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Spatio-Temporal Evolution of the Coupled Coordination of the Digital Economy and the High-Quality Development of the Retail Industry

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Abstract: Based on the available panel data on the digital economy and the high-quality development of the retail industry in 31 provinces in China from 2014 to 2021, we use the entropy weight method, the coupling coordination degree model, the relative development degree model, and the spatial auto-correlation model to analyze the coupling coordination development levels of the digital economy and the retail industry. The results show that the level of development of the digital economy and the retail industry, as well as the degree of coupling and coordination of the development of the digital economy and the retail industry in China, shows a rising trend year by year, but there is significant regional heterogeneity. The development of China's digital economy and retail industry is unbalanced, with the development level of the digital economy lagging behind that of the retail industry in most provinces. The spatial auto-correlation results show that there are strong spatial clustering and spatial correlation characteristics in the coupled and coordinated development of China's digital economy and retail industry, and the spatial linkage pattern is more pronounced in the eastern region. Based on the above conclusions, we propose recommendations for digitally-enabled high-quality development of the retail industry.

Keywords: Digital Economy, High-Quality Development of Retail Industry, Coupling and Coordination

1. Introduction and Literature Review

In the era of the digital economy, digital technologies are gradually changing the meaning of consumption [1-3]. First, the digital economy has changed modes of consumption [4-6]. The networks, platforms, and social aspects of modes of consumption are constantly being improved; moreover, globalization has been achieved with the help of Internet platforms and digital sales [6, 7]. Second, the digital economy has created new consumer demands, as it is more personalized, diversified, and virtualized [8]. Digital products have become the focus of consumption. In the context of upgrading consumption, the high quality of retailing development has become a vital means of stimulating domestic consumption, which is correlated with the high-quality development of China's economy and the realization of the dual cycle strategy [9]. The introduction of digital technology acts as an internal driving force for high-quality retail and lays a technical basis for its innovative development [10, 11]. Retail, a basic industry in China, has seen a boost in high-quality development and residents' consumption has expanded; this is of great significance in expanding domestic demand [12].

The digital economy refers to the use of digital information as a production factor and the use of digital technology to enhance the efficiency of the real economy [13-17]. The existing literature focuses on the digital economy in the following areas. First, some scholars are concerned about the impact of the digital economy on the real economy. Zhang et al. (2021) conducted an empirical analysis using panel data from 30 cities in China from 2015–2019 and found that digital infrastructure, digital industry, and digital integration all have a significant positive impact on regional total factor productivity [16]. Based on data such as provincial total factor productivity, calculated using the dual method, and the digital economy index proposed by principal component analysis, Pan et al. (2022) showed that the digital economy index has a positive non-linear relationship

with total factor productivity in each province, indicating that the digital economy is an innovative driver for the extensive and sustainable development of total factor productivity [17]. Second, some scholars have focused on the impact of the digital economy on innovation. Wang and Cen (2022) found that the digital economy has a significant positive direct effect and a spatial spillover effect on innovation efficiency, but the above effects are heterogeneous across regions and innovation subjects [17]. By analyzing data of Chinese A-share manufacturing firms from 2011 to 2019, Li et al. (2022) found that the development of the digital economy is positively associated with corporate innovation. In addition, the digital economy positively enhances corporate digital transformation, and corporate digital transformation has a significant positive effect on corporate innovation [18]. Luo et al. (2022) found that the development of the digital economy can indirectly improve the level of green innovation by increasing the degree of economic openness, optimizing the industrial structure and expanding market potential [19]. Finally, some other scholars have focused on the impact of the digital economy on the optimization of the industrial structure. Su et al. (2021) found that the development of the digital economy and scientific and technological innovation have a positive effect on promoting the upgrading of the industrial structure; they also proved that the mediating role of heterogeneous technological innovation is crucial in the process of promoting industrial upgrading in the digital economy [20]. Guan et al. (2022) found that the development of the digital economy makes a significant positive contribution to the quantity and quality of industrial structure upgrading, and that it has strong explanatory power for the quality of industrial structure upgrading [21].

