The Impact of Supply Chain Collaboration on the High-quality Development of E-commerce and Its Optimization Strategies

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Abstract. With the development of the digital economy, supply chain cooperation has gradually appeared to promote the high-quality development of e-commerce. Few studies have examined the moderating effect of digital infrastructure in this path. This paper aims to explore how cooperation in the supply chain can enhance the quality of e-commerce development, and to study all sorts of functions and changes that are emerging in the digital infrastructure at present. This study conducted a questionnaire survey, randomly selecting mid-level and senior managers of e-commerce companies as the research subjects. Based on previous research, this study uses validated Likert scale items to evaluate relevant indicators and further optimizes these scales in small-scale experiments. Analysis of heterogeneity shows that the moderating effect is relatively strong in the area of technology-intensive e-commerce compared with the traditional commercial area. Based on this study, specific measures will be taken to strengthen the construction of digital infrastructure and boost the efficiency of supply chain cooperation for high-quality development of e-commerce.

Keywords: Supply chain collaboration, e-commerce, High-quality development, Digital infrastructure, Industry heterogeneity.

1. Introduction

High-quality development has become a central concern for e-commerce enterprises seeking to enhance their competitiveness in the digital economy. As a general index of the company's all-around competitiveness and long-term development ability, improvements in operational performance, such as order-fulfillment efficiency and logistics speed, are shown here, as well as other aspects such as innovation capability, customer satisfaction, financial health and environmental protection. Recently, many studies have begun to show that the source of a company's advantage is now the whole chain of its supply. Therefore, supply chain cooperation is generally required for the high-quality development of e-commerce companies [1]. By conducting a variety of group work, transaction costs and coordination problems among resources have been lowered by sharing data, arranging plans, and coordinating the interests of all parties involved [2]. At the same time, digital infrastructure can support the full realization of supply chain collaboration through hardware deployment for joint operation, software system integration and data governance capabilities [3].

However, some research deficiencies have still been found in the present studies. On the one hand, most of the research on the relationship between supply chain cooperation and the development of high-quality e-commerce has been at the theoretical level, and relatively few empirical studies based on micro-level firm data have been carried out. At the same time, no supporting empirical evidence has been obtained to determine whether the level of change in digital infrastructure affects this relationship or whether the range of the moderating effect varies by e-commerce sector. It is also difficult for the company to know how to balance cooperation and facility construction in its actual operations at present.

Based on the above research deficiencies, this paper presents two research questions. The first question is: Does the cooperation in the supply chain promote high-quality development of e-commerce? The second question is: Is there a positive moderating effect of the level of digital

infrastructure, and do the two types of e-commerce differ in this moderation effect? To answer the above questions, this paper distributed questionnaires to senior managers of several e-commerce companies and collected the data. The three main indices of supply chain cooperation, digital infrastructure, and high-quality development of e-commerce were all measured on a 7-point Likert scale in the previous studies. Based on the results of the first survey, the author adjusted the scale items to improve data quality. By studying different types of e-commerce enterprises empirically, this paper seeks to find more specific mechanisms and boundary conditions through which supply chain collaboration promotes high-quality development in e-commerce, providing a reference for enterprises to optimize the deployment of digital infrastructure and collaboration strategies.

2. Research methods

2.1. Questionnaire Design and Data Collection

This study used a questionnaire survey method to collect primary data. The questionnaire design refers to mature scales at home and abroad: the supply chain collaboration scale is adapted from the information sharing and decision synchronization scale of García-Alcaraz et al. [4] and the supply chain collaboration scale of Chi et al. [5]. The digital infrastructure scale is adapted from Gong et al.'s digital capability scale [6]. The e-commerce high-quality development scale is adapted from Qi et al.'s supply chain resilience and performance scale [7] and Qureshi et al.'s supply chain integration and performance scale [8]. The questionnaire used in this study was a 7-point Likert scale (1=strongly disagree, 7=strongly agree).

