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Original Paper

The Impact of E-commerce on the Upgrading of County-level Industrial Structure—From the Perspective of Export and Enterprise Expansion

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Abstract

This paper takes the "Comprehensive Demonstration Counties for E-commerce in Rural Areas" project as a quasi-natural experiment and empirically analyzes the impact and action mechanism of e-commerce on the transformation and upgrading of the county-level industrial structure through a multi-period DID model. The results show that during the pilot period of the project, e-commerce has significantly promoted the upgrading of the county-level industrial structure. This effect is more pronounced in county-level regions in the western part of China and is influenced by local network resources and agricultural development. Further mechanism analysis shows that e-commerce mainly affects the transformation and upgrading of industrial structure through channels such as expanding product exports and stimulating entrepreneurial vitality.

Keywords

E-commerce, Industrial Transformation, County-level Economy

1. Introduction

As the cornerstone of Chinese society, the county-level economy is an important unit supporting national development and a crucial part of building China's economic system in the new era. County areas in China account for approximately 90% of the country's total land area, with their population and GDP representing 52.4% and 38.5% of the national totals respectively. However, the per capita GDP of the permanent residents within the county-level scope only accounts for 73.5% of the national average level, and the overall development level of counties is still relatively low. At the same time, restricted

by conditions such as resource endowments and environmental factors, the development of different regions is uneven, and the gap between counties has been increasing year by year. In 2024, the number of counties with a GDP exceeding 10 billion yuan nationwide reached 62. In the border areas of China, there are still many counties and cities that have just shaken off poverty and are striving to move towards rural revitalization. How to bridge the economic gap between counties and cities, fully tap the development potential of counties, narrow the urban-rural gap, and accelerate rural revitalization has become an important issue at present.

Since 2014, China has vigorously implemented the comprehensive demonstration project of rural e-commerce for ten consecutive years, injecting strong impetus into the vigorous development of rural e-commerce and effectively promoting the process of rural modernization. Currently, the coverage of rural e-commerce demonstrations continues to expand and is gradually becoming an important emerging force in the development of the county-level economy.

The research topics on the impact of the development of e-commerce on the county-level economy mainly revolve around two aspects: farmers' income and consumption. On the one hand, e-commerce can effectively increase farmers' income through direct or indirect means such as reducing transaction costs, providing digital financial means, and developing the construction of logistics outlets (Couture et al., 2018;Tang et al., 2020;Tang et al., 2022; Zhou et al., 2023).On the other hand, while increasing farmers' income, e-commerce significantly promotes the consumption of farmers' households through channels such as providing convenient digital payment means, reducing consumption transaction costs, and enriching the opportunities for commodity selection (Ma et al., 2023; Wang et al., 2025). E-commerce helps rural families overcome problems such as information asymmetry in terms of prices and technologies (Jensen, 2007), barriers to logistics development (Couture et al., 2021), and spatial consumption inequality (Fan et al., 2018), reduces the living costs of rural families, effectively improves the welfare level of rural residents, narrows the urban-rural income gap, and promotes the economic growth of counties (Wang et al., 2023).

Although existing studies have explored the impact of the development of e-commerce on farmers' income and consumption from different angles, the deficiency lies in that most of the data they use are provincial or municipal-level data, or they study the impact of rural e-commerce on the financial environment of farmers' households from a microscopic perspective. The data used are also in the form of microscopic tracking surveys or questionnaires collected through household visits (Zeng et al., 2018), lacking a comprehensive discussion of the impact brought by rural e-commerce from the county-level perspective. In addition, from a macro perspective, although existing studies have discussed the impact of the development of e-commerce on rural industrial upgrading (Yi et al., 2021; Tan et al., 2022), the research objects are mostly limited to simple index descriptions such as the ratio of the secondary and tertiary industries, and there are few systematic and independent discussions on rural industrial structure upgrading from the perspectives of industrial structure and innovation incentives. Based on this, this article will use the comprehensive demonstration pilot of e-commerce entering rural areas that

started in 2014 as a quasi-natural experiment, further combine county-level data to study the impact of the development of e-commerce on rural industrial upgrading, and analyze its regional heterogeneity and spatial spillover effects.

2. Literature Review and Model Hypothesis

2.1 Policy Background

In July 2014, the Ministry of Finance and the Ministry of Commerce jointly promulgated the "National Rural E-commerce Comprehensive Demonstration Policy". Each county (city) included in the list could receive financial support of about 20 million yuan from the central government, and could also obtain supporting funds at the provincial, municipal and county levels.

As of the end of 2023, the central government's financial investment exceeded 20 billion yuan. The comprehensive demonstration project of e-commerce entering rural areas has cumulatively supported 1,489 regions. The online retail sales of agricultural products nationwide reached 587.03 billion yuan, an increase of 12.5% year-on-year, which is approximately five times higher than that in 2014 when the policy was first launched. The online retail sales in rural areas nationwide reached 2.5 trillion yuan, an increase of 12.9% year-on-year, which is 13 times larger than that in 2014 (Zhang, 2024). The number of rural online stores reached 16.325 million, and it has cumulatively driven 6.188 million poverty-relieved farmers to increase their income (Zhang, 2024). It can be said that the entry of e-commerce into rural areas has achieved remarkable results.Overall, this policy has been implemented with great intensity, has a sound supporting policy system, and a clear assessment and incentive mechanism, which has played a significant role in the development of e-commerce in rural areas.

