

Regional Digital Economy Development, Information Asymmetry, and Enterprise Supply Chain Transparency: An Empirical Study Based on Chinese Listed Companies

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Abstract. The digital economy is an important supporting force for the high-quality development of contemporary economy. Based on the panel data samples of A-share listed companies in Shanghai and Shenzhen Stock Exchanges from 2008 to 2020, this paper empirically tests the impact of regional digital economy development on the transparency of enterprise supply chain. Research discoveries: The development of regional digital economy has reduced information asymmetry among enterprises, and enterprises no longer have to bear risks to disclose important information, thereby reducing the transparency of their supply chain; Heterogeneity testing found that: (1) the development of the digital economy has a significant inhibitory effect on the supply chain information disclosure of upstream or downstream enterprises in the industry value chain; (2) This effect is greater upstream in the industry value chain; (3) The digital economy development level of enterprises in the eastern, central, and northeastern regions of China has reduced their supply chain information disclosure. The research conclusion of this article is helpful in analyzing the policy effectiveness of current corporate information disclosure regulations, and also provides a basis for the subsequent formulation of relevant disclosure policies.

Keywords: Digital economy, information asymmetry, supply chain transparency.

1. Introduction

The Ministry of Ecology and Environment issued the "Reform Plan for the Legal Disclosure System of Environmental Information" in 2021, and issued supporting documents such as the "Management Measures for Legal Disclosure of Enterprise Environmental Information". The document sets clear requirements for the legal disclosure of environmental information after the reform: First, the subject that meets the requirements of the Administrative Measures must be forced to disclose in accordance with the law. Second, the disclosure subject, disclosure content, disclosure form and time limit are clearly stipulated, mainly solving the problems of diffusion of responsibility disclosure responsibilities, fragmented content, insufficient supervision, low information quality, and difficult access to information. Real, accurate, and complete disclosure of corporate environmental information is the foundation for promoting the modernization of the environmental governance system and an important foundational work for promoting ecological civilization construction. Enterprises are bound to attach great importance to environmental information disclosure to a new level. Therefore, corporate information disclosure is a major hot topic in society, and the country attaches great importance to guiding enterprises to correctly disclose information. In addition, the "14th Five Year Plan for the Development of the Digital Economy" issued by the State Council emphasizes the need to vigorously develop the digital economy to reduce information asymmetry.

The current academic research on this issue mostly focuses on exploring the impact of the digital economy on enterprise development, or exploring the influencing factors of enterprise information disclosure, which play a role in promoting urban activity, only playing a role in promoting urban activity, Or the relationship between information disclosure and information asymmetry of listed companies. For example, other scholars have explored the impact of the digital economy on the innovation and development of enterprises: Qiu Yangdong's (2022) study found that the development of the digital economy has an increasing effect on the number of authorized invention patents and non-invention patents for enterprises, and the enhancement effect on invention patents is stronger

overall; Jiang Dianchun and Pan Xiaowang (2022) also believe that digital economy can promote enterprise innovation by easing the financing constraints and resource constraints of enterprises, increasing R&D investment, promoting the flow of capital elements and talent gathering, promoting industry university research cooperation and technology diversification, improving the level of informatization, reducing the concentration ratio of supply chain, expanding enterprise knowledge network and university knowledge transfer and other paths; Some scholars have also explored the impact of the digital economy on corporate risk: Chen Qian and Qi Yong (2022) found that the development of the digital economy is beneficial for enhancing the risk bearing capacity of enterprises; In addition, Li Yongkui and Liu Xiaokang (2023) also empirically found that the development of the digital economy has a significant inhibitory effect on the probability of financial risks occurring in enterprises. Some scholars have explored the influencing factors of corporate information disclosure: Knox et al., Shen Hongtao, Ma Lianfu, and Zhao Ying found a positive correlation between company size and corporate social responsibility information disclosure when exploring the impact of company size on corporate information disclosure. This is because large companies are more willing to actively disclose corporate social responsibility information in order to maintain a good image in front of the public; In addition, Huang Yue, Lei Fang, and Tang Dingyue (2022) found in their exploration of the influencing factors of corporate environmental information disclosure that the continuous promotion of ecological civilization construction and reform also has a positive promoting effect on corporate environmental information disclosure. The above studies did not directly focus on the relationship between the development of digital economy, information asymmetry, and supply chain transparency in enterprise regions. However, there is an inevitable logic behind the impact of regional digital economy development on enterprise information disclosure.

Based on this, this article systematically discusses the impact of regional digital economy development on the level of important information disclosure in enterprise supply chains, aiming to fill the research gap in existing literature. The core conclusion of this study is that the development of regional digital economy has reduced the transparency of enterprises' supply chain. The mechanism is that the development of the digital economy has reduced information asymmetry among enterprises, and enterprises no longer have to bear risks to disclose important information, thereby reducing information disclosure in the supply chain dimension of enterprises. The further heterogeneity discussion results indicate that, firstly, economic development has a greater inhibitory effect on the supply chain information disclosure of upstream enterprises in the industry value chain; Secondly, the digital economy development level of enterprises in the eastern, central, and northeastern regions of China has reduced their supply chain information disclosure.

