sustainability

MDPI

Article

Digital Economy, Industrial Structure, and Regional Trade Dependence: Mechanism Analysis Based on Chinese City Data

Qi Luo [1], Dantong Zhang [1] and Hao Wang [2,3,*]

[1] The Faculty of Economics, Guangdong University of Finance & Economics, Guangzhou 510320, China
[2] School of Economics and Trade, Guangdong University of Foreign Studies, Guangzhou 510006, China
[3] School of Slavonic and East European Studies, University College London, London WC1H 0BW, UK
* Correspondence: hao-wang@ucl.ac.uk

Abstract: This paper aims to study the intricate interplay among the digital economy, industrial structure, and the degree of dependence on foreign trade. We utilize panel data from 284 prefecture-level cities in China spanning from 2011 to 2019 to comprehensively evaluate the level of digital economy development and investigate its influence on regional trade dependence. Additionally, we explore the role played by the industrial structure in the mechanism analysis. Our findings reveal that the digital economy significantly reduces regional trade dependence, while industrial structure upgrading notably enhances regional trade dependence. Moreover, the industrial structure upgrading weakens the influence of the digital economy on regional trade dependence, but such impact varies across regions as the impact of digital economy on foreign trade dependence is more pronounced in inland areas. This paper also facilitates the exploration of how the digital economy empowers domestic economic growth.

Keywords: digital economy; external trade dependence; industrial structure upgrading; internal circulation

Citation: Luo, Q.; Zhang, D.; Wang, H. Digital Economy, Industrial Structure, and Regional Trade Dependence: Mechanism Analysis Based on Chinese City Data. *Sustainability* **2023**, *15*, 13055. https://doi.org/10.3390/su151713055

Academic Editor: Chin-Yi Fang

Received: 30 July 2023
Revised: 28 August 2023
Accepted: 28 August 2023
Published: 30 August 2023

1. Introduction

In recent years, the world economy confronted substantial instability and uncertainty, with noticeable weakening in global trade, investment, tourism and consumption, accompanied by increasing downward pressure on developed economies. Concurrently, China's economic growth exhibits a distinct trend, with various industries flourishing and supply and demand expanding synchronously, leading to overall improvements in economic performance. In the IMF's 2023 report [1], China was considered as the "key engine" for global economic growth, reflecting international recognition of China's stabilizing and constructive role in driving global economic recovery. As the latest dynamic driving force in China's economic and social activities, the digital economy increasingly aligns with various aspects of China's economic and social development. It plays a crucial role in propelling economic development, promoting industrial structure upgrading, and facilitating foreign trade. In 2022, China's digital economy reached a scale of CNY 50.2 trillion, ranking second globally, with its share in the GDP reaching 41.5%. This highlights the increasingly prominent role of the digital economy as a "stabilizer" in the national economy. The "14th Five-Year Plan for the Development of the Digital Economy" points out that China will deepen the implementation of the digital economy development strategy, continuously improve digital infrastructure, accelerate the cultivation of new formats and models, and make positive progress in industrial digitalization and digital industrialization [2].

Existing research demonstrates that the digital economy, by stimulating mass entrepreneurship, effectively promotes high-quality urban economic development, rationalizes industrial structure allocation, and facilitates the expansion and upgrading of import and export industries, thereby impacting regional trade development. Consequently, the question arises as to how the digital economy affects regional trade dependence. Given

the current context of considerable uncertainty, how can the development of the digital economy be harnessed to optimize urban industrial structures and enhance economic resilience? Moreover, what differences exist in the influence of the digital economy on regional trade dependence concerning its own characteristics and spatial patterns? Exploring these questions will not only effectively investigate the role of the digital economy in the development of trade dependence, but will also provide a basis for the continuous and stable development of the digital economy in China, supporting sustained and stable economic growth.

The novel contribution of this paper lies primarily in two aspects. On the one hand, it simultaneously incorporates the influence of industrial structural transformation and upgrading while examining the impact of the digital economy on foreign trade dependence. This approach avoids overemphasizing or underestimating the effects of the digital economy. On the other hand, the study utilizes city-level data instead of focusing on regional or provincial data. There could be substantial disparities in the level of digital economic development among different cities within the same province. Conducting research based on city-level data renders the outcomes more reliable and pragmatically significant.