2.2 Theoretical Analysis and Research Hypotheses

2.2.1 Impact of E-commerce on the Upgrading of Rural Industries at the Production End

At the production end, with the help of the highly penetrative digital economy, e-commerce has rapidly expanded into the primary industry, reducing the search and matching costs of transactions and providing opportunities for the cross-regional circulation of goods. This enables farmer producers at the end of the network to establish direct connections with potential consumers, increasing the profit margin of agricultural and sideline products. Therefore, driven by e-commerce, local characteristic industries have developed rapidly, transforming the agricultural production model into a demand-oriented one. The original production scale of rural enterprises has been further expanded. At the same time, the emergence of advanced industrial models and new occupations has further promoted rural employment and entrepreneurship, thus driving the upgrading of the agricultural industry, increasing the income of rural residents, and accelerating rural revitalization.

Firstly, the development of e-commerce has changed the linear development model of traditional agricultural production and sales that is restricted by regions and interpersonal networks, making the economic organizational structure of agricultural production tend to be flattened and promoting the development of the agricultural industry. On the one hand, the digital economy represented by

e-commerce can effectively break down the information and trade barriers between urban and rural areas and even among different countries. Through information matching that transcends the constraints of time and space, it reduces the information asymmetry in the market and lowers the costs of intermediaries, such as negotiation costs and information costs. It further integrates the market, extends the trade network overseas, and expands the potential customer base of agricultural products (Batte et al., 2007; Shimamoto et al., 2015; Goldfarb et al., 2019). At the same time, it has also given birth to the emergence of cross-border e-commerce.On the other hand, the development of e-commerce has expanded the market scope and also increased the social demand for rural characteristic primary agricultural products and deeply processed agricultural products, bringing about the development of a series of related industries. This enables farmers to break away from the low-end role of merely engaging in agricultural production, promotes the development of local non-agricultural industries, accelerates the upgrading of the rural industrial structure, forms industrial agglomeration around the e-commerce ecological industry, and generates a greater scale agglomeration effect on the production side (Dunt et al., 2002; Zhang et al., 2022). In addition, the accelerated flow of factors and information has promoted market competition, which in turn encourages farmers to use the knowledge, information and advanced planting technologies brought by the digital economy to improve productivity, and promotes the continuous penetration of technology into agriculture (Li, 2019).

Secondly, while expanding the market scale of original enterprises, rural e-commerce has also stimulated the innovative vitality in rural areas. E-commerce has promoted the vertical deepening along the rural industrial chain. The emergence of a large number of new business forms and new occupations has also generated a demand for heterogeneous labor, enabling more farmers to shift to employment in sectors with higher productivity. The development of rural e-commerce will continue to enhance the productivity effect. While driving the improvement of agricultural production efficiency, it reduces the labor force engaged in agricultural production activities and promotes more labor to shift to non-agricultural production, thereby driving the transformation and upgrading of the rural economic structure. Non-agricultural employment has increased significantly (Tian et al., 2022), and the labor force will agglomerate in higher-end industries. At the same time, farmers learn online store technologies and operation skills, such as supporting industries like web design and maintenance, photography, video and image processing, tariff processing and foreign trade documentary handling (Qi et al., 2019). Meanwhile, out of considerations of economies of scale and saving labor employment costs, the rural economy with families as production units generally tends to expand the production scale locally, which further promotes farmers' entrepreneurship and enterprise innovation. The pilot policy of e-commerce demonstration counties has also enhanced the local entrepreneurial vitality through channels such as promoting the development of digital finance, driving agricultural modernization and accelerating infrastructure construction (Guo et al., 2024), improving the employment structure of farmers and thus promoting the transformation and upgrading of rural industries.

Therefore, Hypothesis 1 is proposed: The policy of e-commerce entering rural areas has a positive impact on the transformation of the regional industrial structure at the production end by promoting the growth of entrepreneurial vitality and the expansion of enterprise scale.

2.2.2 Impact of E-commerce on the Upgrading of Rural Industries at the Consumption End

From the perspective of the consumption end, against the backdrop of continuously rising income levels, e-commerce can promote the growth of household consumption, effectively reduce spatial consumption inequality, and improve the level of social welfare (Fan et al., 2018; Luo et al., 2019). At the same time, the diversification of farmers' demands has shifted from basic agricultural products to the consumption of industrial products and services. The change in the demand structure has led to a corresponding transformation of the industrial structure, resulting in the transformation of agriculture to a non-agricultural economy, and within the non-agricultural economy, the transformation from the manufacturing industry to the service industry.

Specifically speaking, firstly, the development of rural e-commerce can boost the use of mobile payment technology in rural areas and enhance the consumption convenience of farmers. With the popularization of digital information technology and the improvement of the convenience of mobile payment, rural e-commerce has increased farmers' marginal propensity to consume through convenient payment methods, smoothed their intertemporal consumption, and promoted the digital transformation and upgrading of commercial and trade circulation enterprises in rural areas through means such as improving network infrastructure and building e-commerce service points (Ma et al., 2023), which leads to the emergence of corresponding industrial clusters and is conducive to the development of international trade.

Secondly, e-commerce platforms have shortened the distance between international buyers and sellers. The diverse choices have triggered the demand for the cross-regional circulation of farmers' products, expanding the cross-regional consumption allocation effect and further increasing the production scale and product variety. The construction of e-commerce service stations in rural areas and the facilitation of customs clearance procedures have unblocked the product transportation routes, which is conducive to the development of agricultural production and sales towards specialized and large-scale production (Tang et al., 2020). The specialized production, distribution and sales models have further reduced the product costs, which is beneficial to promoting product exports.

