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LIBERALIZATION OF SERVICE TRADE, DIGITAL ECONOMY AND THE INTEGRATION OF "M&P INDUSTRIES"

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Abatract: Based on the panel data of transnational industries from 2007 to 2014, this paper studies the impact of service trade liberalization on the integration of manufacturing and producer services (hereinafter referred to as the "M&P industries"), and studies the regulatory role of digital economy in it from both theoretical analysis and empirical test. The results show that the liberalization of service trade has a significant positive promoting effect on the integration of "M&P industries", which is enhanced by digital economy. This conclusion is still valid after a series of robustness tests such as instrumental variable method and alternative variable method. The results of heterogeneity analysis show that the liberalization of trade in warehousing and transportation services and financial and insurance services has a stronger positive promoting effect on the integration of the M&P industries. The digital economy plays a stronger positive moderating role in the liberalization of trade in wholesale and retail, information and communication, and financial and insurance services. The test of nonlinear regulating effect shows that the regulating effect of digital economy on the integration of "M&P industries" also has nonlinear characteristics. The higher the development level of digital economy, the stronger the marginal income of its positive regulating effect is, showing the feature of increasing marginal income.
Keywords: Producer services; Industrial integration; Opening up of the service sector; Digital economy; Regulatory effect

1 INTRODUCTION

China's economy has entered a new phase focused on promoting high-quality development, necessitating a transition from being a manufacturing giant to a manufacturing powerhouse. The 2014 "State Council's Guidance on Accelerating the Development of Producer Services to Promote Industrial Structure Adjustment and Upgrading" highlights that producer services, encompassing multiple sectors such as agriculture and industry, are characterized by strong specialization, active innovation, high industrial integration, and significant driving effects, making them strategic focal points in global industrial competition. Accelerating the innovative development of producer services and achieving organic integration of manufacturing and producer services at a higher level are crucial measures for structural adjustment and promoting stable economic growth, which can elevate industries along the value chain. Thus, exploring how to promote the integration of manufacturing and producer services (hereinafter referred to as the "M&P industries") is of great importance.

In recent years, China's integration of the "M&P industries" has accelerated, yet issues such as development imbalance, weak synergy, and insufficient depth remain. Currently, China's producer services sector has a relatively low share and an unreasonable structure, lagging significantly behind developed countries. Domestic producer services cannot meet the development needs of the manufacturing sector, limiting the extent of the current integration of the "M&P industries" and falling short of supporting manufacturing transformation and upgrading. In recent years, China has adhered to high-level opening-up to promote high-quality development, continuously relaxing market access in the service sector, enhancing cross-border service trade openness, expanding the functionality of foreign opening platforms, and striving to establish a high-standard service sector opening system. Against the backdrop of global high-level opening-up, service trade liberalization can allocate advanced international producer service elements, driving the coordinated development of manufacturing and services, and deepening the integration of the "M&P industries." Furthermore, the digital economy, as the most dynamic field of economic development, is expanding its breadth and depth of integration with various sectors of the economy and society. Alongside introducing advanced international service elements, the innovative application of new-generation digital technologies such as artificial intelligence and 5G in manufacturing and service enterprises is fostering new ecosystems and models for the integration of manufacturing and producer services, providing new directions and paths for the "M&P industries" integration in developing countries.

Based on the above analysis, the pertinent questions arise: Does service trade liberalization positively promote the integration of a country's "M&P industries"? Can the digital economy empower this process, enhancing the role of service trade liberalization? Addressing these questions aids in achieving high-quality development of the manufacturing sector, offers new insights for developing countries' service trade liberalization reforms, and provides empirical evidence for countries worldwide to continuously strengthen the development and application of the digital economy.

2 LITERATURE REVIEW

The relevant studies in this context fall into three main categories:The first category focuses on the connotation, characteristics, quantitative methods, and influencing factors of the "M&P industries" integration. In terms of connotation and characteristics, scholars primarily study the basic activities of the value chain, analyzing the dynamic process of "M&P industries" integration from various perspectives such as the integration process, mechanisms, and methods, thus enriching the related research outcomes. The consensus is that the integration of manufacturing and producer services involves the interpenetration, extension, and reorganization of activities along the value chain. The differences in activities and the degree of coordination between them reflect the development of "M&P industries" integration. Regarding quantitative methods, there is currently no unified standard or specific method for measuring the level of "M&P industries" integration. Domestic and international scholars have employed methods such as input-output analysis[1], correlation coefficient analysis[2], and coupling coordination[3] to measure the degree of integration and empirically study its contribution to manufacturing upgrading, generally concluding positive effects. Concerning influencing factors, scholars mostly based on theoretical research, identify technological innovation[4], deregulation[5], and corporate strategic behavior[6] as the main drivers of "M&P industries" integration.The second category pertains to the quantitative methods and economic benefits of service trade liberalization. In terms of quantitative methods, Arnold et al. use input-output analysis, service BOP import, and service FDI data to depict the penetration rate of service openness in the manufacturing sector[7]. Regarding economic benefits, scholars have examined the impact of service trade liberalization on firm performance from various perspectives, including total factor productivity[7], the cost of service intermediates[8], export technology complexity[9], value chain division index, and product quality. The results uniformly indicate that service trade liberalization positively promotes firm performance.