2. Literature Review

Current literature on the relationship between the digital economy and trade dependence is still limited, with studies primarily focusing on the digital economy's impact on trade competitiveness, trade volume, high-quality trade development, and trade transformation and upgrading. Al-Badrany et al. (2023) [3] emphasized the critical importance of digital transformation in improving services and conducting activities electronically, leading to enhanced accuracy and quality [1]. In turn, it facilitates increased trade exchanges between countries, improves trade efficiency and convenience, disseminates information, and promotes coordination among different sectors. Yao et al. (2022) [4], based on moderating effects research, highlighted that the level of digital economic development significantly enhances China's trade competitiveness [2]. However, the degree of significance varies across different regions. Irrespective of the stage of digital economic development, human capital investment remains a key factor in promoting innovation output growth. Yu et al. (2021) [5], through constructing a multi-mechanism theoretical model, empirically demonstrated that the digital economy significantly promotes the complexity of China's export technologies, exhibiting a dynamic non-linear driving effect. Meanwhile, regional export trade levels are positively related to the dividends generated by the digital economy, and the digital economy's unique network effects have universal application in the real economy. Zhao et al. (2023) [6] employed threshold regression and intermediary effect models to demonstrate that the digital economy effectively promotes the high-quality development of cities' foreign trade through industrial structure upgrading. The spillover effect of this influence exhibits a marginal effect with increasing non-linearity, confirming the significant presence of Metcalfe's Law in the process of cities' foreign trade development, and points out that the increasing digitization of products and services, as well as high levels of innovation and innovative vitality, are key factors in the digital economy (Shkalenko, 2020) [7]. China's service trade exhibits a pronounced regional development imbalance. The service trade in the eastern coastal regions is considerably advanced, while its progress in the central and western areas lags relatively. In the future, the nation should intensify its support for the expansion of service trade in the central and western regions, thereby achieving a harmonious and balanced evolution of China's service trade landscape. Internet enterprises hold the potential to disrupt the monopoly of traditional financial sectors such as banking and insurance over customer information. Through the implementation of data-driven intelligent management technologies such as the internet, they could offer customers services of superior quality compared to those provided by conventional financial institutions (Sato and Hawkins, 2001) [8]. The main driving factors in the internet economy are increased market transparency and decentralization, reduced barriers to market entry and conversion, enabling increased transparency in action accountability in

foreign trade. Amidst this progression, the role of market orientation has also assumed significance. Milner and Tingley (2008) [9] distinguished market orientation as a distinctive competency, bolstering a firm's endeavors in the international market arena. In this context, an intriguing revelation surfaces—the holistic market orientation of a company exerts a positive influence on its acumen in acquiring market insights within foreign domains, as well as its allocation of resources.

Above all, the existing research does not provide a unified framework to answer the question of how the digital economy primarily enhances regional trade dependence. Therefore, this study attempts to explore this issue from the perspective of the digital economy's impact on the industrial structure (Tang et al., 2019) [10] and empirically analyze the impact of inclusive digital finance development on industrial structure upgrading based on urban data, which exhibits a non-linear change process from insignificance to significance. Additionally, different regions display distinct heterogeneity in spillover effects. (Fu et al., 2016) [11] reveal that the high level of manufacturing structure is not accompanied by high value-added production, which is a crucial reason for China's manufacturing remaining at the lower end of the global value chain for an extended period. Industrial structure upgrading ensures the promotion of sustainable economic development and further strengthens regional trade comparative advantages, thereby facilitating trade development. From this perspective, this study attempts to discuss the impact of the digital economy on regional trade dependence within the framework of an interactive model. Furthermore, this study selects the city level as the research object, allowing for the examination of the relationship between the digital economy, industrial structure, and trade dependence at a finer spatial scale.

3. Theoretical Mechanism and Research Hypotheses

3.1. The Impact Mechanism of Digital Economy on Trade Dependence

The digital economy, based on internet communication and information technology, has established a nationwide interactive platform for the network economy. It has propelled the rapid development of e-commerce in China, fostering a dual-driving phenomenon of "mass entrepreneurship and innovation" and "Internet +". This phenomenon is of significant importance as it stimulates the vitality of national production factors and consumption potential, promotes economic upgrading, and reduces the degree of dependence on foreign investment and foreign trade for economic growth. On one hand, with the rapid development of domestic e-commerce and food delivery services, enterprises are vigorously developing digital logistics systems to gain competitive advantages and market shares (Jiang et al., 2021) [12]. As a result, China now possesses a globally leading digital logistics system. Intelligent logistics greatly simplifies the overall delivery process and enhances the response capacity of the logistics system to customer demands, thereby further improving the efficiency of China's economic internal circulation. On the other hand, the digital economy breaks the information asymmetry and geographical restrictions of traditional trade, enhancing the depth and breadth of economic activities among regions and creating a new pattern of coordinated regional development (Duranton and Puga, 2003) [13]. Rather than relying solely on the eastern coastal regions to drive development, there is now a trend of regional joint development with significantly increased economic independence. The digital economy also exhibits strong social interaction, not only promoting the dissemination and accumulation of capital information but also further stimulating consumer spending and purchasing desires among the population. Therefore, this study proposes Hypothesis H1.