It contains three core variables: Supply Chain Collaboration (SCC), Digital Infrastructure (DI) and E-commerce Quality Development (EQD). Among them, the SCC scale contains 6 items, covering sales data sharing, inventory information sharing, joint planning, demand forecast collaboration, risk sharing mechanisms and long-term cooperative relationships. The DI scale contains 6 items, covering cloud computing facilities, network infrastructure, ERP/SCM systems, big data and artificial intelligence applications, data governance systems, and internal and external data integration. The EQD scale contains 6 items, covering order processing efficiency, operating cost reduction, product and service innovation, customer satisfaction, profit margins and long-term development potential.

The survey targets are middle and senior managers of e-commerce companies because they have a relatively comprehensive understanding of the company's supply chain collaboration status, digital investment and business development quality. Using a combination of convenience sampling and snowball sampling, questionnaires were distributed through online platforms to various types of enterprises such as technology-intensive e-commerce, traditional commercial e-commerce, cross-border e-commerce, and social e-commerce. After data cleaning, 157 valid responses remained. The sample covered managers across different company sizes, tenures, and job levels, offering a fair degree of representativeness. Specifically, 45.2% of the sample were senior managers and 35.6% were middle managers. Technology-intensive e-commerce and traditional commerce e-commerce account for a large proportion (28.0% and 25.2%). The size of enterprises is mainly 50-500 people (58.4%). Enterprises established for more than 5 years accounted for 62.8%.

2.2. Variable Measurement and Reliability and Validity Testing

To verify the reliability and validity of the scale, this paper assessed its internal consistency by calculating Cronbach's alpha. Referring to the standard of Hair et al. (2021), an Alpha coefficient greater than 0.9 indicates very high reliability, 0.8-0.9 is high reliability, and 0.7-0.8 is acceptable reliability [4]. The analysis results show that the Cronbach's Alpha of the SCC scale is 0.9428, the DI scale is 0.9333, and the EQD scale is 0.9123, all far exceeding the acceptance threshold of 0.7, indicating that each scale has high internal consistency and can be used for subsequent analysis. The means of all items are greater than 4 (the midpoint of the scale), indicating that the respondents overall tend to agree with the content described in the scale.

2.3. Data Analysis Methods

This paper processed the data by applying descriptive statistics, Pearson correlation coefficients, and multiple linear regression. First, understand the distribution characteristics of each variable through descriptive statistics. Next, Pearson correlation coefficients were calculated to examine the linear relationships among the variables. Finally, the stepwise regression method was used to examine the impact of supply chain collaboration on the high-quality development of e-commerce and the moderating effect of digital infrastructure.

In the regression analysis, this study constructed three models: Model 1 only included the independent variable SCC to test the main effect. Model 2 includes two independent variables, SCC and DI, to test the control effect. Model 3 adds the interaction term between SCC and DI on the basis of Model 2 to test the moderating effect. To avoid multicollinearity problems, the independent variables were centered and tested using the variance inflation factor (VIF). Referring to the recommendations of Hair et al., VIF less than 5 indicates that there is no serious multicollinearity problem [9]. The moderating effect analysis refers to the conditional process analysis method proposed y Hayes and introduces interaction terms to test the moderating effect [10].

3. Research Results

3.1. Summary Statistics

Supply chain collaboration (SCC) records an average score of 4.918 and an SD of 1.163, while Digital infrastructure (DI) has a mean of 4.877 with an SD of 1.162. E-commerce high-quality development (EQD) obtains the highest average value among the three constructs ($M = 5.579$, $SD = 0.793$). These scores are clearly above the midpoint of the seven-point scale, which means that the surveyed managers generally assessed their firms positively in terms of collaboration with supply-chain partners, digital infrastructure readiness, and the quality of e-commerce development. The skewness statistics are all within ±1 and the kurtosis statistics are within ±2. Therefore, the variables do not show serious departures from normality and can be used in the following regression tests.