The third category pertains to the connotation of the digital economy, its quantitative methods, and its impact on the integration of the "M&P industries." The concept of the digital economy was first introduced by Tapscott and Don[10], and later refined by scholars such as Fudenberg D and Villas-Boas JM[11], Bukht R and Heeks R[12]. Currently, the prevailing view is that the digital economy is a new economic form that enhances efficiency and optimizes economic structure by using digitized knowledge and information as key production factors, modern information networks as important carriers, and effective use of information and communication technology. In terms of quantitative methods, there is extensive research on measuring the development level of the digital economy and compiling related indices. Some scholars use the entropy method and index method to select relevant indicators from five aspects: information and communication infrastructure, primary ICT applications, advanced ICT applications, enterprise digital development, and the development of the ICT industry, thus constructing a national-level digital economy development evaluation index system for China. Other scholars employ principal component analysis to construct an evaluation index system from the perspectives of internet development and inclusive digital finance. Additionally, some scholars, based on the classification standards in the "Digital Economy and Its Core Industries Statistical Classification (2021)" published by the National Bureau of Statistics of China, have constructed regional-level digital economy development evaluation index systems from four aspects: digital industrialization, industrial digitization, digital infrastructure, and the digital economy industry ecosystem.

The previous text organized literature related to this study from three aspects. Domestic and foreign scholars have conducted in-depth research on the integration of the "M&P industries," the liberalization of service trade, the digital economy, and their interrelationships. However, many issues still warrant further exploration:Firstly, existing research on the impact of service trade liberalization on the integration of the "M&P industries" is relatively scarce. Studies have mostly focused on the openness of the productive service industry and its integration with manufacturing, finding that the openness of the productive service industry enhances the integration between manufacturing and productive services in China. However, these studies have not analyzed the mechanism from the perspective of value chain structure evolution. Furthermore, existing research has not explored the moderating role of the digital economy in promoting the integration of the "M&P industries" through service trade liberalization.Secondly, there are some deficiencies in the current methods of quantifying digital economy development. Most assessments of the digital economy development levels of various countries are based on institutional guarantees and innovation environments, while the two core indicators of digital economy development, digital industrialization and industrial digitization, are often overlooked.Thirdly, the impact of the digital economy on the integration of the "M&P industries" is multi-dimensional and complex, not merely confined to technological empowerment and upgrading. On one hand, the digital economy can create an industrial development ecosystem that combines economies of scale, economies of scope, and long-tail effects, thereby better matching supply and demand and deepening inter-industry cooperation. On the other hand, it drives industrial transformation and upgrading through new input factors, new resource allocation efficiencies, and new total factor productivity, expanding industry boundaries and promoting the integration of the "M&P industries." Therefore, the impact of the digital economy on the integration of the "M&P industries" requires further expansive research. While some literature has discussed the positive effects of digital technology on the integration of the "M&P industries," digital technologies such as information technology and network technology are merely carriers and supports for the operation of the digital economy. They do not fully reflect the overall structure and ecosystem of the digital economy's impact on the integration of the "M&P industries," presenting an opportunity for this study to make a marginal contribution.

In comparison with existing research, this paper proposes to expand and innovate in three aspects:1.Research perspective: This study elucidates the impact of service trade liberalization on the integration of manufacturing and producer services from the perspective of value chain evolution. It comprehensively considers the moderating role of the digital economy as a new economic form.2.Empirical research: The study adopts a global approach, using multi-

dimensional panel data from 29 countries (regions) and 18 manufacturing industries from 2007 to 2014 to empirically examine the relationship between service trade liberalization and industry integration. It analyzes the moderating effect of the digital economy in promoting integration through service trade liberalization, testing its non-linear moderating characteristics akin to Metcalfe's Law.3. Variable measurement: Following the "Statistical Classification of Digital Economy and Its Core Industries (2021)" issued by the National Bureau of Statistics, this paper constructs a national-level evaluation index system from three aspects: digitalization of industries, industrial digitalization, and digital infrastructure. It employs principal component analysis to measure the digital economy development level of 68 countries, including the research sample, enriching the measurement methods of digital economy development.

3 THEORETICAL ANALYSIS AND RESEARCH HYPOTHESES

3.1 Impact of Service Trade Liberalization on Industry Integration

The integration of manufacturing and producer services encompasses two stages: value chain decomposition and value chain integration[13]: In the value chain decomposition stage, manufacturing and producer services sectors decompose their respective value activities through division of labor, forming a production network with inter-industry factor flows and sharing. Manufacturing sectors outsource highly overlapping value activities such as warehousing, transportation, marketing, and after-sales services to producer services sectors, which provide these services more cost-effectively and efficiently. This refined division of labor creates the preconditions for value chain integration. During the value chain integration stage, both sectors extract and reorganize value activity units from the production network based on their industry characteristics and market demands, forming new value chains. Producer service providers penetrate and extend their operations into the manufacturing value chain, developing integrated products related to physical goods upstream or downstream, ultimately leading to value chain restructuring. This study posits that service trade liberalization promotes value chain decomposition by deepening inter-industry division of labor and facilitates value chain integration by fostering industrial agglomeration and innovating inter-industry linkage models. These two stages ultimately achieve the integration of manufacturing and producer services:

3.1.1 Deepening inter-industry division of labor

In the process of integrating "M&P industries," it is essential for the productive service segments to first detach from the manufacturing value chain. Liberalization of service trade continuously amplifies cost and quality gaps in the same productive service segments through cost and demonstration effects, deepening the division of labor between manufacturing and productive service industries, and promoting the decomposition of the "M&P industries" value chain. On the one hand, after introducing high-end and refined foreign productive services, manufacturing enterprises obtain logistics, warehousing, information communication, financial insurance, and other services at costs much lower than those obtained internally through outsourcing, making internalizing various production stages and "large-scale" operations uneconomical for manufacturing enterprises. Moreover, with the continuous expansion of relative cost gaps, the division of labor and specialization between enterprises continues to deepen. On the other hand, foreign productive services generate technology spillovers through horizontal and vertical industry linkages. Domestic productive service providers can promote the refinement and specialization of domestic productive services through the mobility of personnel across enterprises, technology transfer, or learning from foreign advanced service technologies and management experiences. Strengthening the relative competitive advantages of productive service suppliers over manufacturing enterprises in productive service segments compels manufacturing enterprises to specialize and refine their core value activities such as production and research and development. Continuously increasing the breadth and depth of division of labor between manufacturing and productive service industries creates conditions conducive to the integration of "M&P industries."

