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The Impact and Mechanisms of the Digital Economy on Market Integration

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ABSTRACT

The digital economy is the current development trend. Promoting the construction of a unified large market is a major strategic decision of the new era in our country, and the two must be organically unified. This study constructed a digital economy development index system via the entropy weight method and measured market integration using the market segmentation index. Leveraging 2011–2022 provincial panel data, it empirically examined the impact of digital economy development on market integration and its mechanism. Results indicate that the digital economy significantly advances market integration by enhancing circulation efficiency and deepening the specialized division of labor. This effect is more prominent in Central and Northwestern China than in Eastern China. Findings offer empirical evidence and policy insights for empowering market integration through the digital economy.

KEYWORDS

digital economy, market integration, market segmentation, mechanism of action

INTRODUCTION

The Chinese government has long tirelessly worked to dismantle the tiao-kuai divisions of the planned economy, eliminate local protectionism and market segmentation, improve the efficiency of resource allocation, and promote market integration. Historical experience shows that establishing a unified national market and eliminating inter-regional trade barriers allows resources to flow to industries and regions with higher returns, thereby improving the nation's overall economic efficiency and its citizens' welfare [1]. In 2022, the State Council issued the "Opinions of the CPC Central Committee and the State Council on Accelerating the Construction of a Unified National Market," elevating the comprehensive promotion of a unified national market to a position of overall strategic importance. Under the new development pattern of dual circulation,

China's economic growth will rely more on productivity gains from optimal spatial factor allocation. Building a unified national market can fully unleash the potential of domestic demand, provide foundational support for the domestic economic cycle, deepen the industrial division of labor, and form new, quality productive forces, thereby achieving high-quality economic transformation and development [2,3].

With the rapid development and evolution of digital technologies such as artificial intelligence, the Internet of Things, and the industrial Internet, China's digital economy is flourishing. It has gradually become a new engine for socio-economic development. As an emerging economic form, the digital economy is pervasive, diffused, and rapid, and characterized by its external economies [4]. It fully unleashes the value of advanced production factors like data, information, and knowledge [5], bringing new opportunities for creating market integration. Scholars have conducted in-depth theoretical and empirical research on the relationship between the digital economy and market integration, identifying several main impact pathways. First, the digital economy has transformed the traditional circulation system of trade. Applying digital technology reduces the economy’s dependence on time and space, weakening the restrictions on inter-regional trade caused by factors such as geographic distances, cultural differences, and administrative divisions. This greatly reduces transaction costs and information barriers, accelerates knowledge and technology circulation, and facilitates the precise matching and efficient circulation of production factors, thus contributing to market integration[6,7]. Second, the deep integration of the digital economy and the real economy fosters new business formats and models; it reshapes inter-regional labor division and enhances technological innovation’s efficiency. This significantly advances market integration and the domestic economic cycle [8,9]. Third, developing the digital economy can effectively mitigate information asymmetry, reduce enterprise relocation costs, and make it more challenging to implement local protectionism. It also enhances the transparency of government actions and regulatory effectiveness, promoting fair market competition [10,11]. Thus, the digital economy’s enabling effect has become a crucial dimension to consider in building market integration. An in-depth study of the impact and internal mechanisms of digital economy development on domestic market integration holds significant theoretical and practical importance.

This study therefore employs the entropy weight method to construct an indicator system measuring digital economy’s development level. Based on provincial panel data from 2011 to 2022, we employ a market segmentation index to assess the degree of market integration, empirically examining the impact and mechanisms of digital economy development on market integration. The potential marginal contributions of this

study are twofold. First, it shows how the digital economy affects market integration, specifically by enhancing circulation efficiency and deepening the professional division of labor. This helps to clarify how to effectively unleash digital economy as a driver of market integration, serving as a valuable supplement to existing research. Second, it focuses on the differential impacts of digital economic development across various regions and industries. This provides a decision-making reference for formulating differentiated regional development policies and offers insights for China on empowering market integration through digital economy development to achieve high-quality economic transformation under the new development pattern.

THEORETICAL ANALYSIS AND HYPOTHESIS

In the Digital China initiative context, the digital economy, as the core driving force of the new wave of technological revolution and industrial transformation, has become a key engine for advancing market integration. As the digital economy continues to scale and its influence grows, research on its impact on market integration has progressively expanded.