3.2. Correlations and Collinearity Diagnosis

Figure 1 reports the Pearson correlation matrix for chain collaboration (SCC), digital infrastructure (DI), and e-commerce development (EQD). The strongest association appears between SCC and EQD ($r = 0.739$, $p < 0.001$), showing that firms with stronger supply-chain collaboration also tend to report better e-commerce development outcomes. DI is positively related to EQD as well ($r = 0.391$, $p < 0.001$). The correlation between SCC and DI is also positive and significant ($r = 0.327$, $p < 0.001$). These results indicate that the three constructs move in the expected direction and justify the use of regression analysis for testing the proposed relationships.

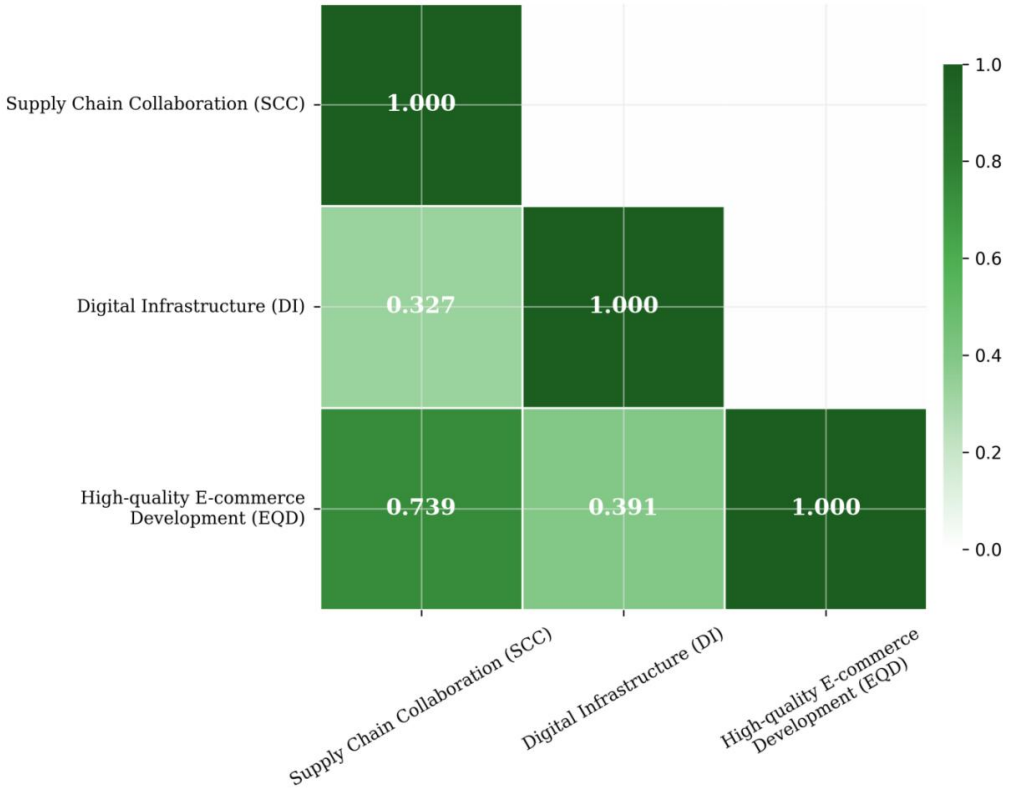


Fig. 1 Pearson correlation coefficient matrix diagram between variables

3.3. Regression Results and Moderation Test

Model 1 includes only SCC as the predictor. Its coefficient is 0.503 and is statistically significant at $p < 0.001$, and the model accounts for 54.59% of the variance in EQD. After DI is entered in Model 2, SCC still shows a strong positive coefficient (0.466, $p < 0.001$). DI also contributes positively to EQD (0.114, $p < 0.001$). R^2 increases from 0.5459 to 0.5709 with the addition of this predictor, indicating that digital infrastructure explains additional variance beyond supply-chain collaboration.