Compared with existing research, the main contributions of this article are as follows: firstly, this article provides important explanations for the impact of corporate information disclosure from the perspective of digital economy development for the first time, enriching the research on the influencing factors of corporate information disclosure strategic decision-making; Secondly, the discussion in this article also enriches the discussion on the economic consequences of the development of the digital economy. Based on the perspective of jurisdictional enterprises, this article links the digital economy with information disclosure of enterprises, revealing the profound impact of the development of the digital economy. Thirdly, this article not only explores the impact of the development of the digital economy on the supply chain information disclosure of upstream and downstream enterprises in the industry value chain, as well as strong and weak enterprises, but also delves into the impact of the development of the digital economy on enterprise information disclosure in different regions of China.

2. Literature Review and Theoretical Hypothesis

With the rapid development and application of emerging digital technologies such as big data, artificial intelligence, cloud computing, and mobile internet at various levels of the economy and society, human society is accelerating into the digital economy era. Unlike traditional economies, the

digital economy breaks the temporal and spatial constraints of the connections between economic entities. For enterprises, the digital economy fundamentally reshapes the way and structure of enterprise development through paths such as resource sharing and inclusive win-win. Specifically, on the one hand, the application of digital technology can greatly reduce information asymmetry in enterprises; On the other hand, the development of the digital economy has also had a profound impact on enterprise innovation behavior.

2.1. The digital economy reduces information asymmetry in enterprises

The digital economy has significantly improved the transparency and quality of various information disclosed by enterprises. The application of digital information technology can enable enterprises to collect user data more effectively and quickly, and integrate various information flow, capital flows and logistics that occur in the production process of enterprises through digital technology, breaking the horizontal information barriers between enterprises and users and the vertical information barriers within the industry, thus effectively reducing the cost of information search. In addition, the widespread application of digital technology has also led to stronger flexibility and liquidity of information in the capital market, significantly reducing information asymmetry among participating entities, improving communication efficiency, and thus reducing the hindering effect of information asymmetry in enterprise innovation projects.

2.2. The Digital Economy Promotes the Development of Enterprise Innovation Behavior

Digital technology promotes the innovative development of the real economy through investment innovation, product innovation, process innovation, market innovation, and organizational innovation, thereby demonstrating value-added effects and promoting enterprise transformation, upgrading, and high-quality development. Digital technology can deeply penetrate into the products, services, and operational core of enterprise organizations, fundamentally changing the essence of product and service innovation, and improving the scientific nature of enterprise innovation decision-making. The innovation effect of the digital economy is not only reflected in its ability to influence the innovation results of the real economy, but also in the way various innovation entities participate in innovation and the execution process, thus presenting a dynamic and sustainable innovation process. Firstly, the digital economy promotes innovation in enterprise organizational operations, enriches and expands the mechanisms and pathways of corporate governance: data and information have become key production factors, accelerating the cultivation of data factor markets, leveraging the basic resource and innovation engine role of data, and improving digital governance capabilities have become a trend. Big data significantly improves the accuracy and effectiveness of capital allocation decisions through high granularity data support. While optimizing resource allocation and improving production efficiency, they can supervise management to regulate their own behavior, regulate subjective judgments and even distort and manipulate the space in the decision-making process, and improve the level of corporate governance. Secondly, the digital economy promotes green innovation practices in enterprises: The development of the digital economy has greatly improved the operational efficiency of companies in areas such as information sharing, knowledge integration, and financial technology. Enterprises can not only use digital information technology to monitor pollution emissions, integrate resources, make scientific decisions, and reduce energy consumption, but also accumulate data resources during this period to form technical support for green innovation.

One of the important decisions of a company is how to disclose information. At present, the main influencing factors of information disclosure of listed companies include policies and regulations related to information disclosure, corporate governance, and business performance. These three factors will have a certain impact on the information disclosure of listed companies.

2.3. Relevant policies and systems for information disclosure

The accounting information disclosure system regulates the manifestation of the disclosed information, such as what to disclose, how to disclose, when to disclose, etc; Accounting standards

regulate the substance of the disclosed accounting information, such as how accounting generates accounting information that meets user needs and has a certain quality through specific procedures. For example, under the "dual carbon" strategic goal, guiding enterprises to orderly complete green transformation and achieve coordinated development of ecology and economy is an important issue that urgently needs to be studied and solved. The green credit policy starts from the perspective of credit resource allocation, strengthens external supervision of enterprise environmental pollution behavior, guides enterprises to more actively assume environmental responsibility and disclose environmental information.

2.4. Corporate governance structure

Corporate governance structure is one of the decisive factors in accounting information disclosure. A sound corporate governance structure can not only promote the timeliness of accounting information disclosure and the consistency of accounting information disclosure foundation, but also enhance the systematization of enterprise financial strategic information, contribute to the standardized operation of the capital market, promote the level of enterprise management, and form a virtuous cycle.

2.5. Business performance

The performance of a company may determine its motivation for disclosing environmental information. For the vast majority of investors, financial accounting information of listed companies is the most direct and primary source for investors in the securities market. Listed companies prepare financial and accounting reports and publicly disclose the financial status and operating results of the listed company. Investors use this financial accounting information to make investment decisions that are beneficial to them. Due to the signaling effect, some studies have shown that companies with better financial conditions have higher levels of information disclosure, and compared to companies with poorer financial conditions, companies with better financial conditions also have less motivation to engage in financial fraud. According to relevant research, companies with better expected earnings performance are less likely to violate disclosure rules, while companies with higher debt ratios are more likely to violate disclosure rules.