On the one hand, ample studies confirm that the digital economy significantly advances market integration by enhancing circulation efficiency. Its rapid development has reshaped commodity circulation, mitigating time, space, and logistics information constraints on market efficiency, with tangible impacts on brick-and-mortar retail and marketing operations. Circulation efficiency hinges on two core factors: time and costs. For circulation time, big data, 5G, and other digital technologies streamline information sharing among manufacturers, suppliers, and distributors—supporting the formation of an integrated e-commerce-logistics intelligent network that boosts factor-matching efficiency and shortens circulation cycles [12,13]. For costs, digital mobile payments improve transaction convenience, cutting expenses related to bank trips, cross-border withdrawal fees, and cash theft [14]; meanwhile, tiered distribution networks (e.g., IXDs, EFCs, sorting centers) and optimally located facilities (determined by digital analysis of market areas, land density, and delivery times) reduce marginal transportation costs [15]. Overall, the digital economy drives online-offline integration, enhances cross-channel cooperation, and lowers market segmentation, thereby smoothing the domestic economic cycle and accelerating a unified domestic market [16].

On the other hand, digital economic development fosters inter-regional professional division of labor, further propelling market integration. Per new classical economics, division of labor depth depends on the trade-off between transaction costs and division benefits. Regarding benefits, the digital economy's versatility, openness, and low-cost interactions enable firms to capture diversified users' long-tail demand, producing

personalized niche goods/services for profit; additionally, digitally skilled labor and firms gain productivity advantages, adjusting division of labor to secure commensurate compensation [17,18]. In industrial structure, the digital economy transforms traditional models by enabling cross-regional flow of commodities, factors, and resources. Its deep integration with the real economy expands industrial chain length, breadth, and depth —creating jobs and stimulating innovation-driven entrepreneurship [19]. By reducing relocation costs and information asymmetry, it encourages firm migration from central to peripheral cities, strengthening regional ties and overcoming geographic market segmentation [20,21,22,23]. Demand-side-wise, the digital economy spurs region-agnostic new consumption/investment (e.g., online education, healthcare, finance), enabling national unified pricing that stimulates domestic demand, lowers entry barriers, and advances market integration.

Based on the preceding analysis, we propose the following hypotheses:

Hypothesis 1: An increase in the level of the digital economy significantly enhances the level of market integration.

Hypothesis 2: The digital economy promotes market integration by weakening the spatiotemporal constraints on economic activities, thereby enhancing circulation efficiency.

Hypothesis 3: The digital economy advances market integration by deepening the professional division of labor and stimulating market vitality.

In summary, this paper outlines the mechanisms through which the digital economy influences the market integration process.

MODEL CONSTRUCTION AND VARIABLE SETTING

Model Construction

To test whether digital economy's development impacts market integration, this study constructs the following baseline regression model, controlling for time and individual fixed effects:

$$\ln Seg_{it} = \alpha_0 + \beta_0 \ln D_{it} + \lambda_0 \ln C_{it} + \mu_i + \mu_t + \varepsilon_0 \quad (1)$$

Where i denotes the province; t denotes the year; the dependent variable $\ln Seg_{it}$ denotes the market segmentation index of province i in year t ; $\ln D_{it}$ is the core explanatory variable, which denotes the digital economy development index of province i in year t ; $\ln C_{it}$ denotes the control variables of province i in year

t , including the degree of regional openness, human capital, the share of the state-owned economy, industrial structure, and infrastructure level; μ_i and μ_t denote the time fixed and regional fixed effects, respectively; and ε_0 denotes the random error term.

In addition to the direct effect shown in Equation (1), and based on the preceding theoretical analysis, we tested for the potential mechanisms through which the digital economy affects market integration. Specifically, whether circulation efficiency and the professional division of labor act as mediating variables was examined. The specific steps are as follows:

$$\ln Seg_{it} = \alpha_1 + \beta_1 \ln D_{it} + \lambda_1 \ln C_{it} + \mu_i + \mu_t + \varepsilon_1 \tag{2}$$

$$\ln Seg_{it} = \alpha_2 + \beta_2 \ln Z_{it} + \beta_3 \ln D_{it} + \lambda_2 \ln C_{it} + \mu_i + \mu_t + \varepsilon_3 \tag{3}$$

where Z_{it} represents the mediating variable, and all other variables are defined as in Equation (1).

Variable Specification

Market Segmentation Index

The literature primarily measures market integration using the trade flow, production, and price methods. Specifically: (1) The trade flow method, based on the analysis of inter-regional trade flows, reflects the degree of market integration by examining dynamic changes in bilateral trade intensity. Its core logic is that an increase in regional trade dependence implies a higher level of market integration. (2) The production method uses the convergence of regional productivity as its criterion, positing that a narrowing of inter-regional productivity differences signifies market convergence. (3) The relative price method's theoretical framework is built on two key economic theories: the law of one price and the iceberg of costs model. The law of one price reveals that in an ideal state of zero trade costs, market arbitrage mechanisms will cause inter-regional price differences to automatically converge. In contrast, the iceberg of costs model takes a more realistic approach, pointing out that the inevitable loss costs during commodity circulation cause regional price differences to fluctuate within a specific range. As trade costs decrease and market integration deepens, the amplitude of these price fluctuations will show a gradually narrowing trend.