The matter of quality runs through the whole process of retail development. Scholars focus on the quality of retailing development from the following perspectives. The first relates to the characteristics of high-quality retail. Zhang et al. (2021) noted that the characteristics of high-quality retail development include higher quality, richer content, and a green and low-carbon status; it must also be intensive and efficient, have diversified business forms and undertake cross-border integration, and put forward a path for high-quality retail development against the background of digital transformation. The second perspective focuses on the measurement of the quality of retail [22]. Pang et al. (2021) used the factor analysis method to measure the quality of retailing development in 31 provinces and cities in China using five indicators: the retail scale index, the retail operation capacity index, the retail performance index, the retail growth index, and the retail contribution index [23]. The third perspective focuses on the factors influencing the quality of retail. Ke (2021) proposed that technological innovation and management innovation have a significant positive enabling effect on high-quality retail [24].

To summarize, scholars have conducted in-depth research on the digital economy and retail development, which has provided important references for subsequent studies, but there are still a number of shortcomings. First, the existing research on the digital economy focuses on studies of macro-economics as well as micro-enterprises [13-18], while there are fewer studies on its relationship with retail development. Second, the methodology of the existing literature is too narrow, with studies mainly adopting qualitative analysis methods. Based on the panel data for the digital economy and high-quality development of the retail industry in 31 provinces in China from 2014 to 2021, we use the entropy weight method, the coupling coordination degree model, the relative development degree model, and the spatial auto-correlation model to analyze the coupled coordination development level of the digital economy and the retail industry. Our study bridges the gap in the existing research.

2. Coordination Mechanism Between the Digital Economy and the High-Quality Development of the Retail Industry

2.1. The Digital Economy Accelerates the Process of the High-Quality Development of the Retail Industry

The key to high-quality retail development lies in technological innovation and management innovation [25]. The introduction of the digital economy can effectively improve the scientific and technological innovation and management innovation of retail, so as to improve the quality of retail. The specific role of the digital economy comprises the following aspects. First, the application of digital technology can effectively enhance the innovation ability of retail enterprises, leading to new, digital-technology-derived business models [26]. Digitalization leads to the close integration of consumers, commodities, and consumption scenes, realizing the transformation of "goods for people" in the retail process, and realizing targeted sales [27]. Second, the application of digital technology has improved the management efficiency of retail enterprises [28]. The application of digital technology in enterprises is conducive to organizational innovation and the integration of internal information, flattening the organizational structure of enterprises and improving the redundancy costs caused by the presence of many organizational levels. At the same time, digital technology helps to integrate the internal information of enterprises, makes enterprise management more targeted, effectively improves the allocation efficiency of the internal resources of retail enterprises, and assists in the high-quality growth of retail enterprises.

2.2. High-Quality Development in Retail Enhances Digital Technology Innovation in Retail

High-quality retail development can provide a material guarantee for digital technology in enterprises; this is mainly reflected in the following aspects. First, high-quality retail development provides material support for digital technological innovation. Digital technological innovation requires high levels of resource investment; high-quality retail development can provide sufficient resources for digital technological innovation and, at the same time, provide an effective application platform

for digital technological innovation. Second, high-quality retail development provides more demand for digital technological innovation. High-quality retail development will generate more market demand, change consumers' consumption habits, and facilitate the integration of advanced digital technology into retail enterprises. Third, high-quality retail development creates a productive innovation environment for digital technological innovation. The high-quality development of the retail industry promotes the formation of a high-quality digital technology innovation environment, facilitates the shaping of digital technological innovation space, and provides favorable environmental conditions for digital technological innovation, thus supporting the continuation of digital technological innovation activities.

To summarize, the high-quality development of the retail industry and the innovation capacity of digital technology produce a synergistic amplification effect through interaction and connection. The system of the high-quality development of the retail industry provides high-quality development conditions and a growth platform for digital technological innovation capacity; meanwhile, digital technological innovation capacity is the core driving force of the high-quality development of the retail industry, which promotes the in-depth integration of the retail industry and digital innovation and realizes the bidirectional promotion and coordinated development of high-quality development of both retail and digital technology.