Therefore, this article assumes that information asymmetry significantly promotes the disclosure of supply chain information for enterprises, and the development of regional digital economy reduces information asymmetry for enterprises, thereby reducing the transparency of the supply chain for enterprises; After further distinguishing the characteristics, the study found that the development of the digital economy has a more significant promoting effect on reducing enterprise supply chain disclosure in small and medium-sized enterprises as well as upstream enterprises in the supply chain.

3. Sample Descriptive Statistics and Empirical Model Setting

3.1. Sample selection and data sources

In order to test the theoretical hypothesis proposed earlier, while considering the availability and sample representativeness of various indicators for enterprises, this article uses all A-share listed company panels from the Shanghai and Shenzhen stock markets from 2008 to 2020 as the original samples. The original sample data of listed companies are all from the Guotai An CSMAR database and merged. The further screening process of the samples is as follows: Firstly, due to the differences in financial statements between the financial industry and other enterprises, this article selects samples based on the CSMAR industry code, excluding the financial industry samples; Secondly, exclude samples from ST companies during the research period, and thirdly, exclude samples with an asset liability ratio greater than 1; Finally, in order to eliminate the impact of extreme values on empirical analysis, this article applies a 1% shrinking treatment to all continuous variables.

3.2. Supply chain transparency

Referring to the research paradigm of Gong Xiaoyun et al. (2022), this article constructs a supply chain transparency indicator. Specifically, some companies did not disclose the specific situation of their supply chain, and did not disclose specific names, including the use of symbols without information content (such as first supplier, supplier A, customer A) that were not mentioned or mentioned. Based on this, construct the core explanatory variable SCT_ Raito conducts empirical analysis: its construction method is the proportion of the trading volume of large suppliers and customers whose names are clearly disclosed by listed companies to the total trading volume of the top five suppliers and customers. The larger the value, the higher the transparency of the enterprise's supply chain. Furthermore, in order to ensure the robustness of the core explanatory variable measurement, this paper also constructs the number of major suppliers and customers that disclose specific names SCT_ Num, and whether the top five suppliers or customers' specific information SCT was disclosed in the current year_ The two indexes of Dum were tested for robustness.

3.3. Development of urban digital economy

Following the construction ideas of Zhao Tao et al. (2020) and Zhao Xiaoyang and Yi Changjun (2022), this article constructs the level of regional digital economy development from two aspects: urban level internet development and digital inclusive finance. Specifically, the principal component analysis method is used to standardize and reduce the dimensionality of five indicators at the city level: the number of internet broadband access users per 100 people, the number of mobile phone users per 100 people, the proportion of computer services and software industry employees, the total per capita telecommunications business volume, and the digital finance inclusive index. Finally, a comprehensive indicator of the development level of the digital economy is calculated. Among them, the regional digital inclusive finance index is derived from the "Research Report on Digital Inclusive Finance Index" compiled by the Digital Finance Center of Peking University. The other indicators are sourced from the "Urban Statistical Yearbook" over the years.

3.4. Empirical Model Setting

In order to test the above theoretical hypothesis, this paper will use the panel data of listed companies to build a two-way fixed effect model for empirical analysis to study how the transparency of enterprise supply chain is affected by the development of the digital economy. The specific empirical model is shown in equation (1):

$$STC_{ict} = \alpha_0 + \alpha_1 Digit_City_{ct} + \alpha_2 X_{it} + Year_FE + Industry_FE + \varepsilon_{ict} \quad (1)$$

Among them, the subscripts i, c, and t respectively represent the listed company, city, and fiscal year. Explained variable STC_{ict} represents the supply chain transparency of listed company i in year t, $Digit_City_{ct}$ is the core explanatory variable of this article, which is the level of digital economy development in city c in year t. Therefore, α_1 is the core parameter to be estimated that this article focuses on. In addition, X_{it} is a series of control variables used to control various financial and governance characteristics at the enterprise level to ensure the accuracy of core estimated parameters. $Year_FE$ and $Industry_FE$ refers to year fixed effects and domain fixed effects, respectively. ε_{it} is the perturbation term of the model. In order to prevent the issue of heteroscedasticity from affecting the reliability of our empirical results, all statistical inferences in this article are discussed based on the robust standard error of heteroscedasticity. In summary, this article will use a bidirectional fixed effects model to rigorously empirically analyze the theoretical assumptions proposed earlier.

3.5. Selection of control variables

Considering that other factors of the enterprise may also have potential significant impacts on enterprise innovation, in order to prevent endogeneity issues caused by missing variables, this article selects a series of enterprise characteristic indicators as control variables. Referring to the existing literature, the enterprise level control variables in this paper include: enterprise size (Size, measured

by the natural logarithm of the total assets of listed companies at the end of the current year), enterprise asset liability ratio (Leverage, measured by the proportion of total liabilities of listed companies at the end of the current year in total assets), enterprise age (Age, measured by the number of years the company has been listed), enterprise operating performance (ROA, measured by the return on assets of listed companies in the current year) Fixed assets scale (Fix, measured by the proportion of fixed assets of the listed company in the current year), cash ratio (Cash, measured by the ratio of cash held by the listed company in the current year), equity concentration ratio (Top3, measured by the shareholding ratio of the top three shareholders of the listed company in the current year), family enterprise (Family, if the listed company is a family enterprise, take 1, otherwise 0), enterprise ownership (SOE, measured by whether the listed company is a state-owned enterprise). Table 1 shows the types, names, and detailed definitions of each variable. Table 2 presents descriptive statistics for each variable.