H1. *The development of the digital economy reduces the trade dependence of regional economies.*

3.2. The Impact Mechanism of Industrial Structure Upgrading on Trade Dependence

Industrial structure upgrading has driven the optimization of China's foreign trade structure. By integrating regional high-end technology and talent resources, industrial structure upgrading triggers changes in the production mode and basic production equip-

ment of enterprises, moving toward regions with products of higher added value and gradually moving away from low value-added regions engaged in processing and assembly activities. In recent years, the national and regional indices of industrial sophistication have significantly increased, and the gaps between eastern, central, and western regions, as well as coastal and inland regions, have narrowed. The tertiary industry has played an increasingly important role in the growth of the national economy, indicating significant optimization of the industrial structure and ongoing industrial upgrading. As a result, China's foreign trade has continuously released new driving forces and demonstrated continuous enhancement in trade transformation. This shift has changed the over-reliance on the export of simple and extensive manufacturing goods and shifted towards exports of technology-intensive and capital-intensive products and services, overall strengthening the competitiveness of foreign trade, reflected in the continuous increase in total import and export trade volume (Antonietti and Cainelli, 2011) [14]. Based on these observations, this study proposes Hypothesis H2.

H2. *Industrial structure upgrading is significantly positively correlated with trade dependence.*

3.3. The Impact of Digital Economy, Industrial Structure Upgrading and Trade Dependence

The relationship between industrial structure upgrading, the digital economy, and trade dependence has two main influences (Keller, 2002) [15]. On one hand, industrial structure transformation and upgrading to a certain extent rely on the introduction of advanced technology, thereby increasing China's trade dependence. Technological innovation is a crucial driving force and key factor for the transformation and upgrading of industrial structure, with enterprises playing a leading role in innovation and entrepreneurship in China. Reform and opening up made China aware of the gap between itself and the international advanced technology level. Relying on the introduction and absorption of foreign advanced technology to transform and upgrade traditional industries is an important reason for the rapid improvement of enterprise technological capabilities and industrial upgrading in China. In recent years, China's independent innovation and entrepreneurship capabilities have significantly strengthened, but many fields still lack relevant core technologies, and there is still a considerable gap compared to developed countries in high-tech fields. Against this background, China will continue to introduce advanced technology to promote faster innovation levels in high-tech industries. On the other hand, industrial structure upgrading enhances the competitive strength of China's service trade, relying on the digital economy to occupy a dominant position globally. This weakens the negative correlation between the digital economy and trade dependence. Industrial structure upgrading improves China's competitive advantage in high-end industrial products. At the same time, studies have found that the global value chain is more sensitive to transportation costs and logistics performance than final product trade. With the support of the digital economy, China has created a globally leading digital logistics system, further amplifying the competitive advantages of advantageous products and increasing China's international market share in export products. Based on these observations, this study proposes Hypothesis H3:

H3. *Industrial structure upgrading weakens the impact of the digital economy on trade dependence.*

4. Methods and Materials

4.1. Methods

Model

To test the direct impact of the digital economy on a city's trade dependence, the following model is constructed:

$$DEp_{it} = \beta_0 + \beta_1 Dige_{it} + \beta_3 Z_{it} + \delta_t + \mu_i + \varepsilon_{it} \quad (1)$$

where DEp_{it} represents the trade dependence of city i in period t, $Dige_{it}$ represents the level of digital economy development in city i in period t, Z_{it} represents a series of control

variables, μ_i represents the individual fixed effects of cities that do not change over time, δ_t represents the time fixed effects, and ε_{it} represents the error term. If the coefficient β_1 is positive, it indicates that the digital economy reduces the city's trade dependence, otherwise, it increases it.

To examine the impact of industrial structure upgrading on the relationship between the digital economy and trade dependence, the following model is established:

$$DEp_{it} = \alpha_0 + \alpha_1 Dige_{it} Stru_{it} + \alpha_2 Dige_{it} + \alpha_3 Stru_{it} + \alpha_4 Z_{it} + \delta_t + \mu_i + \varepsilon_{it} \quad (2)$$

where $Stru_{it}$ represents the level of industrial upgrading in city i in period t, and other variables are defined as above. If the signs of α_1 and α_2 are the same, it indicates that industrial structure upgrading strengthens the relationship between the digital economy and trade dependence; otherwise, it weakens the relationship.

4.2. Variables

4.2.1. Dependent Variable

The dependent variable is the city's trade dependence. Currently, the academic community widely uses the ratio of total import and export trade volume to Gross Domestic Product (GDP) to measure trade dependence. Some scholars argue that this measurement method does not reflect the impact of trade policies, exchange rates, market size, and factor endowments, which may exaggerate a country's economic trade dependence to some extent. However, there is limited research on trade dependence at the city level. Considering data availability and efficiency, this study adopts the the ratio of total import and export volume to GDP to measure a city's trade dependence.