3.1.2 Promoting industrial agglomeration

The liberalization of service trade has introduced a tendency for foreign productive service industries to cluster towards central cities or industrial parks, and can promote the integration of the M&P industries through agglomeration effects. The productive service industry is mainly concentrated in knowledge intensive and human capital intensive industries, with characteristics such as no physical products, information asymmetry, and high contract intensity. Therefore, compared to trade costs, foreign high-end productive service industries are more sensitive to transaction costs based on institutions and need to gather in large cities or industrial parks with abundant human capital and stable institutional environments. The technology spillover effect it brings will also attract the host country's productive service industry to cluster in specific regions, forming high-end and specialized productive service industry parks, and leveraging the externalities of industrial agglomeration to promote the integration of the M&P industries. Firstly, the agglomeration of productive service industry is conducive to the expansion of the intermediate product service market, forming economies of scale for intermediate inputs, thereby providing specialized and low-cost intermediate inputs for upstream and downstream enterprises, and providing impetus for the penetration of productive service industry into the manufacturing value chain. Secondly, the agglomeration of foreign productive service industries strengthens competition among local productive service providers, forcing them to explore new markets and businesses. This provides impetus for productive service providers to explore the market of small and medium-sized manufacturing enterprises that have not yet introduced productive services, develop personalized and customized services, and achieve a long tail effect of supply and demand matching between both parties. Manufacturing enterprises derive flexible manufacturing functions by introducing personalized and customized services, and continuously extend their production

processes to both ends of the value chain, promoting the penetration and restructuring of both value chains. Finally, the agglomeration of productive service industries will attract a large number of high-quality factors, cultivate intermediate product service markets, improve regional resource allocation efficiency, and regulate market order. Promote real-time trading of intermediate input services between manufacturing and productive service industries, reduce industry transaction costs and risks, and create a suitable environment for the integration of the value chain between manufacturing and productive service industries.

3.1.3 Innovation industry correlation model

The liberalization of service trade can also force manufacturing enterprises to innovate their own value activity correlation models, deepen their cooperation with productive service suppliers, and provide impetus for the integration of the M&P industries through knowledge spillovers and the emergence of new "product+service" demands. On the one hand, while liberalization of service trade brings advanced technology and management experience, it also forms a rich and mature service factor supply network and information transmission network through knowledge spillover, effectively reducing the cost of knowledge search for enterprises and accelerating the updating and iteration of new knowledge and products. This provides motivation for manufacturing enterprises to search for and apply new knowledge through cooperation with productive service providers. On the other hand, new products formed by the entry of high-end and refined productive services from outside and their association with the manufacturing industry will inevitably have an impact on traditional products, leading to new demands for "product+service". To meet market demand, manufacturing enterprises need to embed specialized productive services as intermediate inputs into their own value chains, and continuously extend their industrial chains outward, transforming their products into a "product+service" model. In this process, manufacturing enterprises upstream and downstream of the value chain need to search, negotiate, and connect with various productive service suppliers, promoting the restructuring and integration of the manufacturing and productive service value chains. Based on the above analysis, this article proposes the following assumptions:

Hypothesis 1: Liberalization of service trade has a positive promoting effect on the integration of the M&P industries.

3.2 The Regulatory Effect of the Digital Economy

The digital economy can promote the decomposition, aggregation, and restructuring of the value chain between manufacturing and productive service industries through ubiquitous connectivity and penetration, becoming a key force in coordinating resource allocation, reconstructing value creation, and promoting the integration of the M&P industries.

Firstly, the digital economy can promote innovation and upgrading of productive service industries, reduce transaction costs, continuously expand the relative cost gap between manufacturing and productive service industries in the same productive service links, and strengthen the division of labor effect brought about by service trade liberalization. On the one hand, the digital economy uses data information, digital technology, and digital ecology as input factors to drive industrial upgrading, replacing the input factors of productive services themselves, and promoting technological innovation and upgrading in the productive service industry. For example, with the support of data resources and digital ecology, the digital economy can further expand the scope and accessibility of financial services, and improve the inclusiveness of financial services. Information communication, warehousing and transportation, wholesale and retail and other services are constantly upgrading towards digitization and intelligence, giving rise to emerging service forms such as instant messaging, intelligent logistics, and e-commerce, forming an efficient and low-cost digital service system. On the other hand, while liberalization of service trade refines the division of labor between manufacturing and productive services, it also brings about an increase in transaction costs and hinders the division of labor between industries. However, the digital economy can create a digital ecosystem and reduce information costs, enabling businesses to complete transactions with low cost and high efficiency. The unique information technology and digital platforms of the digital economy enable production service providers and manufacturers to achieve instantaneous and precise matching of supply and demand in cooperation, reduce intermediate links in inter industry trade, improve the frequency and efficiency of interaction between production service industry and manufacturing enterprises, and thereby expand industry boundaries while reducing coordination and communication costs for enterprises, promoting the extension of production service industry to manufacturing industry, and creating conditions for the penetration and restructuring of the value chains of both parties.

