticity index of demand. The demand elasticity index is associated with broad market demand and is an important indicator of changes in industrial structure. It is generally believed that industries with high demand elasticity occupy a larger proportion in the economic structure. The calculation formula is:

$$e_i = \frac{\Delta X_i / X_i}{\Delta NI / NI} \quad (3)$$

where, e_i is the demand income elasticity of industry i , the numerator represents the demand growth rate of industry i , and the denominator represents the growth rate of national income elasticity. If $e_i > 1$, it indicates that the demand income elasticity of industry i is high and the market prospects are broad, otherwise it has the opposite meaning.

(2) Industry correlation degree. Industrial correlation refers to the correlation effect between industries. Industries with high industrial correlation will have strong forward and backward impacts on other industries [23]. Choosing industries with high industrial correlation as the leading industry can drive the development of the entire economy. The industrial correlation index is usually reflected by the industrial influence coefficient and the induction coefficient.

1) Industrial influence coefficient:

$$e_j = n \sum_{i=1}^n C_{ij} / \sum_{j=1}^n \sum_{i=1}^n C_{ij} \quad (4)$$

2) Industrial induction coefficient:

$$e_i = n \sum_{j=1}^n C_{ij} / \sum_{j=1}^n \sum_{i=1}^n C_{ij} \quad (5)$$

If the influence of the industry ranks at the upstream level among all industries, and the expansion of social demand in this industry has a greater driving effect on various sectors of society than the average level of other sectors, it indicates that the influence of this industry is at the average level among all industries [24]. If it indicates that the influence of this industry is at the downstream level among all industries. It also indicates that the impact of this industry on other sectors exceeds the average level. Generally, industry sectors with both industry influence coefficient and sensitivity coefficient greater than 1 are selected as the dominant industries.

(3) Industrial scale. Üner et al. [25] believe that industrial scale is an important factor that restricts the degree of division of labor. At the same time, "the leading industry must reach a certain scale and form a certain scale economy in order to play its driving role," which brings about an increasing return to scale effect. A relatively simple measurement method is to calculate the proportion of industrial added value in regional GDP, using the formula:

$$G_n = Y_{nm} / Y_m \quad (6)$$

where, Y_n is the scale indicator of industry n , Y_{nm} is the added value or output value of the n th industry in the m -th region, and G_n is the total output value or GDP of the m -th region. When $G_n > 1$ occurs, it indicates that industry n in region m has formed a certain scale advantage. The larger the value, the more obvious the scale advantage of the industry, and it presents a certain level of specialization.

(4) Global regional value chain. Based on the input-output method, distinguish and measure the proportion of domestic intermediate inputs and foreign imported intermediate inputs in the export value during the production process, and express the level of economic participation in the global domestic value chain. Assuming there are n industrial sectors in the national economy, M_i represents the intermediate input of industry i imports, Y_i represents the output

of industry i , X_i represents the export of industry i , Y_i represents the output of industry i , then the amount of intermediate input of imports included in the export value of industry i represents the quantity of non-integrated production in industry i , denoted as VD , with the following formula:

$$VD_i = \left(\frac{M_i}{Y_i} \right) X_i = \left(\frac{X_i}{Y_i} \right) M_i \quad (7)$$

The proportion of imported intermediate inputs included in the export value of industry i , that is, the proportion of non-integrated production in industry i , is denoted as vdi , and the calculation formula is:

$$vdi = \frac{VD_i}{X_i} = \left(\frac{X_i}{Y_i} * M_i \right) / X_i = \frac{M_i}{Y_i} \quad (8)$$

The proportion of imported intermediate inputs in the exports of various industrial sectors of the national economy, that is, the proportion of non-integrated production in the entire industry, is denoted as vd , and its calculation formula is as follows:

$$vd = \frac{1}{X} uA^M X^v = \frac{1}{X} uA^M (I - (A - A^M))^{-1} X^v \quad (9)$$

where, $u = (1, \dots, 1)_{1 \times n}$ is a vector of element 1 in 1 row and n columns, A^M is the $n \times n$ dimensional import coefficient matrix for various industrial sectors of the national economy, and X^v represents the $n \times 1$ dimensional export vector.