Model 3 includes the interaction term of SCC and DI. The interaction coefficient is 0.065 with a p-value of 0.011, significant at the 5% level. This means DI strengthens the link between SCC and EQD. The more advanced the digital infrastructure of a company, the better it is able to convert collaboration across the supply chain into quality e-commerce development. At a lower infrastructure level, the same cooperation leads to a less significant improvement. Thus, H2 is supported. Model 3 has an R^2 of 0.5821, which means that about 58.21% of the variation in EQD is explained. The F statistics of all three models are significant ($p < 0.001$), which means that the models are statistically meaningful overall.

The moderation pattern is depicted in Figure 2 by dividing the sample into two groups of high-DI and low-DI according to the median of DI. The slope is higher for the high-DI group than the low-DI group. This visual evidence supports the regression result and shows that digital infrastructure enhances the positive effect of SCC on EQD.

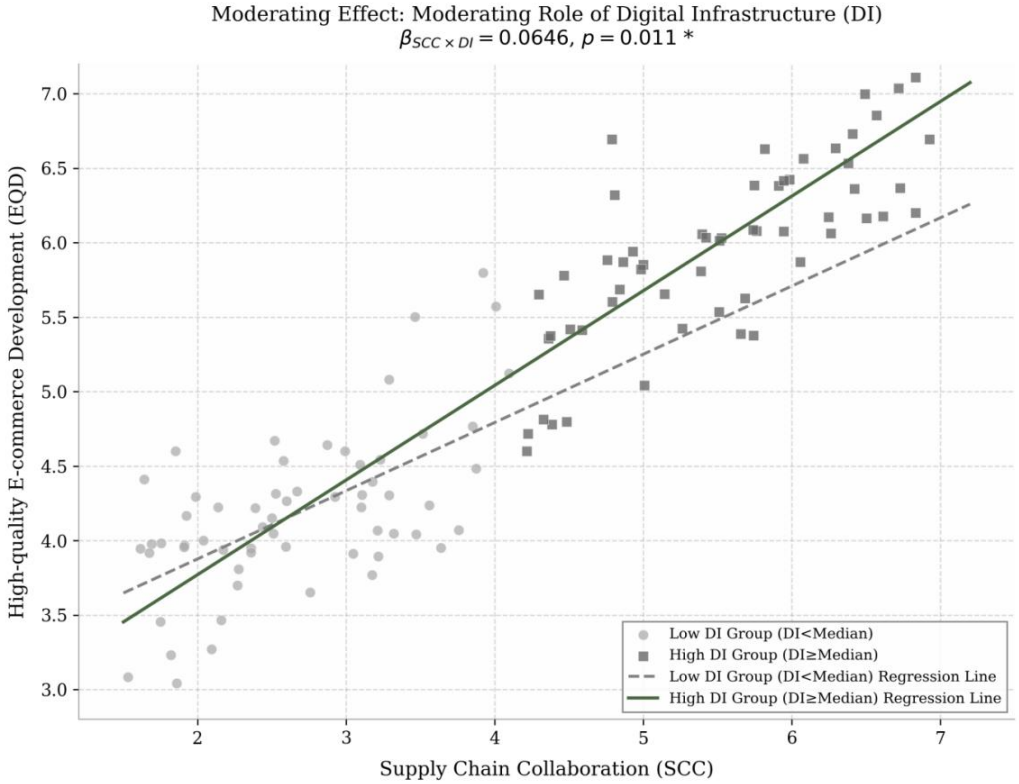


Fig. 2 Diagram of the moderating effect of digital infrastructure (DI)

3.4. Path Model and Industry Variations

The path diagram of the main regression results is shown in Figure 3. SCC has a positive direct path to EQD (β = 0.476). DI also has a positive direct path to EQD (β = 0.105). The interaction between SCC and DI is also positive (β = 0.065). The diagram shows that digital infrastructure directly supports e-commerce development and also facilitates the value created by supply-chain collaboration.