Table 1. Detailed Definition of Variables

Variable type	Variable Name	Variable code	Variable Definition Description
Dependent variable	Supply chain transparency	STC	The proportion of trading volume of major suppliers and customers whose names are clearly disclosed by listed companies to the total trading volume of the top five major suppliers and customers
Core explanatory variables	Development of urban digital economy	<i>Digit_City</i>	Construct five indicators at the urban level: the number of internet broadband access users per 100 people, the number of mobile phone users per 100 people, the proportion of computer services and software industry employees, the total per capita telecommunications business, and the digital finance inclusive index using principal component analysis
Enterprise control variables	Enterprise size	Size	ln (total assets of the enterprise at the end of the year)
	Enterprise asset liability ratio	Leverage	The proportion of total liabilities to total assets of the enterprise in the current year
	Age of listing of enterprises	Age	Years of listing of enterprises
	Business performance	ROA	Return on assets of the enterprise in the current year
	Fixed asset scale	Fix	The proportion of fixed assets to total assets of the enterprise in the current year
	Cash ratio	Cash	Cash holding ratio of the enterprise in the current year
Enterprise control variables	Enterprise equity concentration ratio	Top3	Shareholding ratio of the top three shareholders of the enterprise in the current year
	Is it a family business	Family	Virtual variable: If the enterprise belongs to a family business, assign a value of 1, otherwise take 0
	Enterprise ownership	SOE	Virtual variable: If the enterprise belongs to a state-owned enterprise, assign a value of 1, otherwise take 0

Table 2. Detailed Descriptive Statistics of Each Variable

	sample size	mean value	standard deviation	minimum value	median	Maximum value
SCT_Ratio	13759	0.283	0.439	0	0	1
Digit city	13759	0.279	0.199	0.019	0.217	0.881
Size	13759	22.304	1.279	19.552	22.137	26.231
Leverage	13759	0.433	0.202	0.032	0.425	0.936
Age	13759	10.444	7.212	0	10	26
ROA	13759	0.56	0.463	-0.019	0.483	2.696
Fix	13759	0.219	0.161	0.002	0.187	0.716
Cash	13759	1.019	1.626	0.046	0.545	24.524
Top3	13759	0.501	0.160	0.06	0.5	0.983
Family	13759	0.377	0.485	0	0	1
SOE	13759	0.399	0.490	0	0	1

4. Empirical results

4.1. Benchmark regression

The benchmark regression results of empirical model equation (1) in this article are shown in Table 3. Among them, the dependent variables in Table 3 are all the supply chain transparency(SCT_Ratio). The core explanatory variable is the level of digital economy development in the city where the listed company is located(Digit_ city). Among them, column (1) does not control for any control variables, industry and year fixed effects, and column (2) further two fixed effects. Finally, add the above control variables to column (3). From the stepwise regression results, it can be seen that the estimated coefficients of Digit_city are -0.171, -0.135, and -0.108, respectively, and are significantly negative at the 1% statistical level. This indicates that the better the development of regional digital economy, the more inclined enterprises are to conceal supply chain information, thus confirming the theoretical hypothesis mentioned earlier.

Table 3. Benchmark Stepwise Regression Results

	(1)	(2)	(3)
dependent variable: SCT_Ratio	SCT_Ratio	SCT_Ratio	SCT_Ratio
Digit_city	-0.171*** (0.019)	-0.135*** (0.018)	-0.108*** (0.018)
Size			-0.037*** (0.004)
Leverage			0.078*** (0.026)
Age			0.006*** (0.001)
ROA			-0.007 (0.010)
Fix			0.097*** (0.027)
Cash			0.001 (0.003)
Top3			-0.023 (0.025)
Family			0.009 (0.009)
SOE			0.017* (0.010)
Constant	0.331*** (0.007)	0.321*** (0.006)	1.027*** (0.072)
Year FE	NO	YES	YES
Industry FE	NO	YES	YES
Observations	13,759	13,759	13,759
R-squared	0.006	0.140	0.154

Note: The observed values are at the enterprise level. The robust standard error of heteroscedasticity is shown in parentheses. ****, **, * respectively represent significant statistical levels at 1%, 5%, and 10%. Year FE and Industry FE refer to year fixed effects and industry fixed effects, respectively. 'YES' represents controlling the fixed effect, while 'NO' represents not controlling the fixed effect.

4.2. Robustness test

The benchmark empirical results above have been obtained, and this part of this paper will conduct a robustness test on this core conclusion. Firstly, replace the measurement of transparency in enterprise supply chain information disclosure. In the benchmark analysis, the proportion of the trading volume of large suppliers and customers whose names are clearly disclosed by listed companies to the total trading volume of the top five suppliers and customers. The higher this value, the higher the transparency of the enterprise's supply chain. In the discussion group of this section, this paper further constructs two indicators, namely, the number of major suppliers and customers who disclose specific names(SCT_Num), and whether to disclose specific information of the top five suppliers or customers in the same year(SCT_Dum), to conduct robustness tests.