Finally, rural e-commerce can provide more opportunities for product selection and meet the diversified product demands of farmers. Against the backdrop of continuously rising income levels, there are differences in the price elasticity of demand for different products. The increase in farmers' income will lead to demands for different products, and the emergence of e-commerce has provided rural areas with more diversified and personalized product choices, greatly expanding the variety of consumer products and the consumer market in rural area (Couture et al., 2018). At the same time, the increase in consumption from the global market and the diversification of demands have also brought about changes in the demand structure, ranging from agricultural products to industrial products and then to

service products. Correspondingly, the industrial structure has been upgraded accordingly, achieving the transformation and upgrading from agricultural production to the manufacturing and service industries (Tao et al., 2022).

Therefore, Hypothesis 2 is proposed: The development of e-commerce entering rural areas has a positive impact on the upgrading of the regional industrial structure through consumption growth and transformation on the consumption side.

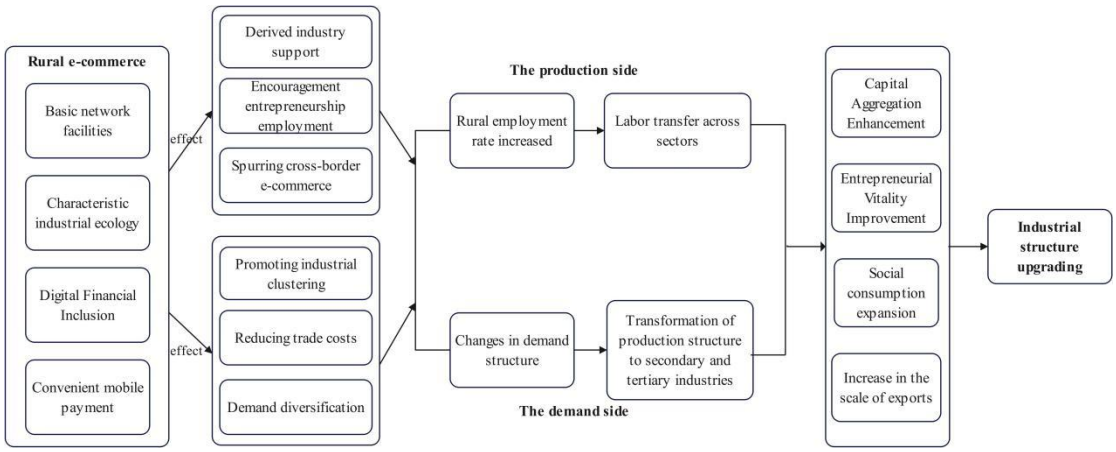

Figure 1. Analysis of the Mechanism of Rural E-commerce Promoting the Upgrading of the Industrial Structure

3. Experimental Design

3.1 Sample Selection and Data Source

This study conducts an empirical analysis using China's county-level panel data from 2005 to 2020. The data spans a time period of 16 years, covering 2,206 county-level administrative regions in 31 provinces across the country. By the end of 2020, 1,163 counties had been included in the scope of the policy pilot program, constituting the core observation dataset affected by the policy. The data mainly comes from the "China Regional Economic Statistical Yearbook" and the "China County Statistical Yearbook".

3.2 Model Specification

In order to accurately assess the impact of the pilot policy of e-commerce entering rural areas on the upgrading of the industrial structure at the county level, this study regards the pilot policy of e-commerce entering rural areas as a typical quasi-natural experiment. Given the characteristic of differences in the approval time of the pilot counties, a staggered difference-in-differences model is adopted. In specific operations, the 1,163 counties included in the pilot list are defined as the treatment group, and the remaining 951 counties that are not selected for the pilot list are used as the control group. The net effect of the policy shock is separated by constructing a two-way fixed effects model. The benchmark regression model is specified as follows:

$$IS_{it} = \alpha_0 + \alpha_1 Ecommerce_{it} + X_{it}^{'}\beta + \lambda_i + \gamma_t + \varepsilon_{it} \quad (1)$$

In Equation (1), is the explained variable, representing the industrial structure upgrading index of sample county i in period t. The core explanatory variable is a dummy variable indicating the policy shock of e-commerce entering rural areas. X_{it} represents the set of other control variables that affect the industrial upgrading of the county. $\lambda_i$ad represent the fixed effects of the county-level region and the fixed effects of the year respectively, and represents the random disturbance term.

3.3 Variable Selection and Explanation

3.3.1 Dependent Variable

In terms of measuring industrial structure upgrading, existing literature mostly uses two dimensions: industrial sophistication and industrial rationalization. Considering the limitations of data completeness and continuity at the county level, this study mainly uses industrial sophistication to quantify the industrial structure upgrading at the county level. Following the approach of Wang (2015),the index of industrial structure upgrading at the county level is calculated according to Equation (2):

$$IS = \sum_{i=1}^{3} y_i \times i, 0 < IS < 3 \quad (2)$$

In the above formula, IS represents the index of industrial structure upgrading, which indicates the proportion of the output value of the i-th industry in the regional gross domestic product (i = 1, 2, 3 correspond to the primary, secondary, and tertiary industries, respectively). This index is mainly used to reflect the development situation between the primary, secondary, and tertiary industries.

3.3.2 Core Explanatory Variable

The core explanatory variable in this paper is $Ecommerce_{it}$, which represents the policy shock of e-commerce entering rural areas. Specifically, when county i is approved to be included in the pilot policy of e-commerce entering rural areas in year t, is assigned a value of 1 for year t and subsequent years; otherwise, it is assigned a value of 0.