4.2.2. Independent Variable

The independent variable is the level of digital economy development. Currently, the data related to the digital economy mainly come from the provincial level, and there is limited data available at the city level. Considering data availability, this study adopts Zhao (2020) [16], who used the number of internet users and mobile phones as indicators to measure digital infrastructure. For the measurement of digital industrialization, it draws on the practice of Zhao et al. (2023) [6]; we use the China Digital Financial Inclusion Index to measure digital financial development. The entropy weight method is used to objectively assign weights to each indicator, and a comprehensive index of the level of digital economy development is calculated for each city. The specific indicators are shown in Table 1.

Table 1. Evaluation system of indicators for the development of China's urban digital economy.

Level 1 Indicator	Level 2 Indicator	Metric Property
Digital Infrastructure	internet broadband access (per 100 population)	+
	mobile phone subscriptions (per 100 population)	+
Digital Industrialization	proportion of employees in computer software and software industry	+
	postal business revenue	+
	telecommunications revenue	+
Digital Financial Inclusion	digital financial inclusion usage breadth index	+
	digital financial inclusion coverage depth index	+
	digital financial inclusion digitalization index	+
	electronic payments index	+

4.2.3. Moderating Variable

The moderating variable is industrial structure upgrading. Following the approach used by Zhao (2023) [6], the proportion of the tertiary industry and the weighted value of

the labor productivity of each industry are used to represent industrial structure upgrading. The formula for calculation is as follows:

$$Stru_{it} = \sum_{j=1}^{3} \frac{Y_{ijt}}{Y_{it}} \cdot \frac{Y_{ijt}}{L_{ijt}}, j = 1, 2, 3 \quad (3)$$

where Y_{ijt} represents the value-added of the tertiary industry in region i in period t; Y_{it} represents the Gross Domestic Product of the region i in period t; and L_{ijt} represents the total number of employees in region i in period t.

4.2.4. Control Variable

To comprehensively analyze the impact of the digital economy on the city's trade dependence, control variables that may affect trade dependence are considered. Based on previous research (Zhao et al., 2020) [16], the economic development level (lnGDP), land resources (lnarea), urbanization level (urban), and urban road area (road) are selected as control variables. Specifically, the economic development level is represented by the logarithm of GDP, land resources are represented by the logarithm of city area, urbanization level is represented by the ratio of urban population to total population, and urban road area is represented by the per capita road area.

4.3. Data

This study focuses on 284 cities and above from 2001 to 2019, forming a panel observation of 2556 city–year data. The data sources are from "China City Statistical Yearbook", EPS database, Peking University Digital Finance Research Center, various city statistical bulletins, and the CNRDS database. Linear interpolation is used to supplement the few missing values. Descriptive statistics for the variables are shown in Table 2.

Table 2. Descriptive statistics of variables (N = 2556).

Variable		Mean	Std. Error	Min.	Max.
Dependent Variable	*DEp*	0.180	0.306	1.40×10^{-5}	3.640
Independent Variable	*Dige*	0.0862	0.0473	0.0147	0.722
Moderating Variable	*Stru*	1.006	0.632	1.32	14.62
Control Variables	*lnGDP*	16.58	0.924	14.08	19.76
	lnarea	9.355	0.806	7.015	12.47
	urban	55.36	14.70	6.491	100
	road	17.34	7.261	1.370	60.07

From the results, it is evident that the mean of the foreign trade dependence index's maximum value is 0.18. The substantial difference between the maximum and minimum values underscores the significant variation in the ratio of total import and export value to Gross Domestic Product (GDP) among different provinces. In terms of the digital economy, the maximum value stands at 0.722, while the minimum value is 0.0147. This disparity indicates significant discrepancies in the development levels of the digital economy among different cities, influenced by factors such as the degree of advancement in information technology and telecommunications. Turning to the tertiary sector, the maximum value reaches 14.64, while the minimum value is 1.32. This observation similarly reveals pronounced differentiation among cities in terms of their third-sector development.

5. Results

5.1. Baseline Regression Results

The results of the Hausman test indicate a p-value of 0.005. As this p-value is below the significance threshold, the null hypothesis is rejected. Therefore, the appropriate choice is to use the fixed effects model. Table 3 presents the baseline regression results. In Model (1), we examine the impact of digital economy development on regional trade dependence.

The results in columns (1) and (2) show that the coefficient of digital economy development is consistently negative and significant, indicating that the digital economy reduces the city's trade dependence and supports Hypothesis H1.

Table 3. Baseline regression results.