The trade flow method is susceptible to interference from exogenous factors like changes in regional industrial structure, and the production method faces challenges in distinguishing between technological spillover effects and market integration effects. In contrast, the price method directly reflects the degree of integration

by observing market equilibrium outcomes (i.e., price convergence), giving it theoretical directness and empirical robustness. Therefore, following Lu Ming and Chen Zhao [24], this study adopts the price method to measure the degree of market integration.

The first step is to calculate the absolute value of the relative price. The relative price of goods or production factors between two provinces (municipalities or autonomous regions), denoted as ΔQ_{ij} , is calculated as follows:

$$\mid \Delta Q_{ijt}^{k} \mid = \mid \ln(\frac{p_{it}^{k}}{p_{it-1}^{k}}) - \ln(\frac{p_{jt}^{k}}{p_{it-1}^{k}}) \mid \tag{4}$$

where ΔQ_{ijt}^{k} represents relative prices; k represents commodities or factors of production $k = 1, 2, ..., m,$; i and j refer to provinces (cities and autonomous regions); $i = 1, 2, ..., n$ and P represent the month-on-month price index; and P_{it}^{k} P_{jt}^{k} represents price indices of k commodities or production factor in provinces (cities and autonomous regions) i and j , at time t .

As the degree of domestic market integration increases, ΔQ_{ij} will gradually decrease and approach zero. To eliminate the effect of positive and negative signs, the absolute value $\mid \Delta Q_{ij} \mid$ is taken. Since the price data are month-on-month, the price ratios are log-transformed and then first-differenced.

The second step is to eliminate commodity-specific fixed effects. In addition to being affected by the regional market conditions, market price volatility is also affected by the intrinsic characteristics of the commodities themselves, that is, by fixed effects. Equation (3) yields the relative price after eliminating fixed effects.

$$q_{ijt}^{k} = \mid \Delta Q_{ijt}^{k} \mid - \mid \Delta \overline{Q}_{t}^{k} \mid = \mid \Delta Q_{ijt}^{k} \mid - \frac{1}{n-1} \left| \sum_{j \neq i}^{n} \Delta Q_{ijt}^{k} \right| \tag{5}$$

where q_{ijt}^{k} represents the relative price, driven solely by market factors, for commodity between provinces i and j provinces in year.

In the third step, the market segmentation index is calculated. The variance of relative price changes $Var(q_{ijt}^{k})$ is calculated for q_{ijt}^{k} to represent the overall relative price between any two provinces in any given year. The market segmentation index ($\ln Seg$) for a single province (city or autonomous region) is obtained by

summing the variances of individual cities i , taking their arithmetic mean, and then applying the logarithm, as follows:

$$\ln Seg = \ln\left(\frac{1}{n-1}\sum_{j\neq i}^{n} Var(q_{ijt}^{k})\right) \tag{6}$$

A higher regional market segmentation index ($\ln Seg$) indicates weaker economic ties between provinces, signifying greater trade barriers and a lower level of market integration. Conversely, a lower index signifies a higher level of market integration.

Digital Economy Index

To comprehensively measure regional digital economy development, this study constructs a DE index from three hierarchical first-level dimensions, with 9 second-level indicators reflecting their core connotations: The Digital Infrastructure dimension (including long-distance optical cable density, broadband access ports per capita, mobile phone switching capacity per capita) measures the hardware foundation for DE, laying the groundwork for cross-regional data transmission and factor flow; the Digital Application dimension (including Internet penetration rate, mobile phone penetration rate, per capita express delivery volume, Peking University Digital Inclusive Financial Index) reflects the integration depth of digital technology with social and economic activities, directly reducing information asymmetry and transaction costs for cross-regional exchanges; the Digital Industrialization dimension (including the share of employment in digital industries and the share of digital industry revenue) represents the industrial support for DE, ensuring sustainable technical and talent guarantees for its role in promoting market integration. The entropy value method is used to calculate the development level of the digital economy (D). Before using the entropy method, in order to avoid the influence of the distribution of numerical values and dimensions on the weighting results, it is necessary to standardize the processing of all data. Given that all the indicators selected in this article are positive ones, the specific handling methods are as follows:

$$X_{ij} = \frac{x_{ij} - \min(x_{1j}, x_{2j}, ..., x_{nj})}{\max(x_{1j}, x_{2j}, ..., x_{nj}) - \min(x_{1j}, x_{2j}, ..., x_{nj})} \tag{7}$$

Among them, represents the values of the provincial indicators before standardization processing, and represents the values of the provincial indicators after standardizing all the

indicators, it is necessary to calculate the entropy value of each indicator and the corresponding weight. The specific formulas are shown in Equations (8) and (9) :

$$E_j = \ln \frac{1}{n} + \sum_{i=1}^{n} \left(\frac{X_{ij}}{\sum_{i=1}^{n} X_{ij}} \ln \frac{X_{ij}}{\sum_{i=1}^{n} X_{ij}} \right) \tag{8}$$

$$W_j = \frac{(1 - E_j)}{\sum_{j=1}^{m} (1 - E_j)} \tag{9}$$

Table 1. Indicator system for evaluating the development level of the digital economy.