3.3.3 Control Variables

During the process of empirical analysis, in order to minimize the interference of other factors on the upgrading of the industrial structure at the county level and reduce estimation bias, based on referring to existing relevant literature, this paper selects control variables from dimensions such as economy, government, labor, and capital. Specifically, the natural logarithm form of the gross domestic product of each county is used to represent the level of economic development(lngdp); the ratio of the fiscal revenue to the fiscal expenditure of each county is chosen to measure the state of fiscal balance (dgov); the number of middle school students enrolled is used to represent the level of human capital at the county level(secede); the per capita disposable income of rural residents (rcmi) is used to represent the income level of residents at the county level; the total retail sales of social consumer goods are used to measure the level of residents' demand at the county level (sale). The relevant variables have all been

logarithmically processed.

Table 1. Descriptive Statistics of Basic Variables

	(1)	(2)	(3)	(4)
VARIABLES	mean	sd	min	max
Ecommerce	0.085	0.279	0	1
is	2.140	0.244	0	3.961
secedu	2.702	2.232	0	26.354
lngdp	13.552	1.206	8.915	18.093
dgov	0.345	0.247	0.000	2.992
rcmi	8.763	0.686	6.504	10.695
sale	0.507	0.798	0.009	15.116

4. Empirical Result Analysis

4.1 Benchmark Regression Results

Table 2 presents the benchmark regression results of the impact of the pilot policy of e-commerce entering rural areas on the upgrading of the industrial structure at the county level. Among them, in column (1), only the policy shock is included in the model as an explanatory variable. The regression results show that the coefficient of the policy shock is significantly positive at the 1% significance level, preliminarily indicating that the policy of e-commerce entering rural areas has played a positive role in promoting the upgrading of the industrial structure at the county level. On this basis, in order to enhance the robustness of the model and reduce the potential bias caused by omitted variables, in column (2), control variables such as the level of economic development, human capital accumulation, and the income level of residents are introduced to construct an extended model. The estimation results show that the coefficient value of the policy variable remains significantly positive and the explanatory power of the model is significantly improved. From the economic meaning of the coefficient estimation value, compared with non-pilot counties, the pilot policy of e-commerce entering rural areas has increased the industrial structure upgrading index of pilot counties by an average of 0.019 units. A comprehensive analysis of the results in Table 2 shows that the pilot policy of e-commerce entering rural areas plays a positive role in promoting the upgrading of the industrial structure at the county level. In addition, the coefficients of the level of economic development, the level of human capital, and the income level of residents are all significantly positive, indicating that the expansion of the total economic volume at the county level, the improvement of the quality of the labor force, and the enhancement of the consumption capacity of residents all have a significant promoting effect on the upgrading of the industrial structure.

Table 2. Impact of E-commerce Entering Rural Areas on the Industrial Upgrading at the County Level: Benchmark Regression Results

	(1)	(2)
VARIABLES	is	is
Ecommerce	0.019***	0.019***
	(0.003)	(0.003)
lngdp		0.008**
		(0.004)
dgov		-0.007
		(0.007)
secedu		-0.003***
		(0.000)
rcmi		0.015**
		(0.006)
sale		0.002
		(0.000)
Constant	2.062***	1.852***
	(0.002)	(0.057)
R-squared	0.290	0.290
Number of county	2,206	2,206
yearfix	YES	YES
idfix	YES	YES

Note. ***, **, and * indicate significance at the 1%, 5%, and 10% levels respectively. The values in parentheses are clustered standard errors, clustered at the city level. The same applies hereinafter.

4.2 Robustness Test

4.2.1 Parallel Trends Test

In order to explore whether there is a consistent development trend between the pilot areas of e-commerce entering rural areas and the non-pilot areas before the implementation of the policy, and at

the same time to examine the dynamic effect of the pilot policy of e-commerce entering rural areas on the upgrading of the rural industrial structure, the following regression equation is specified by referring to the method of Beck (2010):

$$IS_{it} = \delta_0 + \sum_{s=-5}^{5} \delta_s Exommerce_{it} + X_{it}^{'}\beta + \lambda_i + \gamma_t + \varepsilon_{it} \quad (3)$$

Among them, is a binary dummy variable. If county i is an area under the pilot policy of e-commerce entering rural areas, the variable takes a value of 1; otherwise, it takes a value of 0. s>0 indicates that region i implements the policy of e-commerce entering rural areas s periods after period t, and conversely, it indicates that the policy is implemented before period t. It represents the relative time of policy implementation. In the equation, is used to capture the differences in the time trends between the treatment group and the control group. In this paper, the period corresponding to s -1 is set as the event base period to avoid multicollinearity, and the performance within 5 periods before and after the implementation of the pilot policy is reported.

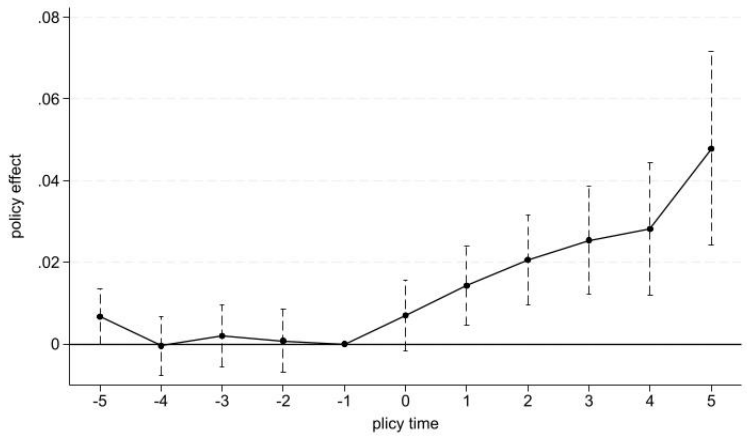

Figure 2. Parallel Trends Test

Figure 2 reports the estimation results based on Equation (3). It can be found that within the 95% confidence interval, the estimated coefficients in all periods before the implementation of the pilot policy of e-commerce entering rural areas are not significant, indicating that there is no obvious difference in the upgrading of the industrial structure between the implementing areas and the non-implementing areas before the implementation of the policy of e-commerce entering rural areas. However, the estimated coefficient one year after the implementation of the policy begins to be significantly positive and shows a trend of increasing year by year, indicating that the pilot policy of e-commerce entering rural areas does have a significant positive effect on the upgrading of the industrial structure at the county level.