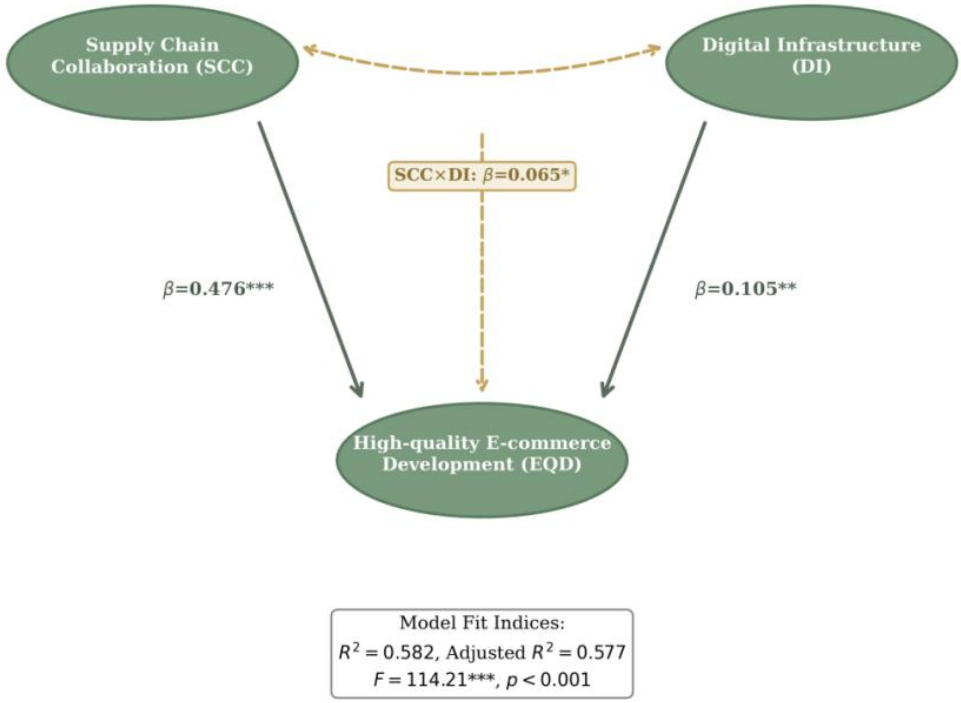


Fig. 3 Research model path analysis results

The pattern of moderation across categories of industry is shown in Figure 4. The difference between the regression lines of high-DI and low-DI is more obvious for technology-intensive e-commerce firms, indicating the moderating role of DI is more powerful. For traditional commerce e-commerce firms, the two lines are closer and the moderating effect is more limited. This difference supports the extended argument of H2 that digital infrastructure is particularly important in technology-intensive e-commerce settings where real-time data exchange and system-based coordination are more central to business operations.