Secondly, the digital economy can promote the transformation of productive service industries from geographical agglomeration to online agglomeration with wider coverage, strengthen the agglomeration effect of service trade liberalization, and promote the integration of the M&P industries. The digital economy can give play to its advantages of rapid online interaction and integrated information platform to form a large-scale online agglomeration of manufacturing enterprises in the Internet space. Transforming the two industrial clusters from unilateral online clustering to bilateral online clustering, making the interaction between the two industrial clusters more efficient and precise, and creating a suitable environment for the integration of the value chains of the M&P industries. Firstly, the rapid development of digital technologies represented by 5G, artificial intelligence, cloud computing, and the Internet of Things continues to reduce transaction costs between enterprises. Among them, the productive service industry is currently the most thoroughly transformed industry by digital technology. Under the influence of the digital economy, the transaction costs of many productive services are almost zero, causing productive service providers to shift from traditional geographical clustering to online clustering, forming industrial clusters with wider coverage, more participating entities, and stronger derivative effects. In addition, unlike productive service industries, manufacturing

enterprises are more sensitive to land costs, so more manufacturing industries tend to cluster in small and medium-sized cities with lower land costs. With the support of digital twin, intelligent supply chain management, industrial Internet and other digital technologies and digital ecology, the manufacturing industry is becoming more and more digital, intelligent and collaborative. Enterprises located in different geographical locations can digitize their manufacturing processes online, achieving online production and clustering throughout the entire manufacturing process. When both manufacturing and productive service industries have achieved online clustering, the expression of demands for products and services between manufacturing enterprises and productive service suppliers becomes more precise, gradually forming an industrial ecosystem of collaborative and integrated development between manufacturing and productive service enterprises, creating a suitable environment for the penetration of productive service industries into the manufacturing value chain.

Thirdly, the digital economy can also promote manufacturing enterprises to innovate their own value activity correlation models, deepen their cooperation with productive service providers, and promote the integration of the M&P industries by improving enterprise management efficiency, resource allocation efficiency, and nurturing new industrial organizational forms. On the one hand, the digital economy can improve enterprise management efficiency and resource allocation efficiency by reducing internal communication and information acquisition costs, driving organizational change, and improving the predictive ability of managers. The improvement of enterprise management efficiency can help enterprises adjust their development strategies according to market conditions and enhance the service orientation of enterprise decision-making. The improvement of resource allocation efficiency can effectively reduce the cost of factor flow required for the integration of the M&P industries, forming a market environment conducive to the deep integration of the M&P industries. On the other hand, the digital economy has penetrated into various industries, gradually weakening and eliminating industry attributes and barriers, allowing different types of enterprises to coexist in the same industry ecosystem, nurturing new forms of industrial organization: in the digital economy era, modern industrial organization forms are developing towards an industry ecosystem dominated by flat enterprises. Platform based enterprises leverage their advantages of integrating resources and gathering enterprises to promote precise and efficient connections between industries. As a module supplier, manufacturing enterprises are committed to being specialized, refined, unique, and innovative at a certain stage of the value chain, integrating into the platform with core capabilities. And continuously divest non core businesses, outsourcing production services in its own production process to specialized suppliers. In this form of industrial organization, the productive service industry penetrates into the manufacturing value chain from various links such as pre production, during production, and post production, providing comprehensive support for technical consultation, product approval, process optimization, and marketing services, promoting deep integration between manufacturing and productive service industries. Therefore, this article proposes the following assumptions:

Hypothesis 2: The digital economy can enhance the promoting effect of service trade liberalization on the integration of the M&P industries.

4 ECONOMETRIC MODELS

4.1 Model Settings

To study the impact of service trade liberalization on the integration of the M&P industries, this article sets the following econometric model:

$$Com_{ijt} = \beta_0 + \beta_1 lnser_{ijt} + \sum \beta Controls_{ijt} + \eta_i + \lambda_t + \mu_j + \varepsilon_{ijt} \quad (1)$$

Among them, Com_{ijt} represents the integration of "M&P industries"; $lnser_{ijt}$ represents the openness of the productive service industry at the industry level; $Controls_{ijt}$ represents a series of control variables; i represents the country or region, j represents the manufacturing industry, t represents the year, η_i represents the country's fixed effect, μ_j represents the industry's fixed effect, λ_t represents the time fixed effect, which are used to control the country differences, industry characteristics, and time trends of the country or region, respectively. ε_{ijt} represents the stochastic disturbance term. The detailed calculations for each variable can be found in the following text.

To study the regulatory role of the digital economy in promoting the integration of the M&P industries through service trade liberalization, the benchmark regression model is extended to:

$$Com_{ijt} = \beta_0 + \beta_1 lnser_{ijt} + \beta_2 dige_{it} + \beta_3 lnser_{ijt} * dige_{it} + \sum \beta Controls_{ijt} + \eta_i + \lambda_t + \mu_j + \varepsilon_{ijt} \quad (2)$$

Among them, $dige_{it}$ represents the overall level of digital economy development in a country, and the definitions of other variables are consistent with the benchmark regression model.