If the complete consumption coefficient matrix $(I - A^D)^{-1}$, domestic consumption coefficient matrix AD , and $A = AM + AD$ are substituted into equation (8), the following can be obtained:

$$vd = \frac{1}{X} uA^M (I - A^D)^{-1} X^v \quad (10)$$

where, $(I - A^D)^{-1}$ is the Leontieff inverse matrix, which represents the cumulative cyclic effect of intermediate inputs imported by the industrial sector at each intermediate stage. Formula (10) can express the direct and indirect technical and economic connections between various industries.

3.3 Dual Model Driven

Based on the theoretical core of new structural economics, with digital factor input as the core driving source, a benchmark nonlinear driving model and a structural adaptation adjustment model are constructed to form a dual model linkage driving mechanism, systematically revealing the transmission path, nonlinear characteristics, and structural constraints of data factor driven global value chain reconstruction [26]. Among them, the benchmark model characterizes the direct nonlinear impact of digital factors on GVC production length and geographic concentration, while the structural adjustment model incorporates four variables: demand income elasticity, industry correlation, industry scale, and global regional value chain division of labor, to identify the amplification or constraint effect of structural adaptation conditions on driving effects [27]. The dual model coupling forms a complete transmission

chain of "power source adapter reconstruction result", as shown in Figure 2.

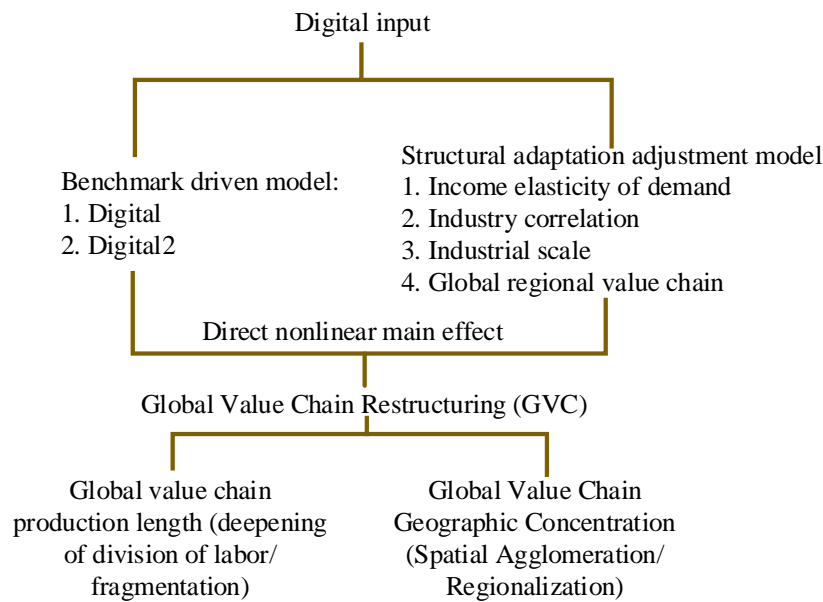


Figure 2: Schematic diagram of dual model driving mechanism

Digital elements directly affect the division of labor in the global value chain by reducing information asymmetry, optimizing production segmentation, and enhancing cross-border collaboration efficiency [28]. The initial investment in digital elements is relatively small, with insufficient technological penetration and weak driving effects; As investment increases, economies of scale and network effects are released, significantly extending GVC production length and promoting geographical layout optimization; When the input exceeds the critical value, the marginal effect decreases and exhibits an inverted U-shaped nonlinear characteristic. The dual model driving mechanism shown in Figure 2 corresponds to the coefficient combination of Digital and Digital2 in the model, verifying the non-monotonic action trajectory driven by data.

The four major control variables of new structural economics serve as moderating variables to determine the efficiency driven by digital factors [29]: (1) the demand income elasticity control variable can strengthen the pulling effect of digital factors on GVC extension; (2) The control variable of industrial correlation degree shows that high correlation industries have significant forward driving and backward supporting effects, which can accelerate the penetration of digital technology throughout the entire chain; (3) Controlling the variable of industrial scale can improve the efficiency of digital factor allocation and amplify the reconstruction effect; (4) Global regional value chains control variables, and a high level of non-integrated production means that digital elements are more likely to optimize cross-border resource allocation.

The benchmark driven model provides the original driving force, determining the basic direction and nonlinear trend of GVC reconstruction; The structural adjustment model provides adaptation conditions, determines driving strength and path selection, and their coupling can accurately depict the inherent logic of global value chain reconstruction under data-driven conditions.