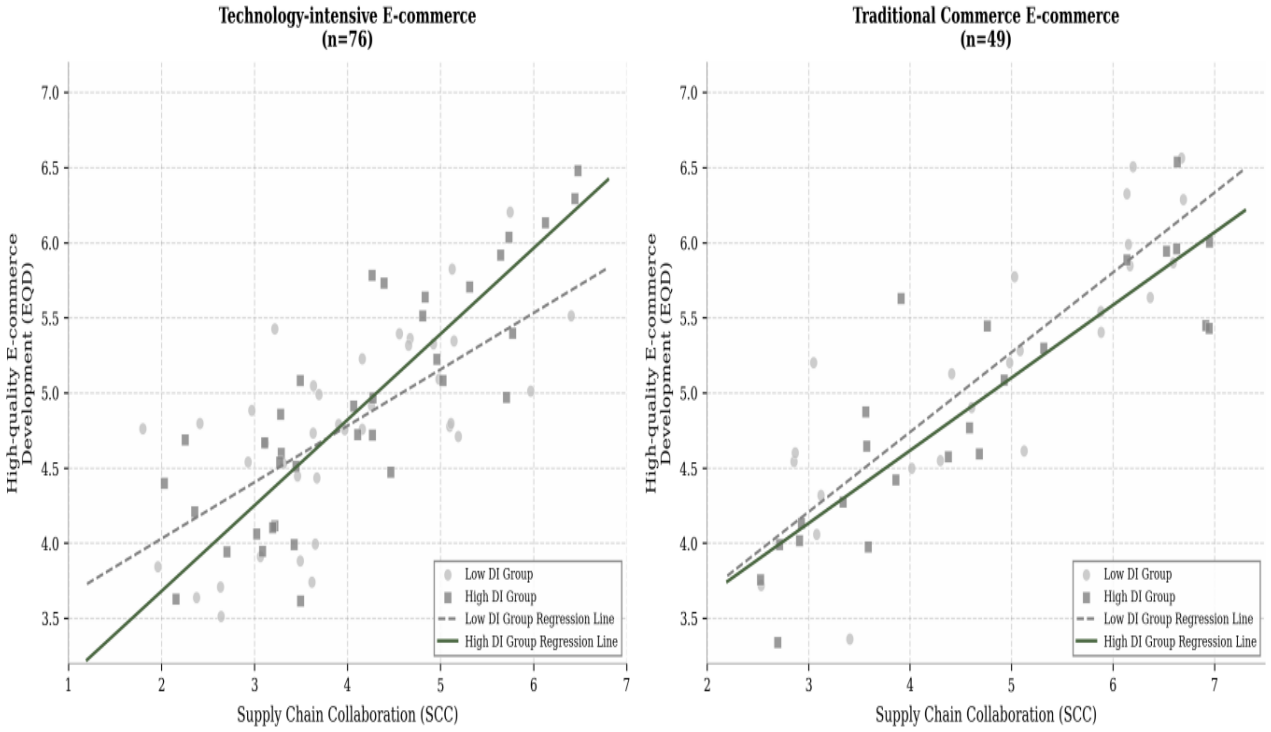


Fig. 4 Analysis of industry heterogeneity: moderating effect of DI in different industry types

4. Conclusion

The research results show that supply chain collaboration has a significant positive impact on the high-quality development of e-commerce ($\beta=0.476$, $p<0.001$), supporting the research hypothesis H1, which is consistent with previous conclusions. It is pointed out that supply chain collaboration enhances competitiveness through mechanisms such as information sharing, decision-making synchronization and goal consistency. This study supplements the empirical evidence with micro-level data on Chinese e-commerce firms. More importantly, the level of digital infrastructure positively regulates the relationship between the two ($\beta=0.065$, $p=0.011$), supporting hypothesis H2. This finding has theoretical and practical significance. Digital infrastructure provides technical support and data guarantee for collaboration, and high-level facilities make information sharing more efficient and amplify synergy effects. At the same time, it echoes the "digital enablement" theory, that is, digital technology can be used as a capability amplifier. Industry heterogeneity analysis shows that this moderating effect is more significant in technology-intensive e-commerce and weaker in traditional commercial e-commerce. The reason is that the former relies on real-time data interaction and intelligent decision-making, and digital improvements can release synergy effects to a greater extent. The latter has a traditional business model and low dependence.

The limitation of this study is that the sample size is relatively small. Although it meets the minimum requirements of the structural equation model, expanding the sample can improve the robustness. Using cross-sectional data, it is difficult to infer causal relationships and dynamic evolution. Based on these suggestions: First, strengthen supply chain collaboration, establish a regular

information sharing mechanism, carry out demand forecasting and inventory management, and ensure consistent goals and coordinated actions. Second, improve digital infrastructure, increase investment in cloud computing and big data, build a data governance system, and achieve effective integration of internal and external data. Third, by implementing industry-specific policies, technology-intensive e-commerce companies should strengthen real-time data interaction and intelligent decision-making. Traditional commercial e-commerce companies should popularize basic digital facilities. Future research can use panel or tracking data to observe long-term effects, and further examine other boundary conditions such as organizational flexibility and environmental uncertainty.

Authors Contribution

All the authors contributed equally and their names were listed in alphabetical order.

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