3. Data Sources and Research Methods

3.1. Data Sources

This study uses the index of high-quality retail development and the digital economy development index of 31 provinces and cities in China from 2014–2021 as the main research object in order to analyze the relationship between the digital economy and the high-quality development of the retail industry. The main data related to high-quality retail development originate from the *China Statistical Yearbook* and the WANDE database. Regarding the digital economy development indicators, the Internet development indicators come from the EPS database. We also use the Digital Financial Inclusion Index that was jointly developed by Peking University and Ant Financial Services [29].

3.2. Construction of the Index System

This study builds an index system for high-quality retail development and the digital economy. For the high-quality index system for retail, we select five first-class indicators, including the development scale of retail, the operational capacity of the retail industry, the performance of retail, the growth of retail, and the contribution of retail [30]. In the digital economy index system, two primary indicators, namely, Internet development and digital financial inclusion, are adopted [31]. The specific secondary indicators are listed in Table 1.

Table 1. *Index system for high-quality retail development and the digital economy.*

Target layer	Level 1 indicators	Secondary indicators	Indicia
High-quality retail development	Retail scale	Retail added value	A_1
		Retail fixed asset investment	A_2
		Number of retail employees	A_3
		Number of retail stores	A_4
	Retail operation capacity	Turnover of total capital	A_5
		Inventory turnover ratio	A_6
		Turnover of current assets	A_7
	Retail performance	Retail sales per capita	A_8
		Retail operating profit margin	A_9
		Retail return on equity	A_{10}
	Retail growth	Retail sales growth rate	A_{11}
		Retail industry profit growth rate	A_{12}
		Retail asset growth rate	A_{13}
	Retail contribution	Tax contribution rate of retail region	A_{14}
		Retail industry employment contribution rate	A_{15}
		Retail economic contribution rate	A_{16}
Digital economy	The development status of the Internet	Internet penetration rate	B_1
		Number of Internet practitioners	B_2
		Internet industry output situation	B_3
		Mobile phone penetration rate	B_4
	Degree of inclusion of digital finance	The breadth of digital finance coverage	B_5
		Use depth of digital finance	B_6
		Degree of digitization	B_7

3.3. Research Method

3.3.1. Entropy Value Method

The entropy method is an objective weighting method, which determines the weights according to the difference of each index datapoint, objectively reflects the importance of each index in the index evaluation system, and effectively overcomes the problems of overlapping information between multiple index variables and the subjective weights determined by human beings. The calculation formulae are as follows:

Data standardization:

$$Z_{ijt} = \frac{X_{ijt} - \min(Xt_j)}{\max(X_{jt}) - \min(X_{jt})} \text{ (Normalization)} \quad (1)$$

$$Z_{ijt} = \frac{\max(X_{tj}) - X_{ijt}}{\max(X_{jt}) - \min(X_{jt})} \text{ (negative polarization)} \quad (2)$$

where Zijt represents the normalized value of the j-th index of the i-th province and urban area in year t, and X denotes the variable value of each index.

The weight of indicator j is calculated as follows:

$$P_{itj} = \frac{Z_{itj}}{\sum_{t=1}^{r}\sum_{i=1}^{m} Z_{itj}} \quad (3)$$

The entropy value of j indicators is calculated as follows:

$$E_j = -K\sum_{t=1}^{r}\sum_{i=1}^{m} Z_{itj} \times \ln(Z_{itj}) \quad (4)$$

The weight of each indicator is given as follows:

$$W_j = \frac{(1-E_j)}{\sum_{j=1}^{n}(1-E_j)} \quad (5)$$

The composite score is calculated as follows:

$$M_{1jt} = \sum_{j=1}^{n} W_j * Z_{ijt} \quad (6)$$

Z_{tij} is the level of development of the digital economy and the retail industry in province i in year t; the larger its value, the better the development of the digital economy and the retail industry in the province.