4.2 Variable Construction

4.2.1 Dependent variable

The dependent variable of this article is the integration of manufacturing and productive services. Using input-output data, the comprehensive integration degree is calculated based on the one-way integration degree of manufacturing and productive services in the sample country. The specific calculation method is as follows:

(1) Unidirectional Integration Degree: In the unidirectional integration degree, GX_{j1} and GX_{j2} represent the proportion of productive service industry and manufacturing industry as intermediate products invested in manufacturing and productive service industry, respectively. This reflects the degree of integration and infiltration between the two. The

specific formula for these two indicators is:

$$GX_{j1} = \frac{\sum_{s=1}^{5} y_{s*j}}{Y_j} (j \in [1,18]; s \in [1,5]) \quad (3)$$

Among them, j represents the classification of the manufacturing industry, and i represents the classification of the productive service industry. This calculation result represents the proportion of productive service industry as intermediate input to the total input of manufacturing industry.

$$GX_{j2} = \frac{\sum_{s=1}^{5} y_{j*s}}{Y_s} (s \in [1,5]; j \in [1,18]) \quad (4)$$

The meanings of i and j are consistent with equation (3), which represents the proportion of manufacturing as an intermediate input to the total input of productive services.

(2) Comprehensive fusion degree: The comprehensive fusion degree Com_{ijt} is calculated based on the unidirectional fusion degree, and the specific formula is as follows:

$$Com_{ijt} = \frac{GX_{itj1}}{GX_{itj2}} \quad (5)$$

The comprehensive integration degree reflects the degree of bi-directional integration of industries at the industry level in a country, specifically defined as the ratio of the contribution of productive service industries to the contribution of manufacturing industries. The larger the indicator, the higher the degree of mutual penetration between the value chains of manufacturing and productive service industries. To increase the robustness of empirical results, this article uses standardized one-way fusion degree as the dependent variable in benchmark regression, and standardized comprehensive fusion degree as a substitute variable for the dependent variable in robustness testing.

4.2.2 Core explanatory variable

This article measures the degree of impact of service trade liberalization on the manufacturing industry by measuring the penetration rate of service openness, that is, the penetration rate of service trade on the manufacturing industry's sub sectors:

$$lnser_{isjt} = \ln \left(\sum_s service_{isjt} \times imports_{ist} \right) \quad (6)$$

Among them, i represents the country, t represents time, j represents 24 manufacturing industries, and s represents five service sectors. Among them, the five service departments are wholesale and retail, warehousing and transportation, information and communication, finance and insurance, and patent technology services. $imports_{ist}$ represents the import volume of various service sectors in a country, and $service_{isjt}$ represents the input coefficient of productive services in various manufacturing industries in country i. The academic community generally uses the complete consumption coefficient to calculate, which represents the sum of direct and indirect consumption of productive services by manufacturing industry j. The specific calculation formula is as follows:

$$service_{sj} = \alpha_{sj} + \sum_{m=1}^{n} a_{sm}\alpha_{mj} + \sum_{m=1}^{n}\sum_{k=1}^{n} a_{sk}\alpha_{km}\alpha_{mj} + \ldots \quad (7)$$

α_{sj} is the direct consumption of J manufacturing industry towards S service department, $\sum_{m=1}^{n} a_{sm}\alpha_{mj}$ is the second round of indirect consumption of J manufacturing industry towards S department through M department, $\sum_{m=1}^{n}\sum_{k=1}^{n} a_{sk}\alpha_{km}\alpha_{mj}$ is the third round of indirect consumption, and so on.

4.2.3 Moderating variable

The moderating variable in this article is the level of development of the digital economy. This article constructs a national level evaluation index system based on the "Statistical Classification of Digital Economy and Its Core Industries (2021)" released by the National Bureau of Statistics, from three aspects: digital industrialization, industrial digitization, and digital infrastructure. The principal component analysis method is used to reduce dimensions and obtain comprehensive indicators of the development level of digital economy in each country. The development level of digital economy in 68 countries, including sample countries, is evaluated. The specific indicator selection is shown in Table 1:

Table 1 Construction of Digital Economy Development Level Indicators

Primary indicators	Secondary indicators	data sources
Digital infrastructure	Fixed broadband penetration rate	WDI
	Fixed line telephone penetration rate	WDI
	Mobile network coverage	WDI
	Number of secure servers/million people	WDI
Industrial digitization	The government promotes the level of domestic ICT application	WEF
	Enterprise Internet application level	WEF
	The Impact of Digital Economy on Local Business Models	WEF
	The Impact of Digital Economy on Local Organizational Models	WEF
	The Impact of Digital Economy on Local Basic Services	WEF
Digital industrialization	The share of ICT information and communication service exports in total service exports	UNCTAD
	The share of ICT product exports in total product exports	UNCTAD

Among them, digital industrialization refers to the development level of the digital sector that produces digital

technology products or provides digital technology services. The products and services of these digital sectors are the foundation for the role of digital technology in economic and social operations. Therefore, this article selects the share of ICT information and communication service exports in the total service exports and the share of ICT product exports in the total product exports to measure a country's digital industrialization process. Industrial digitization refers to the degree of penetration of digital technology and digital ecology into various socio-economic activities such as production and consumption. Therefore, this paper selects the level of domestic ICT application promoted by a government, the level of enterprise Internet application, and the impact of digital economy on local business models, organizational models, and basic services to quantify the process of industrial digitalization in a country. Adding four indicators to measure the infrastructure of the digital economy, a total of 13 secondary indicators were selected for standardization. Three principal components with eigenvalues greater than 1 and reflecting 87% of the data information were calculated using Stata software. The comprehensive evaluation index for the development level of the digital economy was calculated using variance contribution rate as a weighted weight, denoted as $dige_{it}$.