Variable	The Level of Dependence of the City on Foreign Trade			
	(1)	(2)	(3)	(4)
Dige	−1.425 ***	−1.146 ***	−1.752 ***	−1.472 ***
	(0.348)	(0.319)	(0.371)	(0.339)
Stru			0.056 ***	0.046 ***
			(0.019)	(0.013)
Deo × *Stru*			0.691 *	0.620 *
			(0.383)	(0.347)
lnGDP		−0.170 ***		−0.146 ***
		(0.055)		(0.042)
lnarea		0.109 ***		0.087 **
		(0.039)		(0.035)
urban		0.005 ***		0.005 **
		(0.002)		(0.002)
road		0.002 *		0.002 *
		(0.001)		(0.001)
constant term	0.268 ***	1.693 **	0.227 ***	1.523 **
	(0.018)	(0.787)	(0.023)	(0.653)
urban fixed effect	Yes	Yes	Yes	Yes
year fixed effect	Yes	Yes	Yes	Yes
Sample size	2556	2556	2556	2556
R^2	0.063	0.131	0.121	0.171

Note: Values within parentheses represent t-statistics, ***, **, * respectively, significant at the 1%, 5%, and 10% levels.

In Model (2), we investigate the impact of industrial structure upgrading on the relationship between the digital economy and trade dependence. The results in columns (3) and (4) show that the coefficient of the digital economy is consistently negative, and the coefficient of industrial structure upgrading is consistently positive, confirming Hypothesis H2. Additionally, the interaction term between the digital economy and industrial structure upgrading is positively significant, indicating that industrial structure upgrading weakens the import and export effect of the digital economy and supports Hypothesis H3.

Comparing column (1) with column (2), we observe that when control variables are added, the coefficient of digital economy development becomes −1.146, which is significant at the 1% level and slightly lower in magnitude. This suggests that with the inclusion of control variables, the impact of the digital economy on trade dependence is slightly reduced but remains significant. An increase of 1 unit in the level of digital economy development can promote a decrease of 1.146 in trade dependence. The development of the digital economy in a region reduces the cost of comparing and searching for services and products, and more importantly, links more services and goods, breaking the time difference caused by geographical and temporal factors and promoting spatial and temporal matching of supply and demand. This stimulates the consumption potential in the market. Furthermore, the digitization of industries and the development of digital industries in the region have led to the elimination of backward and low-value-added industries, moving towards high-value-added industries. This provides the market with higher-quality products and contributes to the transformation and upgrading of the supply-side of the economy, thereby reducing China's dependence on foreign trade.

Moreover, the impact of regional GDP on trade dependence is also significantly negative. This can be explained by China's rapid economic development in recent years, accumulating substantial material resources, and gradually overcoming extreme imbalances in factor endowments. As the factor endowments become more balanced, there is no longer

a significant need to rely on imports of foreign resources to drive domestic economic development. In addition, China's total capital formation and R&D investment rank among the top in the world, and modern economic sectors have effectively absorbed labor, unleashing enormous economic potential and further reducing the country's dependence on foreign trade. From the perspective of GDP development, the pressure of balanced resource allocation through external circulation has weakened, and the scale of the economy has undergone significant changes. External circulation is no longer sufficient to drive such a large volume of internal circulation, making internal circulation the inevitable choice.

To further investigate the impact of industrial structure upgrading on the regional dependence on foreign trade, we conducted a regression analysis on Equation (2), and the results are presented in Table 3, columns (3) and (4).

The results show that regardless of whether control variables are included, the coefficient for the digital economy consistently remains negative, while the coefficient for industrial structure upgrading consistently remains positive. This indicates that the transformation and upgrading of the industrial structure increase the dependence on foreign trade, confirming Hypothesis 2. Moreover, the interaction term between the digital economy and industrial structure upgrading is significantly positive, suggesting that industrial structure transformation weakens the import–export effects of the digital economy, supporting Hypothesis H3.

China's industrial growth model is referred to as "compressed industrialization" in academic circles (Whittaker et al., 2010) [17]. This is because, since the introduction of economic reforms and opening-up policies, China's industrial structure has been rapidly updated and evolved. The proportion of value-added output from the primary industry sector has declined rapidly, while the proportion of the tertiary industry sector has steadily risen with an accelerated growth rate. Additionally, due to China's ongoing industrialization process, the proportion of the secondary industry sector remains relatively stable. Under open conditions, China has adopted a proactive strategy of participating in global factor allocation. Various regions rely on undertaking a significant amount of industrial production "orders" from multinational corporations in developed countries and import a considerable number of high-tech production equipment and products through foreign direct investment (FDI). In the process of integrating into the global production chain, this has efficiently achieved industrial development through a "follow and imitate" approach, where international advanced technology is introduced and learned to drive the transformation and upgrading of domestic industrial structure. Furthermore, engaging in export trade while integrating into the global value chain has provided regional enterprises with opportunities for training and learning within the global production division system. This includes benefiting from "spillover effects", such as assistance, supervision, and guidance from multinational companies in developed countries, thereby promoting the development of their innovation and upgrading capabilities.

In conclusion, regional industrial structure upgrading benefits significantly from the introduction of foreign capital, advanced technology, and the "spillover effects" of export trade. As a result, it increases the region's dependence on foreign trade and weakens the inhibitory effect of digital economic development on foreign trade dependence.