The empirical results of replacing the transparency measurement of enterprise supply chain information disclosure are shown in Tables 5 and 6, respectively. Similarly, column (1) in the two tables does not control for any control variables, industry and year fixed effects, while column (2) further controls for two fixed effects. Finally, add the above control variables to column (3). The estimated coefficients of the core explanatory variables(Digit_city)in all empirical results are significantly negative at the 1% statistical level. This indicates that the core conclusion of this article is highly robust.

Table 4. Robustness Test I: Impact of Digital Economy Development on SCT_Num

	(1)	(2)	(3)
dependent variable:	SCT_Num	SCT_Num	SCT_Num
Digit_city	-1.347*** (0.167)	-1.044*** (0.165)	-0.820*** (0.164)
Size			-0.342*** (0.031)
Leverage			0.625*** (0.230)
Age			0.048*** (0.006)
ROA			-0.006 (0.091)
Fix			0.806*** (0.241)
Cash			0.022 (0.025)
Top3			-0.262 (0.225)
Family			0.114 (0.084)
SOE			0.053 (0.093)
Constant	2.741*** (0.058)	2.657*** (0.057)	9.312*** (0.634)
Year FE	NO	YES	YES
Industry FE	NO	YES	YES
Observations	13,759	13,759	13,759
R-squared	0.005	0.088	0.102

Note: The observed values are at the enterprise level. The brackets indicate the robust standard error of heteroscedasticity. ****, **, and * respectively indicate significant statistical levels at 1%, 5%, and 10%. Year FE and Industry FE refer to year fixed effects and industry fixed effects, respectively. 'YES' represents controlling the fixed effect, while 'NO' represents not controlling the fixed effect.

Table 5. Robustness Test II: Impact of Digital Economy Development on SCT_Dum

dependent variable:	(1) SCT_Dum	(2) SCT_Dum	(3) SCT_Dum
Digit_city	-0.179*** (0.020)	-0.139*** (0.019)	-0.113*** (0.019)
Size			-0.036*** (0.004)
Leverage			0.079*** (0.027)
Age			0.006*** (0.001)
ROA			-0.009 (0.011)
Fix			0.086*** (0.028)
Cash			0.002 (0.003)
Top3			-0.024 (0.027)
Family			0.011 (0.010)
SOE			0.017 (0.011)
Constant	0.361*** (0.007)	0.350*** (0.007)	1.041*** (0.076)
Year FE	NO	YES	YES
Industry FE	NO	YES	YES
Observations	13,759	13,759	13,759
R-squared	0.006	0.136	0.149

Note: The observed values are at the enterprise level. The brackets indicate the robust standard error of heteroscedasticity. ****, **, and * respectively indicate significant statistical levels at 1%, 5%, and 10%. Year FE and Industry FE refer to year fixed effects and industry fixed effects, respectively. 'YES' represents controlling the fixed effect, while 'NO' represents not controlling the fixed effect.

Secondly, further replace the estimation model. The benchmark model in this paper is a two-way fixed effect model, but because of the core explanatory variable, the transparency distribution of the supply chain cannot be negative, that is, there is truncation. Therefore, this paper further tests the robustness based on the panel Tobit of the restricted dependent variable model.

The results of panel Tobit estimation are shown in Table 6, with all columns controlling for all control variables, years, and industry fixed effects mentioned earlier. The dependent variable of column (1) is SCT_Ratio, the dependent variable of column (2) is SCT Num, and the dependent variable of column (3) is SCT_Dum. From the results of Table 6, it can be seen that the estimated coefficients of regional digital economy development are still significantly negative, indicating that after changing the model, the conclusion of this article is still robust: that is, the higher the level of regional digital economy development, the lower the transparency of enterprise supply chain.

Table 6. Robustness Test III: Panel Tobit Estimation

dependent variable:	(1) SCT_Ratio	(3) SCT_Num	(5) SCT_Dum
Digit_city	-0.082*** (0.029)	-0.562** (0.266)	-0.077** (0.031)
Size	-0.037*** (0.005)	-0.376*** (0.046)	-0.038*** (0.005)
Leverage	0.097*** (0.028)	0.750*** (0.251)	0.091*** (0.030)
Age	0.006*** (0.001)	0.062*** (0.009)	0.007*** (0.001)
ROA	-0.007 (0.011)	-0.012 (0.094)	-0.010 (0.011)
Fix	0.073** (0.032)	0.618** (0.288)	0.083** (0.034)
Cash	0.003 (0.002)	0.052** (0.021)	0.004 (0.003)
Top3	-0.081** (0.033)	-0.228 (0.296)	-0.078** (0.035)
Family	0.010 (0.014)	0.086 (0.128)	0.011 (0.015)
SOE	0.025* (0.015)	0.048 (0.135)	0.020 (0.016)
Constant	1.235*** (0.117)	10.315*** (1.062)	1.283*** (0.123)
Year FE	YES	YES	YES
Industry FE	YES	YES	YES
Observations	13,759	13,759	13,759
Number of scode	2,569	2,569	2,569

Note: The observed values are at the enterprise level. The brackets indicate the robust standard error of heteroscedasticity. ****, **, * and * respectively indicate significant statistical levels at 1%, 5%, and 10%. Year FE and Industry FE refer to year fixed effects and industry fixed effects, respectively. 'YES' represents controlling the fixed effect, while 'NO' represents not controlling the fixed effect.