4 Case analysis

4.1 Source of Case Samples

Since 2016, the research team has visited and researched 66 manufacturing enterprises in China around the research theme of reconstructing GVC, and constructed a "Case Library of Reconstructing GVC Enterprises" [30]. The average duration of existence of 66 case enterprises is 23.5 years, mainly characterized by the following features: firstly, diverse characteristics, which have certain representativeness among manufacturing enterprises in China. Among the 66 enterprises, there are state-owned enterprises, private enterprises, and foreign-funded enterprises (including Sino foreign joint ventures): there are listed companies and non-listed companies; It is geographically distributed in Taiwan, China, the Yangtze River Delta, the Pearl River Delta and other regions. Its industries cover 20 major categories of manufacturing industries in the national economic industry classification, including labor-intensive industries, technology intensive industries and capital-intensive industries. Secondly, enterprises are all participants in GVC and are the target objects for studying the reconstruction of GVC. 66 companies are or have been in the low-end segment of GVC, and have implemented or are exploring enterprise upgrades, with the motivation to restructure GVC. Among them, 36 are or have been OEM enterprises of developed countries. Thirdly, there are cases of both positive and negative aspects of reconstructing GVC. The research on restructuring GVC is a more in-depth study based on enterprise upgrading. Some enterprises have achieved restructuring GVC during the upgrading process, while others have not yet achieved or attempted to fail.

4.2 Data Collection

This article collected a large amount of first-hand and second-hand information from 66 case companies, including electronic documents and paper texts, totaling approximately 3.17 million words. In order to improve the reliability and validity of the research, enhance the accuracy, persuasiveness, and interpretability of the research conclusions, multiple methods and channels were used to obtain case materials, achieving cross validation and mutual supplementation of multi-source data. In addition, executives from all 66 companies participated to varying degrees in the research interviews and case analysis process. All company data and the measurement results of the research team on the company's capabilities and the restructuring of GVC performance were fed back to the companies for revision and confirmation. The reliability of the data and the rigor of the analysis of the measurement results can be guaranteed.

4.3 Result Analysis

This section is based on survey data from 66 manufacturing enterprises, and conducts quantitative measurements from four dimensions: digital factor input intensity, global value chain (GVC) restructuring performance, structural adaptation variable score, and dual model driving effect. Through mean comparison, coefficient significance test, and group regression method, the effectiveness of the dual model driving mechanism from the perspective of new structural economics is verified. Firstly, based on the intensity of digital factor input, the top 33 companies were classified as the high digital factor input group, while the bottom 33 companies were classified as the low digital factor input group. A significant difference test was conducted on the mean value between the groups for the core variables of the study. Table 1 shows the comparison of GVC reconstruction performance between high/low input groups of digital elements.

Table 1: Performance Comparison of GVC Restructuring (High/Low Input Group of Digital Elements)

Indicator	symbol	High digital investment group	Low digital investment group	Mean difference	Significance
Input of digital elements	Digital	4.15	1.72	2.32	***
GVC production length (logarithmic)	Ln_length	2.06	1.31	0.74	***
GVC geographic concentration	Concentration	0.65	0.37	0.26	**
income elasticity of demand	Elasticity	1.21	0.80	0.40	**
Industry correlation degree	Relevance	1.16	0.75	0.40	**
industrial scale	Scale	0.23	0.18	0.13	***
Non integrated production level	VD	0.36	0.27	0.16	***

Note: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$; The data is sourced from standardized scoring in the case library.

According to the results shown in Table 1, the GVC production length, geographic concentration, and structural adaptation variable levels of the high digital factor input group are significantly higher than those of the low digital factor input group. Among them, the mean difference in GVC production length between the two groups is the most prominent, and the industrial scale and production non integration level also show significant inter group differences, confirming that economies of scale and cross-border division of labor embedding are important pathways for the release of digital factor dividends.

Secondly, GVC production length and geographic concentration were selected as the dependent variables to empirically test the nonlinear main effect of digital factor inputs on global value chain reconstruction. Table 2 shows the regression results of the benchmark driven model.

Table 2: Regression Results of Benchmark Driven Model

variable	Ln_length	Concentration
Digital	0.512***	0.305***
Digital2	-0.074**	-0.043**
control variable	control	control
Country/Year Effect	control	control
R ²	0.412	0.340

Note: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

According to the results shown in Table 2, (1) the Digital coefficient is significantly positive, indicating that digital input has a direct driving effect on GVC extension and spatial agglomeration. (2) The Digital coefficient is significantly negative, indicating that the driving effect of digital input increases within the critical value, and the marginal effect decreases beyond the critical point. (3) The good fit of the model indicates that benchmark driven can effectively explain the core trend of data-driven GVC reconstruction.