In order to further discuss the robustness of the parallel trends, this paper conducts a sensitivity test of

the parallel trends. In order to rule out possible estimation errors and result distortions in the parallel trends assumption and ensure the effectiveness of the pre-treatment trend test, this paper refers to the studies of Rambachan (2023) and Roth (2023) relaxes the parallel trends assumption and observes the distance between the corresponding confidence interval and zero to test the sensitivity of the parallel trends of the treatment effect after the implementation of the pilot policy. As can be seen from Figure 3, when the parallel trends assumption is relaxed to a deviation of more than one time (Mar = 1.06), the treatment effect is still significant within the 95% confidence interval; that is, when the coefficient deviates by more than one time from the standard error, the regression coefficient is still significantly positive.

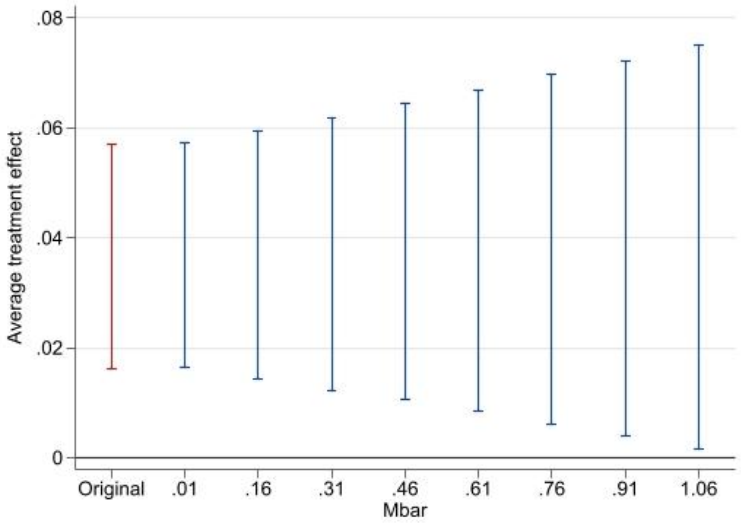

Figure 3. Average Treatment Effect

4.2.2 Heterogeneity of Treatment Effects

The staggered difference-in-differences method may be affected by the heterogeneity of treatment effects and the problem of negative weights. Generally speaking, the problem of negative weights will be more severe only in two situations: one is that the treatment time of some individuals is in the early stage, and the other is that there are no untreated samples in the overall sample. In this paper, the treatment time of the sample counties for the implementation of e-commerce in rural areas started as early as 2012, and the effective time of the corresponding policy only covers the middle and later stages of the overall sample. Moreover, there have always been sample counties that have not been affected by the policy shock in the sample. This means that the estimation bias caused by the problem of negative weights will not significantly affect the robustness of the estimation results.

Furthermore, referring to the Bacon decomposition method proposed by Goodman-bacon(2021) the average treatment effects under different conditions are distinguished, and the estimation bias is achieved through the decomposition of the coefficient values. The decomposition weight results are shown in Figure 3. It is found that although there are negative weights, the proportion is only 4.6%. As

can be seen from Figure 3, the weights of the post-treatment group with negative weight effects compared to the pre-treatment group (Later Group Treatment vs. Earlier Group Comparison) are concentrated around the value of 0. Specifically, the proportion of the corresponding estimated coefficients obtained from the decomposition is 4.6%, and the proportion of the weights is not enough to affect the robustness of the final result, confirming that the estimator of the benchmark result is credible.

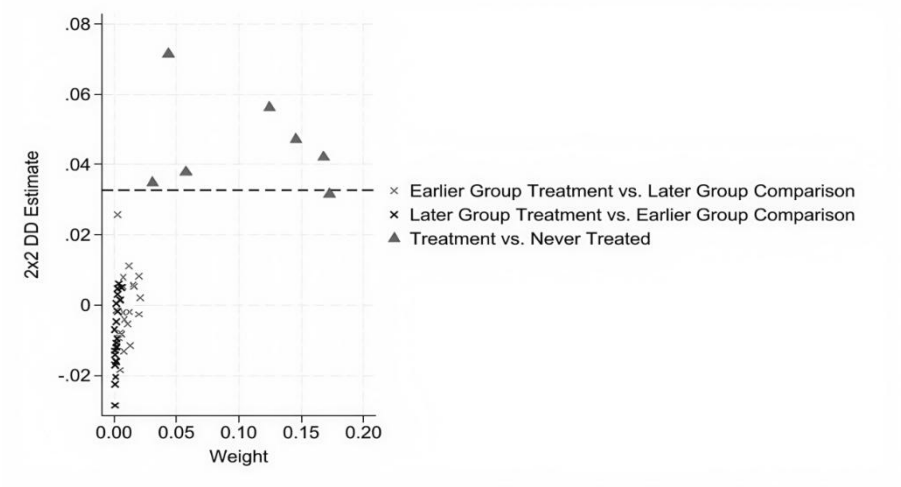

Figure 4. Bacon Decomposition

4.2.3 Placebo Test

The differences between the treatment group and the control group may not entirely be due to the impact of the pilot policy of e-commerce entering rural areas. In order to rule out the possible influence of other factors, this paper conducts a placebo test on the possible random factors. Referring to the method of Li (2023), this paper conducts an unconstrained mixed placebo test on the staggered difference-in-differences used in this paper. As can be seen from Figure 5, the regression results are less affected by random factors. The obtained estimated values are approximately zero and are far from the true values, and the relevant t-values are densely distributed around zero. This indicates that in the analysis of this paper, the pilot policy of e-commerce entering rural areas fully and truly reflects its impact on the upgrading of the industrial structure at the county level.