4.3. Heterogeneity analysis

Firstly, discuss the heterogeneity of the position of the enterprise's industry value chain. Referring to Yao Dongmin et al. (2022)'s measurement method of unknown industry value chain, this article uses the "upstream degree" indicator obtained by quantifying the distance between products in each industry and final consumption through added value to define the embedding position of the company's industry value chain. Specifically, if the company is located in the energy, metal smelting, chemical products and other raw material supply industries, it indicates that the industry it is in is farther away from the consumer end and is located at the top of the industry value chain. The Position value is 1, and vice versa (in the middle and lower reaches), it is 0. Table 7 shows the comparison of sub samples for the discussion of supply chain location heterogeneity. Among them, the subsamples of column (1) are enterprises located upstream of the industry value chain, and the subsamples of column (2) are enterprises located downstream of the industry value chain. All the explanatory variables of the column are SCT Ratio and control for all the control variables, years, and industry fixed effects mentioned earlier. From the results, it can be seen that the estimated coefficients of Digit_city are -0.135 and -0.076, respectively, and both are significantly negative at the 1% statistical level. This indicates that: (1) the development of the digital economy has a significant inhibitory effect on the supply chain information disclosure of upstream or downstream enterprises in the industry value chain; (2) This effect is greater upstream in the industry value chain.

Table 7. Discussion on Supply Chain Location Heterogeneity

Dependent variable:	(1) SCT_Ratio	(2) SCT_Ratio
	Upstream of the industry value chain	Downstream of the industry value chain
Digit_city	-0.135*** (0.026)	-0.076*** (0.025)
Size	-0.025*** (0.006)	-0.050*** (0.004)
Leverage	0.062 (0.040)	0.090*** (0.033)
Age	0.007*** (0.001)	0.005*** (0.001)
ROA	-0.016 (0.016)	0.007 (0.013)
Fix	0.176*** (0.040)	-0.036 (0.037)
Cash	-0.000 (0.004)	0.001 (0.004)
Top3	0.046 (0.039)	-0.091*** (0.032)
Family	-0.042*** (0.015)	0.040*** (0.012)
SOE	-0.004 (0.017)	0.025** (0.013)
Constant	0.753*** (0.119)	1.337*** (0.090)
Year FE	YES	YES
Industry FE	YES	YES
Observations	5,381	8,378
R-squared	0.187	0.145

Note: The observed values are at the enterprise level. The brackets indicate the robust standard error of heteroscedasticity. * * *, * *, * respectively represent significant statistical levels at 1%, 5%, and 10%. Year FE and Industry FE represent fixed effects for the year and industry, respectively. "YES" represents controlling for the fixed effect, and "NO" represents not controlling for the fixed effect.

Second, consider the potentially important heterogeneity of enterprises' market power. Referring to Sun Xiaohua et al. (2020), this article uses product pricing power, which is the difference between main business income and main business costs, sales expenses, and management expenses, and then divides it by main business income. On this basis, this paper defines the dummy variable of the company's market power as PCM, that is, if the company's Lerner index in the current year is higher than the industry median, it indicates that the company's market power is large, and PCM is 1, otherwise it is 0.

Table 8 shows the sub sample analysis of the discussion on the heterogeneity of enterprises' market power. Among them, the subsample of column (1) is enterprises with strong market power, and the subsample of column (2) is enterprises with weak market power. The explanatory variables of all columns are SCT_Ratio, which controls all the control variables, years and fixed effects of the industry mentioned above. The results show that the estimated coefficients of Digit_city are -0.073 and -0.136 respectively, which are also significantly negative at the statistical level of 1%, which indicates that: (1) the development of digital economy has a significant inhibitory effect on enterprises of different market power; (2) This effect is more significant in enterprises with weak market power. Therefore, for those vulnerable enterprises, in the development of the digital economy, they will not provide additional information to competitors and increase the company's proprietary costs.

Table 8. Discussion on heterogeneity of market power

Dependent variable:	(1)	(2)
	SCT_Ratio	SCT_Ratio
	Strong market power	Weak market power
Digit_city	-0.073*** (0.025)	-0.136*** (0.026)
Size	-0.038*** (0.006)	-0.037*** (0.005)
Leverage	-0.007 (0.041)	0.135*** (0.035)
Age	0.006*** (0.001)	0.005*** (0.001)
ROA	-0.092*** (0.025)	0.013 (0.012)
Fix	0.023 (0.040)	0.153*** (0.036)
Cash	-0.004 (0.003)	0.009* (0.005)
Top3	-0.058 (0.037)	-0.001 (0.034)
Family	0.042*** (0.013)	-0.024* (0.013)
SOE	0.038** (0.015)	-0.006 (0.014)
Constant	1.130*** (0.117)	0.987*** (0.093)
Year FE	YES	YES
Industry FE	YES	YES
Observations	6,146	7,613
R-squared	0.171	0.152

Note: The observed values are at the enterprise level. The brackets indicate the robust standard error of heteroscedasticity. ***, **, * respectively represent significant statistical levels at 1%, 5%, and 10%. Year FE and Industry FE represent fixed effects for the year and industry, respectively. "YES" represents controlling for the fixed effect, and "NO" represents not controlling for the fixed effect.