3.3.2. Coupled Coordination Degree Model

Coupling is often used to quantify the degree of association between systems, and it is an important indicator in quantitatively measuring the degree of interaction between the system as a whole or the internal elements of the research object. Considering that regional development is in a state of imbalance and insufficiency, the coupling coordination degree model is used to measure the coupling coordination relationship between the digital economy and the high-quality development of the retail industry. The coupling coordination degree for the two objects is calculated using the following formula:

$$D = \alpha M + \beta N \quad (7)$$

$$F = \left[\frac{M \times N}{(\alpha M + \beta N)^2}\right]^{\frac{1}{2}} \quad (8)$$

$$G = \sqrt{D \times F} \quad (9)$$

where G is the degree of coupling coordination, taking a value in the range of 0 to 1; larger values of G indicate that the two are in a good coordinated development situation. D is a comprehensive inter-system coordination index. F denotes the degree of coupling, and the closer its value is to 1, the higher the degree of coupling between the digital economy and the high-quality development of the retail industry. α, β are used for the pending weight coefficient, and the sum of the two is 1. This paper posits that the digital economy and the high-quality development of the retail industry are equally important in the process of coordinated development, so α=β=0.5. According to the actual situation and research needs, the degree of coupling coordination is divided into 4 categories: dysfunction, antagonism, friction, and coordination.

3.3.3. Relative Development Model

Relative development refers to the degree of relative development between different systems. The relative development (β) between the digital economy and the high-quality development of the retail industry is expressed as the ratio of the level of the digital economy (A) to the level of the high-quality development of the retail industry (B):

$$\beta = \frac{A}{B} \quad (10)$$

where β is the relative degree of development. When $0<\beta\leq 0.8$, the digital economy is of the lagging type; when $0.8<\beta\leq 1.2$, the digital economy and the high-quality development of retail are synchronized; when $\beta>1.2$, the high-quality development of retail is lagging. The degree of coupling and coordination between the digital economy and the high-quality development of the retail industry in China is divided into 12 different types, and the specific types and criteria are shown in Table 2.

Table 2. *Classification and discriminatory criteria for the degree of coordination and coupling between the digital economy and the high-quality development of the retail industry.*

Type of coupled coordination	Harmonized development intervals	Relative degree of development	Type	Level of coordination
Dysfunction	0<G≤0.3	0<β≤0.8	I	Dysfunctional: lagging digital economy
		0.8<β≤1.2	II	Dysfunctional: synchronous development
		β>1.2	III	Dysfunctional: lagging high-quality retail development
Antagonism	0.3<G≤0.5	0<β≤0.8	IV	Antagonistic: lagging digital economy
		0.8<β≤1.2	V	Antagonistic: synchronous development
		β>1.2	VI	Antagonistic: lagging high-quality retail development
Friction	0.5<G≤0.7	0<β≤0.8	VII	Friction: lagging digital economy
		0.8<β≤1.2	VIII	Friction: synchronous development

Type of coupled coordination	Harmonized development intervals	Relative degree of development	Type	Level of coordination
		β>1.2	IX	Friction: lagging high-quality retail development
		0<β≤0.8	X	Coordinated: lagging digital economy
Coordination	0.7<G≤1	0.8<β≤1.2	XI	Coordinated: synchronous development
		β>1.2	XII	Coordinated: lagging high-quality retail development

3.3.4. Spatial Auto-correlation Test

The spatial auto-correlation model can further determine whether the coupled coordination of the digital economy and high-quality retail development has the characteristic of spatial clustering, and whether there is a spatial spillover effect in the degree of coupled coordination of each province. The global Moran's index and the local Moran's index are used to test the spatial correlation and spatial agglomeration, respectively.

Global Moran's Index:

$$I = \frac{\mathrm{n} \times \sum_{\mathrm{i}=1}^{\mathrm{n}} \sum_{j=1}^{n} W_{ij}(x_i - \bar{x})(x_j - \bar{x})}{\sum_{\mathrm{i}=1}^{\mathrm{n}} (x_i - \bar{x})^2 \times (\sum_{\mathrm{i}=1}^{\mathrm{n}} \sum_{j=1}^{n} W_{ij})} \tag{11}$$

Local Moran's index:

$$I_{\mathrm{i}} = X_{\mathrm{i}} \sum_{\mathrm{j} \neq 1}^{\mathrm{n}} \mathrm{W_{ij}X_{ij}} \tag{12}$$

where n is the number of provinces (i. e., 31). x_i and x_j are the coupling coordination values of regions i and j, respectively, and W ij is the neighbor space weight matrix. If region i is adjacent to region j, then W_{ij} =1; otherwise, W_{ij} =0. Moran's I takes values in the range of [-1, 1], with values greater than 0 representing a positive correlation and values less than 0 representing a negative correlation.