4.2.4 Control variables

The control variables used in this article include national and industry levels. The national level control variables include: Gross Domestic Product (lnGDP), Population Size (lnpopulation), Per Capita Gross Domestic Product (lnperGDP), Industrial Value Added to GDP (invalue a), Medium and High tech Enterprise Value Added to Industrial Value Added (mahvalue), and R&D Investment to GDP (ri). Among them, the gross domestic product, population size, and per capita gross national product are logarithmically processed. Industry level control variables include industry added value (lnsva), represented by the added value of each industry in a country. Forward GVC Participation (GVCPF) is expressed as the share of added value from value chain activities in the final product produced by a certain industry in a country. Backward GVC Participation (GVCPD) is expressed as the share of added value created by a certain industry in a country for value chain activities. The Industry Explicit Comparative Advantage Index (RCA) is expressed as the ratio of the share of a certain industry in a country's exports to the share of that industry in the total world trade. Industry size (lnfpv), expressed as the total final product value of a certain industry in a country. The upstream degree of the value chain (lnup) is expressed as the distance from product production to final demand in a certain industry in a country, and is logarithmic. Downstream degree of the value chain, expressed as the average number of production stages included in a country's industry products.

4.3 Data Source and Sample Description

The fusion data of the M&P industries used in this article, the direct consumption coefficient and the complete consumption coefficient, are sourced from the 2016 World Input Output Database (WIOD). This database contains input-output data from countries around the world from 2000 to 2014. In addition, the service trade data used in this article to calculate the liberalization of service trade is sourced from the United Nations Trade and Development Database (UNCTAD Statistics). The country level control variables in the control variables are sourced from the World Development Indicators Database (WDI) of the World Bank, and the industry level control variables are sourced from the UIBE-GVC indicator system database of the University of International Business and Economics. The sources of secondary indicators used to measure the development level of the digital economy are detailed in Table 1.

Considering the statistical caliber and years of explanatory and moderating variables, this article selects input-output data from 29 countries, including China, from 2007 to 2014 as the econometric sample. In terms of industry statistics and classification, based on existing literature research, 18 industries including C5-C22 are considered as manufacturing industries, and C28-C35, C37-C43, and C45-C49 are used as productive service industries to calculate the degree of integration between a country's manufacturing and productive service industries.

5 REGRESSION RESULT ANALYSIS

5.1 Basic Regression Results

According to column (1) of Table 2, the coefficient before service trade liberalization is significantly positive at the 1% significance level, indicating that service trade liberalization has a significant positive promoting effect on the integration of the M&P industries. As can be seen from column (3), this conclusion still holds even after adding control variables. Once again, it has been verified that liberalization of trade in services is conducive to the integration of the M&P industries, and hypothesis 1 has been confirmed. To test hypothesis 2 in theoretical analysis, this article uses econometric model (2) for regression analysis. According to column (2) of Table 2, the coefficient before the interaction term between service trade liberalization and the level of digital economy development is significantly positive at the 1% significance level, indicating that the digital economy enhances the positive promotion effect of service trade liberalization on the integration of the M&P industries. Hypothesis 2 is confirmed.

Table 2 Basic regression results

Variables	(1)	(2)	(3)	(4)
lnser	5.090***	8.185***	4.546***	7.946***
	(13.99)	(16.33)	(13.54)	(16.75)
dige		-7.118***		-3.522***
		(-7.981)		(-4.231)

lnser*dige		0.500*** (7.868)		0.219*** (3.825)
controling variables	NO	NO	YES	YES
Industry fixed effects	YES	YES	YES	YES
Country fixed effects	YES	YES	YES	YES
Time fixed effect	YES	YES	YES	YES
N	3132	3001	3132	3001
R2	0.725	0.791	0.728	0.791

5.2 Endogeneity Testing

There may be endogeneity issues of reverse causality in benchmark regression, and liberalization of service trade can promote the integration of the M&P industries. On the contrary, the higher the degree of integration between the M&P industries in a country, the more likely it is to increase its demand for high-quality productive foreign services, thereby promoting the liberalization of service trade. To eliminate endogeneity, this article uses the first-order and second-order lag values of service trade liberalization as instrumental variables to perform two-stage least squares estimation on the original model, and the results are listed in Table 3. The first and second columns represent the results of re estimation using the first-order lag value of service trade liberalization as instrumental variables, while the third and fourth columns represent the results of re estimation using the second-order lag value of service trade liberalization as instrumental variables. Based on all the results in Table 3, regardless of which instrumental variable is used, liberalization of service trade still has a significant positive promoting effect on the integration of the M&P industries, while the digital economy expands this promoting effect. Meanwhile, the endogeneity test results rejected the hypothesis of weak instrumental variables and identification of instrumental variables, indicating that the core conclusion of this article has not changed.

Table 3 Endogeneity test results

Variables	(1)	(2)	(3)	(4)
	Lagged first-order		Lagged second-order	
lnser	8.304*** (15.02)	8.042*** (15.47)	8.246*** (13.89)	7.897*** (14.03)
dige		-3.388*** (-4.185)		-3.522*** (-4.334)
lnser*dige		0.210*** (3.82)		0.219*** (4.027)
controling variables	YES	YES	YES	YES
Kp rk Wald F	2513.999***	3819.652***	210.185***	178.693***
Kp rk Wald LM	12.995***	13.853***	13.020***	13.750***
Industry fixed effects	YES	YES	YES	YES
Country fixed effects	YES	YES	YES	YES
Time fixed effect	YES	YES	YES	YES
N	3001	3001	3001	3001

5.3 Robustness Test

To further test the robustness of the regression results, this article uses multiple robustness testing methods to test the core conclusions of this article. Firstly, considering that the liberalization of trade in services has a certain time lag in its impact on the integration of the M&P industries, the core explanatory variables were introduced into the benchmark model after lagging for one and two periods respectively, and re estimated. The regression results of the core explanatory variables lagging for one and two periods are shown in columns (1) - (4) of Table 4. Secondly, the replacement variables of the core variables were selected for robustness testing. The regression results of the integration calculation method for the replacement manufacturing and productive service industries are presented in columns (5) and (6) of Table 4. Thirdly, add an interaction term between the fixed effects of country x time and industry x time, and strengthen the constraint of fixed effects. To further examine the impact of other unmeasurable factors on the regression results and avoid endogeneity and heteroscedasticity caused by improper selection of control variables, the test results are listed in columns (7) and (8) of Table 4.