Secondary indicator	Tertiary indicator	Calculation method	Indicator description
Digital infrastructure	Long-distance optical cable density	Optical cable length/land area	Investment in and construction of fiber optic infrastructure
Digital infrastructure	Broadband access ports per capita	Number of Internet broadband access ports/permanent population	Level of Internet access equipment construction
Digital infrastructure	Mobile phone switching capacity per capita	Mobile phone switching capacity/ permanent population	Level of mobile access equipment construction
Digital adoption	Internet penetration rate	Number of broadband users/permanent population	Level of Internet use
Digital adoption	Mobile phone penetration rate	Mobile phone users per 100 inhabitants	Level of mobile Internet usage
Digital adoption	Express delivery volume per capita	Express delivery volume/permanent population	Development of e-commerce
Digital adoption	Peking University Digital Inclusive Financial Index	Peking University Digital Inclusive Financial Index	Penetration of digital finance
Digital industrialization	Share of employment in digital industries	Proportion of employees in the information transmission, software, and information technology services industry	Size of the digital talent pool
Digital industrialization	Share of revenue from the digital industry	Ratio of telecom and software business revenue to regional GDP	Revenue-generating capacity of the digital industry
Digital industrialization	Main business revenue of other electronic manufacturing industries	Main business revenue of the computer, communications, and other electronic equipment manufacturing industry	Revenue-generating capacity of other electronic manufacturing industries

Control Variables

In order to analyze more accurately and reasonably the impact of the digital economy on the integration of the domestic market, it is also necessary to control the possible influencing factors of market integration. This paper selects the following indicators from relevant data such as economic, administrative and geographical

ones as control variables to ensure the scientificity and rationality of the model. (1) Industrial Structure: It is generally believed that regions with developed manufacturing industries export relatively more industrial products, and the volume of trade in goods with other regions is correspondingly larger. The ratio of the added value of the secondary industry to the GDP of each province is adopted to reflect the contribution of the secondary industry to the economy and the changes in the level of industrialization. Therefore, the control of the industrial structure in this paper may have an impact on the integration of the domestic market. (2) Human Capital (Humcap) : It is expressed as the ratio of postgraduate degrees to the total number of employed people. According to the human capital theory of Schultz [25] and Becker [26], education is the core way of human capital accumulation. As the core labor force of technology research and development and knowledge-intensive industries, the postgraduate group represents a higher level of skills and knowledge reserves. The higher its proportion, the more likely it is to promote the technology spillover effect of market integration. (3) Degree of regional openness (Open) : It is expressed by the volume of goods turnover. It reflects the transportation efficiency and market size of the logistics system, separating out the additional synergy brought by digital technology. Generally speaking, the higher the participation of a province in the domestic large circulation, the stronger the volume of commodity circulation. (4) Share of state-owned economy: It is expressed as the ratio of the total assets of state-controlled industrial enterprises to the total assets of industrial enterprises above designated size. This indicator reflects the degree of government intervention in the economy and can measure the impact of institutional factors on market integration, avoiding the attribution of administrative monopolies or political barriers to the level of digital economic development. (5) Infrastructure level: Represented by the density of the railway network, it reflects the degree of improvement of regional transportation infrastructure. It can measure the impact of traditional transportation networks on market integration and avoid attributing the improvement of logistics efficiency solely to the promoting effect of the digital economy. The names and codes, calculation methods or data sources of the explained variable, core explanatory variable and control variable are shown in Table 2. The descriptive statistical results of the variables used in this paper are shown in Table 3, including five aspects: sample size, mean, standard deviation, minimum value and maximum value.

Table 2. Description of main variables and descriptive statistics.

Variable category	Variable name and code	Variable definition
Dependent variable	Market segmentation index (lnSeg)	The market segmentation index is derived from the variance of inter-regional relative prices for 11 categories of retail goods with continuous data
Core explanatory variable	Digital economy development level (lnD)	Calculated using the entropy weight method; see Table 1 for the specific indicators
Control variables	Industrial structure (lnStructure)	Ratio of secondary industry value added to provincial GDP
Control variables	Human capital (lnHumcap)	Ratio of individuals with postgraduate degrees to the total employed population
Control variables	Degree of regional openness (lnOpen)	Freight turnover
Control variables	Infrastructure level (lnInfrastructure)	Railway network density
Control variables	Share of state-owned economy (lnShare)	Ratio of the total assets of state-controlled industrial enterprises to the total assets of industrial enterprises above a designated size

Table 3. Descriptive statistics of variables.