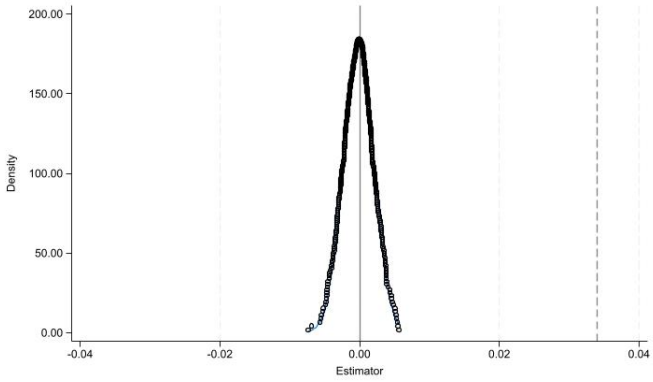

Figure 5. Individual Placebo Test

4.2.4 Sample Selection Problem

As mentioned above, there is significant heterogeneity among the many districts and counties studied in this paper, and the most prominent ones are the top 100 national districts (counties) selected and evaluated by relevant consulting institutions every year. In order to address the possible outliers, this paper removes the data of the top 100 counties from the samples. The list of the top 100 counties comes from the "Research Report on the High-quality Development of Urban Economy in China in 2022 and the Top 100 Districts of CCID in 2022" released by the Urban Economic Research Center of CCID Consulting (affiliated to the China Electronics Information Industry Development Research Institute of the Ministry of Industry and Information Technology) on July 27, 2022. It requires that the selected districts and counties should meet the dual standards of "a regional gross domestic product of more than 80 billion yuan and a general public budget revenue of more than 2 billion yuan". Since 2021, this evaluation system has been adjusted, involving five evaluation dimensions: economic strength, growth momentum, internal support, regional level, and shared development, as well as 23 secondary indicators and more than 70 supporting indicators. The obtained results are shown in Table 3:

Table 3. Results after Sample Screening: Deleting the Top 100 Counties

	(1)	(2)	(3)
VARIABLES	is	is	is
Ecommerce	0.140***	0.020***	0.020***
	(0.003)	(0.003)	(0.003)
lngdp			0.009**
			(0.004)
dgov			-0.004

			(0.008)
secedu			-0.002*
			(0.001)
rcmi			0.013**
			(0.007)
sale			0.004
			(0.002)
Constant	2.116***	2.059***	1.852***
	(0.005)	(0.002)	(0.058)
R-squared	0.104	0.290	0.290
Number of county	2,083	2,083	2,083
yearfix	NO	YES	YES
idfix	NO	YES	YES

According to the results, after deleting the data of the top 100 counties, the regression coefficient of the key variable only decreases by 0.001. The results do not change significantly, and the significance is not affected either. In addition, since many urban districts in large and medium-sized cities also belong to the county-level administrative division, and these districts in the sample are mostly in developed areas. The industrial structure within these districts is mainly composed of the secondary and tertiary industries, and they already have a high level of industrial sophistication. Therefore, this paper removes the relevant urban districts and special economic zones and then conducts the regression. The obtained results are as follows:

Table 4 Results after Sample Screening: Deleting Districts and Special Economic Zones

	(1)	(2)	(3)
VARIABLES	is	is	is
Ecommerce	0.141***	0.006***	0.006***
	(0.002)	(0.002)	(0.002)
lngdp			0.000
			(0.003)
dgov			0.020***
			(0.006)

secedu			0.000
			(0.000)
rcmi			0.015***
			(0.004)
sale			0.006***
			(0.000)
Constant	2.102***	2.048***	1.916***
	(0.004)	(0.001)	(0.040)
R-squared	0.182	0.529	0.530
Number of county	1,794	1,794	1,794
yearfix	NO	YES	YES
idfix	NO	YES	YES

According to the results, the significance of the policy is still not affected. However, the regression coefficient after controlling for the two-way fixed effects decreases significantly. A possible reason is that the number of controlled samples is relatively large (accounting for about 25% of the total samples), and urban districts are the main force for the development of districts and counties, occupying a large share in terms of the total economic volume, which will have a certain impact on the regression results.

4.2.5 Replacing the Index of Industrial Structure Upgrading

As mentioned above, the process of industrial structure transformation and upgrading is a process in which the production structure shifts from an agricultural economy to a non-agricultural economy, and it is also accompanied by the inclination of production resources such as labor and capital towards the secondary and tertiary industries. Therefore, the ratio of the added value of the tertiary industry to that of the secondary industry (Indicator 1) and the proportion of the sum of the output values of the secondary and tertiary industries in the GDP of the current year (Indicator 2) are selected as the new measurement indicators for the variable of industrial structure upgrading:

$$IS = \frac{y_2 + y_3}{Y}, 0 < IS < 1 \quad (4)$$

Among them, represents the output value of the i-th industry, Y represents the GDP (total population) of the county in that year, represents the industrial structure upgrading index, and its value range is [0,1]. In addition, by replacing the explanatory variable with the proportion of the rural population (Indicator 3), the transfer of the rural population is tracked, which is represented by the ratio of the rural population to the total population at the end of the year. Table 5 reports the estimation results after replacing the explained variable. The results show that after changing the index of industrial structure upgrading, the coefficient of the policy shock of the pilot program of e-commerce entering rural areas is still significantly positive, further indicating that the previous conclusions are robust. At the same

time, as can be seen from column (3) of Table 5, the implementation of the policy of e-commerce entering rural areas has significantly reduced the proportion of the rural population, which indirectly confirms the important promoting effect of the pilot policy on the migration of rural labor force to non-agricultural industries.