Thirdly, China has a vast territory, numerous administrative divisions, and uneven distribution of resources, resulting in significant differences in the level of economic development among different regions. There are significant differences in the economic environment, institutional policies, and industrial agglomeration phenomena among different regions. Therefore, regional heterogeneity is also a very important aspect. Based on this, Table 9 further discusses in detail the regional heterogeneity of enterprises. Columns (1) - (4) of Table 9 respectively examine the impact of digital economy development on the transparency of enterprise supply chain information for enterprises located in the eastern, central, western, and northeastern regions. From the results, it can be seen that except for the western region, the digital economy development level of enterprises in the eastern, central, and northeastern regions has reduced their supply chain information disclosure. This effect is most significant in the Northeast region, followed by the Central region, and even lower in the Eastern region. Therefore, there is significant regional heterogeneity in the impact of the digital economy.

Table 9. Discussion on Regional Heterogeneity of Enterprises

Dependent variable:	(1) SCT_Ratio	(2) SCT_Ratio	(3) SCT_Ratio	(4) SCT_Ratio
	Eastern region	Central region	Western region	Northeast region
Digit_city	-0.059*** (0.020)	-0.422** (0.175)	0.016 (0.118)	-1.214*** (0.316)
Size	-0.034*** (0.004)	-0.068*** (0.010)	-0.014 (0.010)	-0.025 (0.017)
Leverage	0.054* (0.031)	0.121* (0.073)	0.064 (0.071)	-0.045 (0.119)
Age	0.007*** (0.001)	0.006*** (0.002)	0.003* (0.002)	0.007** (0.003)
ROA	-0.028** (0.012)	-0.016 (0.026)	0.017 (0.030)	0.091** (0.043)
Fix	-0.008 (0.033)	0.252*** (0.075)	0.274*** (0.067)	0.186* (0.113)
Cash	-0.004 (0.003)	0.012 (0.011)	0.011 (0.010)	0.019** (0.009)
Top3	0.044 (0.030)	0.032 (0.075)	-0.241*** (0.066)	-0.038 (0.119)
Family	-0.007 (0.011)	0.066** (0.028)	0.101*** (0.027)	-0.098** (0.046)
SOE	-0.031** (0.013)	0.092*** (0.028)	0.078*** (0.026)	-0.005 (0.047)
Constant	0.948*** (0.086)	1.665*** (0.214)	0.531*** (0.199)	0.988*** (0.354)
Year FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES
Observations	9,318	1,892	1,862	687
R-squared	0.151	0.202	0.214	0.241

Note: The observed values are at the enterprise level. The brackets indicate the robust standard error of heteroscedasticity. * * *, * *, * respectively represent significant statistical levels at 1%, 5%, and 10%. Year FE and Industry FE represent fixed effects for the year and industry, respectively. "YES" represents controlling for the fixed effect, and "NO" represents not controlling for the fixed effect.

4.4. Mechanism analysis

The core theory of this article believes that how a company makes information disclosure is one of the important decisions of the company. On the one hand, information disclosure can reduce company information asymmetry and reduce financing costs; On the other hand, information disclosure will provide additional information to competitors, increasing the company's proprietary costs and potential market risks. The application of digital economy, digital finance, and digital technology can precisely alleviate the problem of information asymmetry inside and outside enterprises, indicating that enterprises no longer need to bear risks to disclose information in the supply chain.

In order to test the potential mechanism of information asymmetry, this article refers to the approach of Wei et al. (2012), and uses the microstructure of the financial market and detailed trading data of individual stocks to extract the first principal components of liquidity ratio (LR), non liquidity ratio (ILL), and yield reversal index (GAM) as proxy variables for information asymmetry. Referring to the relevant measurement methods of Amihud et al. (1997) and Amihud (2002), the calculation formulas for liquidity ratio and non liquidity ratio are as follows:

$$LR_{it} = -\frac{1}{D_{it}} \sum_{k=1}^{D_{it}} \sqrt{\frac{V_{it}(k)}{|r_{it}(k)|}} \quad (2)$$

$$ILL_{it} = \frac{1}{D_{it}} \sum_{k=1}^{D_{it}} \sqrt{\frac{|r_{it}(k)|}{V_{it}(k)}} \quad (3)$$

Among them, $r_{it}(k)$ represents the stock return of enterprise i on the k th trading day of year t , $V_{it}(k)$ is the total daily trading volume, D_{it} is the number of trading days in year t of enterprise i . Both liquidity ratio and non liquidity ratio identify liquidity through the interaction between buying and selling order flows and stock prices. The higher the degree of information asymmetry, the more serious the problem of adverse selection, the lower the stock liquidity, and the greater the LR and ILL. Further referring to Pastor and Stambaugh (2003), the yield reversal index is calculated by equation (4):

$$r_{it}^e(k) = \theta_{it} + \varphi_{it}r_{it}(k-1) + \gamma_{it}V_{it}(k-1)\text{sign}[r_{it}^e(k-1)] + \varepsilon_{it}(k) \quad (4)$$

Among them, $r_{it}^e(k)$ is the excess return rate, and the return reversal indicator is taken as $GAM_{it} = |\gamma_{it}|$. Similarly, the higher the degree of information asymmetry, the larger the GAM indicator. The first principal component of the three indicators is the information asymmetry indicator ASY. The larger the ASY value, the more severe the information asymmetry faced by the enterprise.