Variable name	Variable symbol	Sample size	Mean	Standard deviation	Minimum value	Maximum value
Market segmentation index (MSI)	lnSeg	348	0.00022	0.00015	0.000015	0.00113
Digital economy index	lnD	348	0.223	0.127	0.112	0.615
Industrial structure	lnStructure	348	0.411	0.075	0.159	0.619
Human capital	lnHumcap	348	9.330	0.914	7.513	12.681
Degree of regional openness	lnOpen	348	6121.037	6114.910	398.43	34074.6
Share of state-owned economy	lnShare	348	0.472	0.166	0.133	0.826
Infrastructure level	lnInfrastructure	348	2.891	2.207	0.259	11.504

Data Sources

The raw data for all variables were sourced from the National Bureau of Statistics, the China Statistical Yearbook (from previous years), the China City Statistical Yearbook, and the Peking University Digital Inclusive Finance Index. Missing values were imputed using the average of the preceding and succeeding periods or the average growth rate of the last five years. Data for Tibet, Hainan, Hong Kong, Macao, and Taiwan were excluded from the sample owing to an excessive amount of missing data. After data processing, the final research sample consists of panel data for 29 provinces, autonomous regions, and municipalities from 2011 to 2022, excluding the aforementioned regions, totaling 348 samples.

RESULTS ANALYSIS

Baseline Regression

First, this study conducted a Hausman test to assess the suitability of using a fixed effects model. Given the differences between provinces in economic development, natural conditions, and other factors, the fixed effects panel model controls for province-specific effects to improve the reliability of the estimated coefficients. Hence, a fixed effects panel econometric model is adopted.

A panel data analysis was conducted based on the variables and models specified in this study. Table 4 reports the baseline regression results for the impact of the digital economy on market integration. Columns (2)-(5) sequentially add controls for natural factors (infrastructure level) and institutional factors (degree of regional openness), and other influencing factors (human capital) and institutional factors (share of the state-owned economy), respectively. Column (6) presents the results after including the digital economy index and all control variables into the model, while controlling for both province and time fixed effects. The results show that in all six models, the estimated coefficients of the core explanatory variable ($\ln D$) are negative and statistically significant at the 1% level. This indicates that the market segmentation index decreases as the digital economy development index increases; that is, a higher level of digital economy development significantly reduces regional market segmentation.

Regarding economic significance, column (1) shows that each 1% increase in the level of digital economy development weakens the degree of market segmentation between provinces by about 0.471%. This suggests that digital economy development promotes market integration. In columns (2) to (7), this study gradually added control variables that may impact market integration. Evidently, the estimated coefficient of $\ln D$ is always negative and is significant across all specifications, confirming once again that the impact of the digital economy on market integration is robust. Even after including control variables, the level of digital economic development continues to have a strong and significant impact on market integration. Overall, these preliminary test results are consistent with the theoretical mechanisms and the prediction of Hypothesis 1.

Table 4. Baseline regression results

Variable	(1)	(2)	(3)	(4)	(5)	(6)
	lnSeg					
lnD	−0.471***	−0.327***	−0.281***	−0.348***	−0.387***	−0.337***
	(−8.80)	(−4.09)	(−3.40)	(−3.77)	(−3.90)	(−3.00)
lnInfrastructure		−0.218**	−0.228**	−0.277***	−0.281***	−0.276***
		(−2.41)	(−2.53)	(−2.92)	(−2.96)	(−2.91)
lnOpen			−0.270**	−0.272**	−0.243*	−0.256*
			(−2.03)	(−2.05)	(−1.80)	(−1.88)
lnHumcap				0.146	0.158*	0.185*
				(1.61)	(1.73)	(1.93)
lnShare					−0.470	−0.423
					(−1.08)	(−0.96)
lnStructure						0.463
						(0.95)
Constant term	−9.038***	−7.170***	−5.187***	−5.150***	−5.523***	−4.669***
	(−57.93)	(−9.08)	(−4.14)	(−4.12)	(−4.26)	(−2.96)
Province fixed effects	NO	YES	YES	YES	YES	YES
Time fixed effect	NO	YES	YES	YES	YES	YES
Sample size	348	348	348	348	348	348
R-squared	0.3366	0.3486	0.3570	0.3622	0.3646	0.3664

Robustness Tests

Substitution of Dependent Variables

This study uses the marketization index of each province as a substitute for the market segmentation index. The marketization index is a comprehensive indicator that quantifies the degree of development of a region's or country's market economy system, reflecting the relative strengths of the market mechanism versus government intervention in resource allocation. The data are derived from the China Marketization Index Report. There is a significant negative correlation between the marketization index and market segmentation. Therefore, if the digital economy index coefficient is positive in the new regression, it would confirm that the digital economy's development enhances marketization, which is equivalent to reducing market segmentation.