Table 5. Robustness Test: Results of Replacing the Index of Industrial Structure Upgrading

	(1)	(2)	(3)
VARIABLES	Indicator 1	Indicator 2	Indicator 3
Ecommerce	0.102***	0.005***	-0.013***
	(0.028)	(0.001)	(0.003)
Constant	8.867***	-0.482***	0.925***
	(0.524)	(0.018)	(0.042)
R-squared	0.084	0.571	0.043
Number of county	2,190	2,190	2,074
yearfix	YES	YES	YES
idfix	YES	YES	YES
Controls	YES	YES	YES

5. Further Analysis

5.1 Mechanism Test

Through the previous theoretical analysis, it is found that e-commerce can have an impact on the upgrading of the industrial structure at the county level from two aspects: the production side and the consumption side. On the production side, the labor force shifts from agricultural labor to non-agricultural labor. Whether it is manifested as the addition of manufacturing enterprises or the agglomeration of the service industry, it will ultimately be reflected in the accumulation of enterprise funds and the change in the number of enterprises. This paper constructs an index of county-level entrepreneurial activity (undertake) around the number of newly added enterprises each year, and the formula is as follows:

$$\text{undertake} = \log\left(1 + \frac{N_i}{P_i}\right) \tag{5}$$

Among them, the county-level entrepreneurial activity index (undertake) = ln (1 + the number of newly registered enterprises in the current year / the number of registered population in ten thousand people). The regression results are shown in column (1) of Table 6. In addition, this paper takes the number of loans from financial institutions in the county each year (lnfin)as a proxy variable for enterprise financing, and the regression results are shown in column (2) of Table 6. The results show that, whether in terms of the variables of entrepreneurial situation or capital borrowing, the coefficient of the policy

shock is also significantly positive at the 1% level, indicating that the emergence of the pilot policy of e-commerce entering rural areas has effectively alleviated the problem of financing constraints in rural areas. While promoting the improvement of the level of capital agglomeration, it also promotes the entrepreneurial vitality of rural enterprises, which is conducive to the sound development of local enterprises.

Regarding the changes in the consumption level on the consumer side, phenomena such as the diversification of consumer products and the upgrading of the consumption structure have also emerged. However, all these will be reflected in the increase in residents' consumption. In this paper, the proportion of export value to GDP (exports) is introduced to describe the promoting effect of e-commerce on the export of local products. And the residents' consumption propensity (the ratio of the total retail sales of social consumer goods to the disposable income of residents) is introduced to test Hypothesis H2 from the consumption side. As can be seen from Columns (3) to (4) of Table 6, after controlling for relevant variables, the regression coefficients of product exports and residents' consumption as the explained variables are both significantly positive. This indicates that the policy of introducing e-commerce into rural areas has greatly promoted the growth of consumption from both domestic and international aspects.

Table 6. Results of the Mechanism Test

	(1)	(2)	(3)	(4)
VARIABLES	undertake	lnfin	exports	consume
Ecommerce	0.004***	0.077***	0.007*	0.031***
	(0.001)	(0.009)	(0.004)	(0.005)
lngdp	0.010**	0.372***	0.020***	0.324***
	(0.004)	(0.012)	(0.004)	(0.006)
dgov	-0.007	0.088***	-0.012*	-0.010
	(0.007)	(0.023)	(0.007)	(0.011)
secedu	-0.001	0.015***	-0.001	0.341***
	(0.000)	(0.000)	(0.001)	(0.000)
rcmi	0.017***	0.206***	0.051***	0.165***
	(0.006)	(0.020)	(0.009)	(0.010)
sale	0.003	-0.003	-0.006***	7.328***
	(0.000)	(0.000)	(0.002)	(0.000)
Constant	1.806***	5.344***	-0.083	5.909***
	(0.057)	(0.175)	(0.082)	(0.086)
R-squared	0.292	0.861	0.134	0.944
Number of county	2,154	2,054	817	2,206

yearfix	YES	YES	YES	YES
idfix	YES	YES	YES	YES

5.2 Heterogeneity Analysis

5.2.1 Heterogeneity of Regional Resources

The unbalanced pattern of economic development among regions profoundly influences the allocation direction of core production factors such as capital, technology, and talent. Specifically, economically developed regions, by virtue of their complete industrial supporting systems, efficient infrastructure networks, and active market entities, form a remarkable factor agglomeration effect. In contrast, less developed regions, due to their insufficient resource absorption capabilities, experience a continuous outflow of production factors. This polarization in resource allocation not only widens the gap in economic aggregates among regions but also accelerates the formation of a development pattern where "the strong get stronger and the weak get weaker".

In view of this, to deeply explore the regional heterogeneity of the effects of the pilot policy of e-commerce entering rural areas, this paper divides all the sample counties into three major regional groups, namely the eastern region, the central region, and the western region, according to the economic and geographical characteristics of China's county-level economies, and conducts estimations for each group separately. The measurement results in Table 7 show that the pilot policy has produced positive effects to varying degrees in the county-level regions of the eastern, central, and western regions, but there are gradient differences in the intensity of these effects.