5.2. Further Extension: Regional Heterogeneity

China has a vast territory, and different cities in different regions exhibit obvious heterogeneity in terms of geographical location, development stage, and resource endowment. Therefore, the impact of the digital economy on trade dependence may also vary at the city level and across regions. It is necessary to further explore this aspect. This study first divides cities into coastal and inland cities according to general literature practices and then classifies provincial capital cities, sub-provincial cities, and directly administered municipalities as central cities, while other prefecture-level cities are classified as peripheral cities, following the approach of Zhao Tao (2020) [16]. The regression results are shown in Table 4.

Table 4. Regional heterogeneity regression results.

Variable	Coastal Cities	Inland Cities	Central Cities	Peripheral Cities
	(1)	(2)	(3)	(4)
Dige	−1.739	−1.299 ***	0.139	−0.819 ***
	(1.157)	(0.368)	(0.460)	(0.263)
Stru	0.074	0.048 ***	0.383 ***	0.047 ***
	(0.057)	(0.014)	(0.070)	(0.004)
Deo × *Stru*	0.060	0.781 **	−1.300 *	0.562 ***
	(1.729)	(0.349)	(0.744)	(0.108)
constant term	4.908 **	1.017	1.072	1.114 ***
	(2.304)	(0.633)	(1.177)	(0.196)
control variables	Yes	Yes	Yes	Yes
number of cities	43	241	35	249
R^2	0.309	0.170	0.190	0.139

Note: Values within parentheses represent t-statistics, ***, **, * respectively, significant at the 1%, 5%, and 10% levels.

The results of Models (1) and (2) show that the development of the digital economy in inland regions significantly suppresses trade dependence, and industrial structure upgrading weakens the effect of the digital economy. However, this effect is not significant for coastal cities. This can be explained by the fact that coastal regions have always been the gateway for foreign trade, with a higher degree of economic internationalization, playing a leading role in driving the import and export trade of goods nationwide. The development of the digital economy cannot significantly reduce the import and export trade volume of coastal cities. In contrast, inland cities, due to their geographical disadvantages, have trade development significantly lagging behind coastal cities, and the development of the digital economy has further promoted the flow of economic resources and the development of trade among inland cities and between coastal and inland cities. Economic development in inland cities relies more on internal circulation, significantly reducing their trade dependence.

Models (3) and (4) show that the development of the digital economy significantly inhibits the trade dependence of peripheral cities, and industrial structure upgrading significantly weakens the effect of the digital economy. However, this effect is not significant for central cities. Central cities, such as provincial capital cities, sub-provincial cities, and directly administered municipalities, often hold a central position in regional economic development. Compared to peripheral cities, they enjoy more urban preferential policies, have stronger attractiveness to innovative factors and resources, and have a higher level of digital economy development. Therefore, the digital economy's development does not significantly reduce their trade dependence. In contrast, the development conditions of peripheral cities in terms of foreign trade are far inferior to those of central cities. The development of the digital economy has a greater role in stimulating internal economic circulation, leading to a significant decrease in trade dependence.

5.3. Robustness Tests

5.3.1. Sample Exclusion

In this study, the sample covers 284 prefecture-level cities, including ordinary prefecture-level cities, sub-provincial cities, provincial capital cities, and directly administered municipalities. For robustness testing, we only retain the sample of ordinary prefecture-level cities and exclude sub-provincial cities, provincial capital cities, and directly administered municipalities. We then conduct a regression analysis on the remaining sample of ordinary prefecture-level cities. The results are shown in Table 5, column (1), which indicates that the impact of digital economy development remains significant, confirming the robustness of the regression results.

Table 5. Robustness test result.

Variable	Sample Transformation	Instrumental Variable Method
	(1)	(2)
Dige	−2.252 ***	−0.098 *
	(0.847)	(0.053)
Stru	0.042 ***	0.072 ***
	(0.016)	(0.023)
Deo × *Stru*	0.514 *	0.014 *
	(0.303)	(0.013)
constant term	1.187 **	2.613 ***
	(0.458)	(0.565)
control variables	Yes	Yes
urban fixed effect	Yes	Yes
year fixed effect	Yes	Yes
sample size	2213	2556
R^2	0.172	0.185

Note: Values within parentheses represent t-statistics, ***, **, * respectively, significant at the 1%, 5%, and 10% levels.