Table 4 Robustness Test Results

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Lagged first-order regression		Lagged second-order regression		Replace the dependent variable		Increase the constraint on fixed items	
lnser	7.891*** (17.17)	7.768*** (17.17)	4.821***(8.28)	4.395*** (7.84)	0.125*** (3.29)	0.104** (2.25)	8.221*** (16.58)	7.957*** (16.59)
dige		-1.750**		-5.826***(7.41)		-		-2.026**(2.54)

		(-2.37)				0.000457 (-0.0061)		
lnser*dige		0.104** (2.59)		0.465***(9.63)		0.010* (1.817)		0.251*** (4.31)
controling variables	YES	YES	YES	YES	YES	YES	YES	YES
Industry fixed effects	YES	YES	YES	YES	YES	YES	YES	YES
National fixed effects	YES	YES	YES	YES	YES	YES	YES	YES
Time fixed effect	YES	YES	YES	YES	YES	YES	YES	YES
Time # Country	NO	NO	NO	NO	NO	NO	YES	YES
Time # Industry	NO	NO	NO	NO	NO	NO	YES	YES
N	3001	3001	3001	3001	3002	3002	3001	3001
R^2	0.781	0.781	0.747	0.749	0.551	0.553	0.787	0.787

5.4 Heterogeneity Test

Considering the differential impact of trade liberalization in different service sectors on the integration of the M&P industries, this article divides the main service sectors into five categories: wholesale and retail services, warehousing and transportation services, information and communication services, financial and insurance services, and patent technology services. According to columns (1) - (5) of Table 5, it can be seen that trade liberalization in the five types of service sectors has a significant promoting effect on the integration of the M&P industries, and the digital economy can enhance the promoting effect of trade liberalization in these five types of services. From the perspective of core explanatory variable coefficients, the coefficients before the liberalization of trade in warehousing and transportation services and financial insurance services are relatively large, which has a stronger positive promoting effect on the integration of the M&P industries. This may be because manufacturing enterprises need to first utilize intelligent production lines and intelligent logistics systems to improve their supply chain efficiency during transformation and upgrading. Therefore, manufacturing enterprises have a stronger demand for warehousing and transportation services, and external specialized and intelligent warehousing and transportation services have a stronger positive promoting effect on the integration of the M&P industries. In addition, the introduction of foreign financial services through the liberalization of financial and insurance service trade can effectively reduce the financing costs and risk coefficients of manufacturing enterprises, provide impetus for manufacturing enterprises to innovate their own industry related models, transform to the "product+service" model, and promote the integration of the "M&P industries".

Table 5 Heterogeneity analysis and expansion analysis results

	(1)	(2)	(3)	(4)	(5)	(6)
Variables	Wholesale and retail services	warehousing and transportation services	information and communication services	financial insurance services	patent technology services	non-linear regulatory effects
lnser	0.262*** (13.78)	1.251*** (5.989)	0.952*** (11.88)	1.163*** (6.148)	0.876*** (8.255)	8.644*** (16.63)
dige	0.116 (1.71)	-0.408*** (-3.061)	-0.970*** (-5.152)	-0.123 (-1.574)	-0.509*** (-3.868)	9.225*** (6.43)
lnser*dige	0.0326*** (3.61)	0.0141** (2.37)	0.0778*** (3.946)	0.0397*** (5.017)	0.0284** (2.113)	0.665** (2.19)
digesq						-3.479*** (-9.21)
lnser*digesq						0.378*** (9.44)
controling variables	YES	YES	YES	YES	YES	YES
Industry fixed effects	YES	YES	YES	YES	YES	YES
National fixed effects	YES	YES	YES	YES	YES	YES
Time fixed effect	YES	YES	YES	YES	YES	YES
N	3001	3001	3001	3001	3001	3001

R2	0.738	0.766	0.635	0.628	0.735	0.788

On the other hand, from the perspective of the interaction coefficient size, the digital economy has a stronger positive regulatory effect on the liberalization of wholesale and retail, information and communication, and financial and insurance service trade. The reason may be that the digital economy is more in line with the input factors, business models, and ecology of these service industries, making it easier to promote technological innovation and upgrading. With the support of digital technology and digital ecology, wholesale and retail services have shifted from traditional negotiation, payment, and delivery to e-commerce centered on digital platforms. Information and communication services have derived functions such as instant messaging and digital twins in the digital ecosystem, which have a stronger innovative effect on the production processes and associated models of manufacturing enterprises. With the support of big data, cloud computing and other technologies, financial and insurance services have further expanded their service scope and reach capabilities, enhancing the inclusiveness of their services. In the context of the digital economy, the productive service industry is increasingly developing towards digitization and intelligence, presenting characteristics of high efficiency, high quality, and high efficiency, adding impetus for manufacturing enterprises to replace their original value chains with specialized productive services.