Specifically, in the western region where the economic development level is relatively lagging behind, the impact of the policy is the most prominent, and its promoting effect exceeds the national average level. The policy effect in the central region is the second, and the impact coefficient is basically consistent with the national overall level. In the eastern region where the economic development level is relatively good, the impact of the policy is still significantly positive, but the policy effect is lower than that in the central and western regions. A possible reason is that, for the relatively less developed western region, the pilot policy of e-commerce entering rural areas, through such means as building digital circulation platforms and cultivating new rural market entities, effectively alleviates the long-standing dilemma of insufficient net inflow of factor resources, and injects new impetus into the optimization of the industrial structure. In the developed eastern region, there are locational advantages such as the siphon effect of large cities, and the market-oriented allocation efficiency of factor flows is relatively high. Therefore, the marginal promoting effect of the pilot policy is relatively limited.

Table 7. Heterogeneity Analysis: Results of Regional Grouping

	(1)	(2)	(3)
	East	Middle	West

Ecommerce	0.010**	0.016***	0.035***
	(0.004)	(0.004)	(0.010)
Constant	1.564***	2.691***	1.656***
	(0.099)	(0.179)	(0.226)
Number of county	715	566	925
R-squared	0.911	0.701	0.889
yearfix	YES	YES	YES
idfix	YES	YES	YES
Controls	YES	YES	YES

5.2.2 Heterogeneity of Network Resources

In addition to economic factors, the local network infrastructure and the number of users also affect the development of e-commerce. In this paper, the counties whose numbers of fixed-line telephones, mobile phones, and broadband accesses are ranked in the last 30%, between 30% and 70%, and in the top 30% are respectively defined as regions with low network resources, medium network resources, and high network resources.

As can be seen from the results in Table 8, in regions with higher network resources, the impact of e-commerce on the upgrading of the industrial structure is more significant. However, for regions with the lowest network resources, this effect is not significant. This result further emphasizes the importance of network infrastructure for the development of e-commerce.

Table 8. Heterogeneity Analysis: Grouping by Network Resources

	(1) low network resources	(2) medium network resources	(3) high network resources
Ecommerce	0.012	0.012***	0.016***
	(0.012)	(0.003)	(0.005)
Constant	2.582***	2.324***	1.852***
	(0.233)	(0.058)	(0.089)
R-squared	0.127	0.491	0.371
Number of county	848	1,649	1,261
Controls	YES	YES	YES
yearfix	YES	YES	YES
idfix	YES	YES	YES

5.2.3 Heterogeneity of Agricultural Resources

The policy studied in this paper is aimed at the development of e-commerce in rural areas of various counties. Therefore, for traditional agricultural counties, the effect of e-commerce on the transition of industries to the secondary and tertiary industries will be more obvious. Thus, in this paper, the counties whose total output values (in ten thousand yuan) of agriculture, forestry, animal husbandry, and fishery are ranked in the last 30%, between 30% and 70%, and in the top 30% are respectively defined as Grade I agricultural counties, Grade II agricultural counties, and Grade III agricultural counties.

The regression results are shown as table 9. According to the regression results, for places that are more dependent on agricultural production, the impact of the e-commerce pilot on the local industrial structure is more obvious. That is, the pilot policy of e-commerce entering rural areas has significantly changed the industrial structure of areas that are heavily dependent on agriculture. This further emphasizes the crucial role played by e-commerce in the process of seeking the transformation and upgrading of the industrial structure in agricultural counties.

Table 9. Heterogeneity Analysis: Grouping by Agricultural Resources

	(1) Grade I agricultural counties	(2) Grade II agricultural counties	(3) Grade III agricultural counties
Ecommerce	0.013	0.015***	0.013***
	(0.008)	(0.004)	(0.004)
Constant	2.913***	2.049***	1.528***
	(0.102)	(0.072)	(0.123)
R-squared	0.309	0.423	0.290
Number of county	925	1,498	1,854
Controls	YES	YES	YES
yearfix	YES	YES	YES
idfix	YES	YES	YES

6. Conclusions

This paper takes the pilot policy of e-commerce entering rural areas as a quasi-natural experimental scenario and conducts an empirical study on the interactive relationship between the development of e-commerce and the upgrading of the industrial structure at the county level. Based on the panel data set of 2,206 county-level administrative units across the country from 2005 to 2020, this study uses a staggered difference-in-differences econometric model to systematically evaluate the impact of the

implementation of the pilot policy on the transformation of the industrial structure at the county level. The empirical results show that the pilot policy of e-commerce entering rural areas has significantly promoted the process of upgrading the industrial structure at the county level. In terms of the action mechanism, the policy promotes the upgrading of the industrial structure at the county level by boosting export growth and the vitality of innovation and entrepreneurship. The results of the heterogeneity analysis show that the pilot policy of e-commerce entering rural areas has a more significant impact on regions with a lower level of economic development. The policy effect is affected by the level of regional network facilities and the scale of agricultural output value. In underdeveloped regions with abundant network resources and a high agricultural output value, e-commerce has a more obvious promoting effect on the upgrading of the industrial structure at the county level. Therefore, relevant incentive policies for e-commerce entering rural areas should be continuously implemented, and a long-term mechanism of "policy guidance, market operation, and social participation" should be established to fully release the potential of e-commerce in empowering the upgrading of the rural industrial structure. Relying on the technological empowerment of digital platforms, the professional agglomeration and high-quality coordination of the secondary and tertiary industries should be accelerated, and policy momentum should be continuously injected into the economic development at the county level.

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