Table 5 shows the test results using substituted variables. Column (1) reports the model's results, including only the core explanatory variable while controlling for time fixed effects. Columns (2) and (3) report the model's results that include the digital economy index, infrastructure, and regional openness. Column (2) controls for time fixed effects only, while column (3) controls for both province and time fixed effects. Columns

(4) and (5) report the model's results that include the digital economy index along with all control variables. Column (4) controls only for province fixed effects, while column (5) controls only for time fixed effects.

Table 5. Robustness tests for substituted variables.

Variable	(1)	(2)	(3)	(4)	(5)
	lnSeg				
lnD	0.071***	0.043***	0.181***	0.093***	0.027***
	(0.016)	(0.016)	(0.013)	(0.036)	(0.016)
lnInfrastructure		0.241**	0.228**	0.277***	0.281***
		(−2.41)	(−2.53)	(−2.92)	(−2.96)
lnOpen		0.218**	0.270**	0.272**	0.243*
		(−2.03)	(−2.03)	(−2.05)	(−1.80)
lnHumcap				−0.146	−0.158*
				(1.61)	(1.73)
lnShare				−0.207	−0.470
				(0.037)	(0.022)
lnStructure				−0.457**	−0.146*
				(0.138)	(0.087)
Constant term	9.038***	7.170***	5.187***	5.150***	5.523***
	(−57.93)	(−9.08)	(−4.14)	(−4.12)	(−4.26)
Province fixed effects	NO	NO	YES	YES	NO
Time fixed effect	NO	YES	YES	NO	YES
Sample size	348	348	348	348	348
R-squared	0.3366	0.3486	0.3570	0.3622	0.3646

As Table 5 shows, the coefficients of the digital economy index in Columns (1) to (5) are all significantly positive at the 10% level or higher, indicating that an increase in digital economy development can significantly enhance regional marketization. In other words, the digital economy's development can contribute to forming a unified national market, suggesting that the baseline regression results are robust.

Addressing Endogeneity

The endogeneity issues that may exist between the development of the digital economy and the degree of market integration mainly stem from the following two aspects. First, there may be a two-way causal relationship between the two, that is, the development of market integration may in turn affect the improvement of its digital economy level. Secondly, due to data limitations, although benchmark regression introduces control variables that may affect market integration, there may still be various difficult-to-measure variables such as policy systems and cultural customs that could have an impact on market integration, that is, there

is a possibility of missing other variables. Therefore, considering the above two points comprehensively, this paper adopts the instrumental variable method for identification and estimation. Under the premise of strictly meeting the basic assumptions of exogeneity and correlation of instrumental variables, this paper constructs two groups of instrumental variables respectively based on geographical features and historical factors.

First, drawing on the instrumental variable construction method of Huang Qunhui et al. [27], this study chose the number of fixed-line telephones per 100 people and the number of post offices per 10,000 people in each province in 1984 as the first type of instrumental variable. The theoretical logic lies in the fact that the development and evolution of China's Internet infrastructure is highly correlated with the fixed-line telephone network. As a key carrier of the traditional communication network, the historical distribution of the postal system has influenced the development of the Internet and the digital economy. However, it has had no significant impact on market segmentation, thereby satisfying the exclusion restriction. The raw data on the number of fixed-line telephones per 100 people and the number of post offices per 10,000 people in each province in 1984 were obtained from the China City Statistical Yearbook. It should be noted in particular that since Chongqing was still under the jurisdiction of Sichuan Province in 1984, it needed to be reported separately to ensure the comparability of data before and after the administrative change. To align with the panel data structure of this study, the original method is further extended: the logarithmic forms of the two variables mentioned above are multiplied by the logarithm of each province’s fixed asset investment in the Internet. This yields time-varying instrumental variables, which are used to address the endogeneity problem.

Second, in order to mitigate the endogeneity bias, this study follows Zhao Jingmei et al. [28] by adopting the spherical distance from each provincial capital to Hangzhou as the second type of instrumental variable. On the one hand, given Hangzhou's role as a key hub of China's digital economy development (it is home to companies such as Alibaba), geographic proximity significantly reduces the cost of technological diffusion, enabling provinces closer to Hangzhou to enjoy more advanced digital economy infrastructure and development levels. This satisfies the instrumental variables’ relevance requirement. In contrast, geographic distance, as a historically established exogenous variable, is not correlated with the current market integration process, thus satisfying the exogeneity requirement.