5.5 Expansion Analysis: Nonlinear Regulatory Effects of Digital Economy

Considering the network externalities of the digital economy, that is, with the development of the digital economy, the marginal cost of collaboration among various departments in the digital ecosystem continues to decrease, showing a non-linear characteristic of increasing marginal benefits. We speculate that the regulatory effect of the digital economy on the integration of the M&P industries may also have non-linear characteristics. This article introduces the quadratic term $dige\_sq_{it}$ of the development level of the digital economy and the cross term $lnser_{ijt} * dige\_sq_{it}$ it with the openness of the productive service industry into model (2). Construct the following model (8) to test the nonlinear regulatory effect of the digital economy, and present the results in column (6) of Table 5.

$$Com_{ijt} = \beta_0 + \beta_1 lnser_{ijt} + \beta_2 dige_{it} + \beta_3 lnser_{ijt} * dige_{it} + \beta_4 dige\_sq_{it} + \beta_5 lnser_{ijt} * dige\_sq_{it} + \sum \beta Controls_{ijt} + \eta_i + \lambda_t + \mu_j + \varepsilon_{ijt} \quad (8)$$

The results showed that after introducing the quadratic term of the development level of the digital economy, the coefficients of its first and second terms and the cross terms $lnser_{ijt} * dige_{it}$, $\beta_5 lnser_{ijt} * dige\_sq_{it}$ of service trade liberalization were significantly positive at the 1% significance level. This indicates that the development level of the digital economy positively and nonlinearly regulates the relationship between service trade liberalization and the integration of the M&P industries. The higher the level of development of the digital economy, the stronger the marginal benefits of its positive regulatory effect, which is significantly manifested as a positive non-linear regulatory effect. With the widespread application of the digital economy in various fields of the economy and society, the number of manufacturing enterprises and productive service providers participating in it continues to increase, forming economies of scale. The marginal cost of linkage between various participating entities continues to decrease, resulting in a significant decrease in the cost of acquiring knowledge, information, and technology for these participating entities, and a geometric increase in the benefits they receive, promoting the integration of manufacturing and productive service industries. When the digital economy develops to a certain level and the number of participating entities exceeds a certain critical point, a positive feedback mechanism will be triggered, and its regulatory effect will show explosive growth, exhibiting positive nonlinear regulatory characteristics.

6 CONCLUSION

This article uses panel data from multinational industries from 2007 to 2014 to study the impact of service trade liberalization on the integration of the M&P industries, and analyzes the role of the digital economy in it. The research results indicate that firstly, the liberalization of service trade has a significant positive promoting effect on the integration of the M&P industries. Among them, the liberalization of trade in warehousing and transportation services, as well as financial and insurance festival services, has a stronger positive promoting effect on the integration of the M&P industries; Secondly, the digital economy strengthens the promoting effect of service trade liberalization on the integration of the M&P industries through positive regulatory effects. The above conclusion still holds after a series of robustness tests, including endogeneity testing of instrumental variables, replacement of the method of calculating the dependent variable, lagged treatment of core explanatory variables, and strengthening the constraint of fixed effects; Thirdly, the non-linear moderation effect test shows that the regulatory role of the digital economy in promoting the integration of the M&P industries through service trade liberalization also has non-linear characteristics. The higher the level of development of the digital economy, the stronger the marginal benefits of its positive moderation effect.

Based on the above research conclusions, this article proposes the following suggestions: Firstly, make high-level opening up of the service industry a top priority in building a new open economy system, and use it as a lever to promote the integration of the M&P industries and build a strong manufacturing country. According to the Service Trade Restriction Index released by the Organization for Economic Cooperation (OECD), as of 2021, the degree of openness in some industries in China has exceeded that of developing countries, but there is still significant room for improvement compared to developed countries represented by Europe and America. Faced with the increasingly complex international political and economic environment, China should actively promote international economic and

trade cooperation, establish more stable trade relations with trading partners, and leverage regional trade agreements such as RCEP to integrate into the global productive service network. By implementing high-level opening up to the outside world, allocating international high-quality service elements, enhancing the interaction and integration between manufacturing and productive service industries, we will provide impetus for China's transformation and upgrading from a "manufacturing powerhouse" to a "manufacturing powerhouse". Secondly, optimize the industry structure of service trade liberalization and formulate differentiated opening policies for different service industries. According to the previous conclusion, in the process of promoting the integration of the M&P industries, we can take the lead in promoting the liberalization of trade in warehousing and transportation services and financial and insurance services. By introducing high-level service elements, we can help manufacturing enterprises optimize their supply chain management, expand financing channels, and promote the integration of the M&P industries. At the same time, attention should also be paid to policy strength, and in combination with actual development situations, orderly and gradient open policies should be formulated for different service industries. Thirdly, we should attach importance to the role of the digital economy in the high-level opening up of the service industry to the outside world, increase investment in the construction of digital economy infrastructure, and vigorously promote the process of digital industrialization and industrial digitization. Improve the policy system for supporting the management of the digital economy, and refine regulatory mechanisms such as data security and network security. Provide policy support for the development of new industrial forms such as digital service trade, and leverage the empowering role of the digital economy in the integration of the M&P industries. To form a policy synergy with the liberalization of service trade and promote the integrated development of the M&P industries. Fourthly, we should fully utilize the network externalities of the digital economy. With the development of the digital economy, the marginal cost of interaction between various participating entities continues to decrease, and the benefits obtained from it increase geometrically. In the process of promoting the integration of the M&P industries, it is necessary to continuously promote the participation of manufacturing and service industry enterprises in the construction of the digital economy. The government should introduce relevant preferential policies to guide enterprises to adapt to the trend of digital development and transform their business processes and management models towards digitalization. At the same time, we should pay attention to building industry benchmarks and leading enterprises, and play a demonstrative and leading role. In addition, it is necessary to enhance the ecological support capacity of enterprises in the process of digital upgrading. Accelerate the construction of information platforms and guide enterprise participation to create a favorable environment for the integrated development of the M&P industries.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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