5.3.2. Instrumental Variable Approach

Since the level of digital economy development is a composite index, it may suffer from endogeneity issues due to measurement errors and omitted variable bias in the calculation process. One common method to address this problem is the instrumental variable approach. In this study, we adopt the instrumental variable approach following the method used by Huang Qunhui et al. (2019) [18]. We use the number of fixed telephone lines per 100 people in each prefecture-level city in 1984 as the instrumental variable for digital economy development. Additionally, since the selected instrumental variable data are cross-sectional and cannot directly participate in the panel data regression analysis, we follow Nunn et al. (2014) [19] and construct an interaction term using the number of internet users in China from 2010 to 2018 and the number of fixed telephone lines per 100 people in 1984. This interaction term is used as the panel instrumental variable for the level of digital economy development in each city. The results in Table 5, column (2), show that after considering the endogeneity issue of the core explanatory variable, the negative inhibitory effect of digital economy development on trade dependence is significant at the 10% level, the positive promoting effect of industrial structure upgrading is significant at the 1% level, and the moderating effect is significant at the 10% level, supporting the robustness of the results.

6. Discussion, Limitation, and Further Research

6.1. Contributions of the Study

Based on the significant changes in the domestic and international economic situation and the significant impact of the digital economy on the quality and efficiency of China's domestic circulation, this study uses panel data from 284 cities in China from 2011 to 2019 to investigate the impact of the digital economy on urban trade dependence and the role of industrial structure transformation and upgrading. The results indicate the following.

First, the development of the digital economy significantly reduces the trade dependence of cities, while industrial structure transformation and upgrading lead to an increase in trade dependence. Industrial structure upgrading weakens the impact of the level of digital economy on the import and export trade of cities, indicating that the digital economy is essential for improving the quality and efficiency of domestic circulation, stimulating national consumption potential, enhancing economic autonomy, and stability. Second, this conclusion remains robust after removing central cities from the sample and introducing instrumental variables. Third, the results of heterogeneity analysis show that the impact of the digital economy development level in coastal cities on trade dependence is not significant, while the impact of the digital economy development level in inland cities is

significantly negative, indicating that coastal cities continue to play a leading role in China's foreign trade and foreign trade remains a significant economic activity. The development of the digital economy has significantly reduced information asymmetry and geographical limitations between regions, improved the quality and efficiency of internal circulation, and thereby reduced trade dependence.

The finding of this paper supports the pivotal role of the digital economy in propelling the development of internal circulation while diminishing external trade dependency. It lays the foundation for the high-quality progression of China's digital economic advancement. Furthermore, it is worth noting that the majority of existing studies concerning the import and export effects of the digital economy merely take into account its direct impacts, overlooking the influence of industrial structural upgrade. For the first time, this paper examines the ramifications of industrial structure on local foreign trade reliance from this distinct perspective, addressing the gaps in the current discourse on the export effects of industrial structure upgrading and the limitations of the literature confined to the direct effects of the digital economy.

6.2. Policy Implications

The findings of the present research have several policy implications. First, due to the differences in geographical locations, production factors, and human resources, the development of the digital economy varies significantly across different cities. Therefore, each city should tailor its development of the digital economy to its characteristics, promote the digitalization of high-quality industries, and unlock the potential of the digital economy to improve resource allocation efficiency, enhance the adaptability of supply and demand in the national economic cycle, achieve dynamic balance between supply and demand, and maintain a sustained and positive cycle.

In addition, excessive reliance on foreign trade due to industrial structure transformation and upgrading may lead to a "crowding-out effect" on China's independent innovation capabilities. In fact, the digital economy directly improves production efficiency by integrating with physical enterprise operations, thereby promoting the transformation and upgrading of the industrial structure. The government should promote the digitalization process of various industries in a targeted manner, fully releasing the vitality of the digital economy.

6.3. Limitations and Further Research

Empirical studies are also subject to certain limitations that restrict the generalizability of the findings. In such a scenario, if the research were to encompass other countries and regions, the magnitude and orientation of relationships within the model might exhibit variance. Our study, however, does not encompass political factors in its purview. Introducing political factors as control variables could potentially yield divergent outcomes. Furthermore, due to the relatively abbreviated duration of digital economic development, the temporal span for data acquisition remains limited. Amplified data availability would inevitably bolster the robustness and credibility of experimental findings. Future research may embark on various avenues of exploration. Drawing from the "industrial economy paradigm", it would be intriguing to investigate the moderating impact of the political environment on the relationship between a city's digital economic development and its trade dependence. The research objective would involve delineating the intricate influence mechanism of the digital economy's impact on trade dependence contingent upon the political milieu of the city. This trajectory is bolstered by the scholarly contributions of Milner and Tingley (2011) [20] and has seen recent elaboration in studies (Mao Qilin 2020) [21].