Table 6. Endogeneity analysis.

Variable	(1)	(2)	(3)	(4)
	lnD	lnSeg	lnD	lnSeg
iv1	−8.993***			
	(3.29)			
iv2			−1.983***	
			(2.87)	
lnD		−0.289***		−0.989**
		(3.27)		(2.49)
Control variables	Controls	Controls	Controls	Controls
Province fixed effects	Controls	Controls	Controls	Controls
Time fixed effect	Controls	Controls	Controls	Controls
Kleibergen-Paap rk LM statistic	5.019 [0.0247]	2.687 [0.0734]		
Kleibergen-Paap rk Wald F statistic	17.198 {8.96}	16.364 {8.96}		
Sample size	348	348	348	348
R-squared	0.996	0.996	0.943	0.944

As shown by columns (1) and (3) in Table 6, both sets of instrumental variables (iv1 and iv2) are significantly correlated with the digital economy. Columns (2) and (4) indicate that, after controlling for endogeneity, the development of the digital economy still exerts a significant inhibiting effect on market segmentation. However, the magnitude of the effect varies depending on the instrumental variables. Regarding variable coefficients, those of the digital economy index are all negative at the 1% significance level, indicating that after the endogeneity problem has been dealt with, the baseline regression results still hold. In other words, developing the digital economy can alleviate regional market segmentation and promote the formation of a unified national market, further verifying Hypothesis 1.

Heterogeneity Tests

To more accurately examine the impact of the differences in the level of the digital economy on market integration in different regions, provinces are divided into four sub-samples according to their geographic location: Eastern, Central, Western, and Northeastern. As Table 7 shows, the coefficients of the core explanatory variable $\ln D$ for the Central, Western, and Northeastern regions are negative at the 1% significance level, indicating that in areas with lower levels of digital economy development, the mitigating effect on market segmentation is stronger. This may be because in such regions, improvements in digital infrastructure, reductions in trade costs, and the removal of information barriers play a more pronounced role in breaking down market segmentation. In contrast, the digital economy in the Eastern region is already at an advanced

level, and the marginal benefits of using digital technology to reduce the circulation costs of products, factors, and information are likely to diminish.

Table 7. Analysis results of regional heterogeneity.

	(1)	(2)	(3)	(4)
Region	Eastern region	Central region	Western region	Northeastern region
Variable	lnSeg	lnSeg	lnSeg	lnSeg
lnD	0.043	−1.891***	−0.237***	−1.726***
	(0.112)	(0.127)	(1.152)	(0.631)
Control variables	Controls	Controls	Controls	Controls
Model	Fixed effects	Fixed effects	Fixed effects	Fixed effects
Sample size	120	72	132	36
R-squared	0.631	1.000	0.998	0.998

Industrial Structural Heterogeneity

The advancement of industrial structure is a key measure of industrial upgrading. This study employs the ratio of the tertiary industry to the secondary industry as the indicator. This indicator can effectively capture the trend of China's economic structure shifting from being industry-oriented to service-oriented. This study takes the 0.25 quartile of industrial upgrading levels across provinces and classifies the samples into high-level and low-level industrial structures. This reveals the heterogeneous impact of China's digital economy on market integration under different levels of service industry transformation.

The regression results in Table 9 show that in the low-level industrial structure group, the coefficient of the digital economy is significantly negative, with an absolute value larger than the baseline regression, while the coefficient in the high-level group is not statistically significant. This difference may stem from the heterogeneous nature of the industries within the tertiary sector, such as those in non-tradable sectors, which include retail, real estate and public services. These industries are highly localized, and an increased share of these sectors would weaken the digital economy’s effect in reducing market segmentation. This suggests that provinces dominated by the manufacturing sector can better leverage digital economy development to effectively reduce market barriers, thereby accelerating their integration into constructing a unified national market.

Table 8. Industry heterogeneity analysis results.

	(1)	(2)
Industrial structure level	High-level	Low-level
Variable	lnSeg	lnSeg
lnD	−0.601	−12.90***
	(1.331)	(2.56)
Control variables	Controls	Controls
Province fixed effects	YES	YES
Time fixed effect	YES	YES
R-squared	0.509	0.699

Impact Mechanism Test

Existing studies show that the digital economy significantly promotes forming a unified national market. Building on this research, and in line with the above mechanism analysis, the level of the digital economy's development influences market integration by improving the circulation efficiency and deepening the professional division of labor. To measure circulation efficiency, this study uses the ratio of total retail sales of consumer goods to the number of employees in circulation enterprises at year-end, thereby measuring sales per capita as an indicator of the circulation efficiency level. The number of employees in circulation enterprises at year-end includes those employed in retail, wholesale, accommodation, and catering industries. All data was obtained from the official website of the National Bureau of Statistics of China.