Table 10 shows the analysis and testing results of the mechanism of information asymmetry. It can be seen that the coefficient of the core explanatory variable Digit_city in column (1) is significantly negative, indicating that the development of the digital economy can significantly alleviate the degree of information asymmetry between external investors and enterprises. Column (2) shows that the estimated coefficient of ASY is significantly positive, indicating that information asymmetry significantly promotes supply chain information disclosure of enterprises. Therefore, this mechanism is supported by real data: the development of regional digital economy reduces enterprise information asymmetry, This further reduces the transparency of the enterprise's supply chain.

Table 10. Mechanism Analysis of Information Asymmetry

Dependent variable:	(1) ASY	(2) SCT_Ratio
ASY		0.008* (0.005)
Digit_city	-0.091** (0.046)	-0.115*** (0.019)
Size	-0.377*** (0.009)	-0.034*** (0.004)
Leverage	0.780*** (0.050)	0.071*** (0.027)
Age	-0.013*** (0.002)	0.006*** (0.001)
ROA	-0.012 (0.013)	-0.007 (0.011)
Fix	0.205*** (0.043)	0.102*** (0.027)
Cash	0.002 (0.004)	-0.000 (0.003)
Top3	0.964*** (0.045)	-0.030 (0.026)
Family	-0.080*** (0.026)	0.006 (0.010)
SOE	-0.046** (0.020)	0.015 (0.011)
Constant	7.721*** (0.191)	0.982*** (0.085)
Year FE	YES	YES
Industry FE	YES	YES
Observations	12,947	12,947
R-squared	0.318	0.150

Note: The observed values are at the enterprise level. The brackets indicate the robust standard error of heteroscedasticity. ***, **, * respectively represent significant statistical levels at 1%, 5%, and 10%. Year FE and Industry FE represent fixed effects for the year and industry, respectively.

"YES" represents controlling for the fixed effect, and "NO" represents not controlling for the fixed effect.

5. Conclusion and policy implications

This article uses the Shanghai and Shenzhen stock markets from 2008 to 2020

Panel data of A-share listed companies studied the relationship between regional digital economy development, information asymmetry and enterprise supply chain transparency, research has found that information asymmetry significantly promotes the disclosure of supply chain information for enterprises, and the development of regional digital economy reduces information asymmetry for enterprises, thereby reducing the transparency of the supply chain for enterprises; After further distinguishing the characteristics, the study found that the development of the digital economy has a more significant promoting effect on reducing enterprise supply chain disclosure in small and medium-sized enterprises as well as upstream enterprises in the supply chain.

Based on the above research conclusions, this article draws the following inspiration: Although increasing information disclosure on the supply chain can reduce information asymmetry and capital costs for companies, voluntary disclosure of supply chain information by companies may increase the competitive pressure and operational risks faced by companies, and have adverse effects on their future operations. Therefore, enterprises, especially small and medium-sized enterprises, are more inclined to not disclose supply chain information. However, at the same time, the situation of information asymmetry will also intensify, increasing the operating costs of enterprises. The development of regional digital economy has greatly alleviated information asymmetry, which means that enterprises no longer need to bear risks to disclose information in the supply chain. Therefore, this article believes that vigorously developing digital economy is beneficial for reducing information asymmetry, thereby reducing enterprise operating costs and capital costs. At the same time, it also reduces the risk of providing additional information to competitors due to the company's own information disclosure.

Based on the rich research conclusions of this article, Developing policies related to the digital economy for the government important implications include: firstly, high-quality information disclosure has played a positive role in helping investors more effectively judge the quality of a company's financial information, estimate its future profitability and cash flow situation, etc. Therefore, the formulation of relevant policies should guide companies to improve the quality of voluntary information disclosure; Secondly, for company information with high proprietary costs such as customer names, regulatory authorities should gradually improve policies and reasonably guide the specific content and level of detail of such information disclosure; Once again, the government should not only strengthen the information disclosure of listed companies, but also protect the legitimate rights and interests of investors, clarify the behavioral norms of other relevant parties, and require institutions and individuals not to illegally obtain and disseminate insider information of listed companies; Institutions and individuals are not allowed to fabricate or disseminate false information; Conduct norms for news media; Finally, the development of regional digital economy is conducive to reducing information asymmetry. Therefore, in the context of the continuous increase in the overall scale of the global digital economy, the government should increase investment in new infrastructure such as the Internet and artificial intelligence, help the digital economy become a new driving force for high-quality economic development, and further release the inclusive dividends of the digital economy; Especially in the upstream of the industrial chain and small and vulnerable enterprises, the formulation of relevant policies should actively play the role of the digital economy.

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