Thirdly, incorporating demand income elasticity, industry correlation, industry scale, and global regional value chain embedding characteristics into the model, we will examine the moderating effects of these variables on the impact of digital factors on the process of enterprise GVC reconstruction. Table 3 shows the regression results of the interaction term in the structural adjustment model.

Table 3: Regression results of interaction terms in the structural adjustment model

interaction term	Ln_length	Concentration	Adjust direction
Digitalx Elasticity	0.214**	0.146*	positive reinforcement
Digitalx Relevance	0.268***	0.183**	positive reinforcement
Digitalx Scale	0.195**	0.137*	positive reinforcement
Digitalx VD	0.241***	0.169**	positive reinforcement

Note: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

According to the results in Table 3, the interaction coefficients of the four major structural variables are significantly positive: (1) high demand income elasticity can expand the boundary of market demand and strengthen the endogenous driving force of value chain extension; (2) High industrial correlation can achieve digital penetration throughout the entire industrial chain, improving the efficiency of industrial collaborative allocation; (3) Large scale economies can dilute production unit costs and further unleash the resource allocation dividends of data elements; (4) The high level of non integration in production deepens the embedding of cross-border division of labor in enterprises and accelerates the optimization process of global value chain spatial layout.

The above case analysis results indicate that: (1) Digital elements are the core driving force for enterprise GVC restructuring, directly determining the degree of evolution of global value chain restructuring. Manufacturing enterprises with high digital investment intensity are more likely to achieve international division of labor status and value chain regionalization layout transformation. (2) Digital elements exhibit significant nonlinear driving characteristics for GVC reconstruction, and excessive addition of digital elements will lead to diminishing marginal efficiency, making it difficult to sustainably promote value chain upgrading. (3) Structural adaptability is a key condition that constrains the effectiveness of digital empowerment. Under the framework of new structural economics, the dual model driving mechanism is established, and the benchmark effect of digital elements constitutes the fundamental driving force for GVC reconstruction. The moderating effect of structural adaptability variables determines the efficiency of empowerment release. (4) On a practical level, manufacturing enterprises should moderately increase their investment in digital elements, simultaneously enhance demand income elasticity, industrial linkage level, industrial scale and depth of cross-border division of labor, which can achieve high-quality reconstruction and upgrading of the global value chain.

5 Conclusion

This article takes data-driven global value chain reconstruction as the core topic, constructs an empirical system of benchmark nonlinear driving model and structural adaptation adjustment model dual model linkage, and conducts quantitative testing based on case data of 66 manufacturing enterprises in China, obtaining rich research conclusions. Main tasks: (1) Clarify that digital elements are the core driving force behind the current global value chain division of labor, spatial layout, and governance structure changes, filling the gap in existing research on

the synergistic effects of data elements and structural conditions. (2) We have improved the structural constraint system for value chain reconstruction driven by data, achieving an organic connection between macro structural theory and micro enterprise behavior. (3) By constructing a dual model driven mechanism, it was identified that the four major structural variables all have a positive reinforcing regulatory effect on the digital driving effect, clearly depicting the complete transmission chain of "data-driven structural adaptation GVC reconstruction". (4) Based on multi-source case data, empirical tests were conducted to provide micro evidence for Chinese manufacturing enterprises to climb to the high-end of the global value chain through digital transformation.

Future research direction: (1) Heterogeneity differentiation has not been made between labor-intensive, technology intensive, and capital-intensive industries. There are differences in the pace and structural constraints of data element penetration in different industries, and comparative studies can be conducted by industry in the future. (2) Failed to capture the long-term dynamic evolution characteristics of digital driven global value chain reconstruction. In the future, cross year panel data can be constructed and dynamic econometric models can be used to conduct long-term effect tests. (3) The exploration of the regulatory role of macro policies such as national institutional environment, digital trade rules, and regional trade agreements is insufficient. In the future, a multi-level nested model of "macro meso micro" can be constructed. (4) This article does not address the impact of new risks such as data security, platform governance, and cross-border data flow on value chain reconstruction. In the future, risk constraints can be incorporated into the model to enhance the practical applicability of research conclusions.

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