To measure the deepening of the professional division of labor across provinces, this study follows the approach of Su Yi et al.[29] and applies the calculation of Equation (11). Data was obtained from the China Statistical Yearbook.

$$SPE_i = \sum_{j=1}^{n} \left| \frac{E_{ij}}{\sum_{j=1}^{n} E_{ij}} - \frac{\sum_{i=1}^{m} E_{ij}}{\sum_{j=1}^{n} \sum_{i=1}^{m} E_{ij}} \right| \tag{10}$$

where SPE_i represents the degree of professional division of labor in region i; E_{ij} represents the number of people employed in industry j within region i; m represents the total number of industries (there are three in this study, namely the primary, secondary, and tertiary sectors); and n represents the total number of regions (29 provinces). The larger the value of SPE_i , the greater the difference between the overall industrial structure of region i and the overall national structure, indicating a higher degree of professionalization.

This study uses the Bootstrap three-step method to assess the validity of the relationship between the explanatory and dependent variables, the explanatory and mediating variables, and the mediating and dependent variables. It thereby verifies the validity of the mediating effect and confirming the existence of the impact mechanism. Table 9 presents the test results.

Table 9. Impact mechanism test.

Pathway	Pathway 1		Pathway 2	
	lnD→Circ→lnSeg		lnD→Spe→lnSeg	
Variable	(1)	(2)	(3)	(4)
	Circ	lnSeg	Spe	lnSeg
lnD	0.022***	−0.003**	0.019***	−0.020**
	(0.050)	(0.020)	(0.011)	(0.083)
Circ		−0.004***		
		(0.002)		
Spe				−0.133***
				(0.016)
Control variables	Controls	Controls	Controls	Controls
Province fixed effects	YES	YES	YES	YES
Time fixed effect	YES	YES	YES	YES
R-squared	0.947	0.943	0.689	0.896

As Table 9 shows, in columns (1) and (2), the regression coefficient of the core explanatory variable $\ln D$ on the mediating variable Circ (circulation efficiency) is 0.022, which passes the 1% significance test. Meanwhile, the regression coefficients of $\ln D$ and Circ on the dependent variable $\ln Seg$ are significantly negative (-0.003*** and −0.004). This suggests that circulaton efciency has a signifcant mediatng efect between the level of digital economy development and market integraton. Improvements in the digital economy will likely enhance circulaton efciency and thereby reduce market segmentaton. Similarly, in columns (3) and (4), the regression coefcient of $\mathbf{ln}\ \boldsymbol{D}$ on Spe is signifcantly positve (0.019), while the regression coefficients of $\ln D$ and Spe on $\ln Seg$ are significantly negative (-0.020** and −0.133***). This indicates that professional division of labor has a significant mediating effect between the level of digital economy development and market integration. Accordingly, the greater the degree of professional division of labor across regions, the more pronounced the industrial differences among them. As a result, the incentive for regions to adopt local protectionist policies is reduced. This weakens regional administrative barriers and promotes market integration. Summing up the results of the mechanism tests, two pathways exist: “digital economy → circulation

efficiency → market integration" and "digital economy → professional division of labor → market integration." Thus, Hypotheses 2 and 3 of this study are validated.

CONCLUSIONS

Market integration underpins and is inherent to building the dual-circulation development pattern. Today's booming digital economy not only fuels high-quality economic transformation but also inspires new approaches to market integration. Using 2011–2022 provincial panel data, this paper explores the digital economy's impact and mechanism on market integration. The research findings are as follows: (1) The digital economy has promoted the formation of a unified national market. Even after using the instrumental variable method to address endogeneity issues, replacing variables, and handling outliers, the conclusion remains valid. (2) The results of mechanism tests show that the digital economy promotes the formation of a unified national market by enhancing circulation efficiency and deepening specialized division of labor. (3) The impact of digital economy development on different regions varies. Compared with the eastern region, the promoting effect of digital economy on market integration is more significant in the central and western regions. The research conclusion has certain policy implications: First, promote the deep integration of the digital economy and the real economy, and empower the construction of market integration with the development of the digital economy. The high-quality development of the digital economy not only provides new impetus for economic growth but also offers new ideas for the integrated construction of the market. The previous analysis indicates that the digital economy can enhance circulation efficiency, deepen specialized division of labor, and thereby promote the construction of market integration.

Author Contributions

Conceptualization – Tianxing Tang; methodology – Tianxing Tang; formal analysis – Tianxing Tang; investigation – Fei Wang; resources – Fei Wang; writing-original draft preparation – Tianxing Tang; writing-review and editing – Fei Wang; visualization – Tianxing Tang; supervision – Fei Wang. All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

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