Author Contributions: Conceptualization, Q.L. and H.W.; methodology, D.Z.; software, D.Z.; validation, Q.L., D.Z. and H.W.; formal analysis, Q.L.; investigation, Q.L.; resources, Q.L.; data curation, D.Z.; writing—original draft preparation, D.Z.; writing—review and editing, H.W.; visualization, Q.L.; supervision, Q.L.; project administration, Q.L.; funding acquisition, H.W. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by National Science Foundation of China, grant number 72203050.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data sources are from "China City Statistical Yearbook", EPS database, Peking University Digital Finance Research Center, various city statistical bulletins, and the CNRDS database.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. International Monetary Fund's. World Economic Outlook. Available online: https://www.imf.org/en/Publications/WEO/Issues/2023/04/11/world-economic-outlook-april-2023 (accessed on 20 August 2023).
2. State Council's Issuance of the "14th Five-Year Plan" for Digital Economic Development. Available online: https://www.gov.cn/gongbao/content/2022/content_5671108.htm (accessed on 29 August 2023).
3. Al-Badrany, A.S.S.; Al-Din Al, E.J.S. The Impact of the Digital Economy on International Trade, the Case of Egypt for the Period (1990–2020). *Integr. J. Res. Arts Humanit.* **2023**, *3*, 163–173. [CrossRef]
4. Yao, Z. The Multifaceted Impact of the Digital Economy on China's Foreign Trade Competitiveness. *Res. Financ. Econ. Issues* **2020**, *1*, 110–119. [CrossRef]
5. Yu, S.; Fan, X. Agglomeration of High-Tech Industries, Innovation, and High-Level 'Going Global' of Manufacturing Industry—Based on the Perspective of Export Technology Complexity Enhancement. *Res. Technol. Econ. Manag.* **2022**, *2*, 110–115.
6. Zhao, W. Digital Economy and High-Quality Development of Urban Foreign Trade—Empirical Evidence from 284 Cities in China. *Chin. Circ.* **2023**, *37*, 96–106.
7. Shkalenko, A.V.; Fadeeva, E.A. Analysis of the impact of digitalization on the development of foreign economic activity during COVID-19 pandemic. In Proceedings of the 2nd International Scientific and Practical Conference "Modern Management Trends and the Digital Economy: From Regional Development to Global Economic Growth" (MTDE 2020), Yekaterinburg, Russia, 16–17 April 2020; Atlantis Press: Amsterdam, The Netherlands, 2020; pp. 1190–1195.
8. Sato, S.; Hawkins, J. Electronic finance: An overview of the issues. *BIS Pap.* **2001**, *7*, 1–12.
9. Tammi, T.; Reijonen, H.; Saastamoinen, J. Are entrepreneurial and market orientations of small and medium-sized enterprises associated with targeting different tiers of public procurement? *Environ. Plan. C* **2017**, *35*, 457–475. [CrossRef]
10. Tang, W.; Li, S.; Tao, Y. Development of Inclusive Digital Finance and Industrial Structure Upgrading—Empirical Evidence from 283 Cities. *J. Guangdong Univ. Financ. Econ.* **2019**, *34*, 35–49.
11. Fu, Y.; Ye, X.; Wang, Z. Structural Transformation of Manufacturing and Enhancement of Economic Growth Efficiency. *Econ. Res.* **2016**, *51*, 86–100.
12. Jiang, X.; Meng, L. Main Focus on Internal Circulation, Empowerment of External Circulation, and Higher-Level Dual Circulation—International Experience and Chinese Practice. *Manag. World* **2021**, *37*, 1–19.
13. Duranton, G.; Puga, D. Micro-foundations of urban agglomeration economies. In *Handbook of Regional and Urban Economics*; Elsevier: Amsterdam, The Netherlands, 2004; Volume 4, pp. 2063–2117.
14. Antonietti, R.; Cainelli, G. The role of spatial agglomeration in a structural model of innovation, productivity and export: A firm-level analysis. *Ann. Reg. Sci.* **2011**, *46*, 577–600. [CrossRef]
15. Keller, W. Trade and the Transmission of Technology. *J. Econ. Growth* **2002**, *7*, 5–24. [CrossRef]
16. Zhao, T.; Zhang, Z.; Liang, S. Digital Economy, Entrepreneurial Activity, and High-Quality Development—Empirical Evidence from Chinese Cities. *Manag. World* **2020**, *36*, 65–76.
17. Whittaker, D.H.; Zhu, T.; Sturgeon, T.; Tsai, M.H.; Okita, T. Compressed Development. *Stud. Comp. Int. Dev.* **2010**, *45*, 439–467. [CrossRef]
18. Huang, Q.; Yu, Y.; Zhang, S. Internet Development and Manufacturing Productivity Enhancement: Intrinsic Mechanism and Chinese Experience. *China Ind. Econ.* **2019**, *8*, 5–23.
19. Nunn, N.; Qian, N. US food aid and civil conflict. *Am. Econ. Rev.* **2014**, *104*, 1630–1666. [CrossRef]
20. Milner, H.V.; Tingley, D.H. Who supports global economic engagement? The sources of preferences in American foreign economic policy. *Int. Organ.* **2011**, *65*, 37–68. [CrossRef]
21. Mao, Q.L. Does Trade Policy Uncertainty Affect Chinese Firms' Imports? *Econ. Res.* **2020**, *55*, 148–164.