4. Results and Analysis

4.1. Spatial and Temporal Characterization of the Digital Economy and Retail Industry's High-Quality Development

In temporal terms, the levels of development of the digital economy and retail in China have increased year by year. In this study, we analyze level of development of China's digital economy and retail industry in general, as well as from the perspective of four regions (east, middle, west, and northeast). As shown in Table 3, China's digital economy level and retail development level increased from 2014–2021, during which time the digital economy level was raised more rapidly, from 0.135 in 2014 to 0.320 in 2021, an increase of up to 137%, which indicates that China's digital economy is developing at a fast pace. The retail development level increased more slowly, and its index has only risen by 0.069. However, on the whole, China still does not have a high-level digital economy, and its development level has been lower than that of retail development for a long time.

Table 3. *The digital economy and the level of the high-quality development of the sales industry.*

Index	Region	2014	2015	2016	2017	2018	2019	2020	2021
Digital economy	China	0.135	0.152	0.201	0.219	0.251	0.292	0.302	0.320
	East	0.214	0.246	0.294	0.304	0.356	0.403	0.435	0.468
	Middle	0.107	0.138	0.175	0.196	0.224	0.267	0.291	0.308
	West	0.081	0.106	0.148	0.156	0.175	0.201	0.221	0.248
	Northeast	0.091	0.120	0.158	0.165	0.182	0.224	0.261	0.267
High-quality retail development	China	0.360	0.377	0.384	0.394	0.406	0.415	0.426	0.429
	East	0.410	0.435	0.446	0.450	0.458	0.479	0.482	0.491
	Middle	0.335	0.351	0.366	0.372	0.384	0.391	0.406	0.426
	West	0.310	0.331	0.341	0.356	0.367	0.375	0.386	0.389
	Northeast	0.384	0.406	0.416	0.423	0.426	0.428	0.424	0.438

In spatial terms, the development levels of China's digital economy and retail are unbalanced, and there are significant regional differences. As shown in Table 3, China's digital economy level was at its highest in the east and lowest in the west in 2021. The level of retail development exhibits the same status as the level of the digital economy. The reason for this phenomenon is that the eastern region has a first-mover advantage, with the highest levels for both the digital economy and retail development; it is significantly ahead of the mid-west and northeastern regions, and well above the average level of China. The mid-west region is lagging behind in the development of the digital economy and the retail industry due to its weaker foundation, and the level of both the digital economy and agricultural modernization in the mid-west region is lower than the average level of China.

4.2. Spatio-Temporal Coupling Analysis of the Degree of Coupling Coordination of the Digital Economy and the Retail Industry's High-Quality Development

In temporal terms, the degree of coupled synergy between China's digital economy and retail development has increased year by year. The coupling of China's digital economy and the development of the retail industry increased from 0.373 in 2014 to 0.641 in 2021, showing an increasing trend year by year, and the overall coupling degree improves from antagonistic- to friction-type coupling. From a regional perspective, the degree of coupling between the digital economy and the development of the retail industry has

increased to different degrees in all regions of China, with the eastern region entering the coordinated coupling stage in 2019, and the middle, western, and northeastern regions entering the grinding coupling stage in 2018, 2020, and 2017, respectively. This indicates that the degree of synergistic development of China's digital economy and the retail industry continuously improved in the period from 2014–2021, and that the two are in a benign and mutually reinforcing relationship.

Table 4. *Coupling and harmonization of the digital economy and retail development.*

Region	2014	2015	2016	2017	2018	2019	2020	2021
China	0.373	0.435	0.492	0.518	0.549	0.581	0.606	0.641
East	0.531	0.575	0.601	0.627	0.654	0.672	0.710	0.722
Middle	0.341	0.402	0.461	0.485	0.526	0.564	0.594	0.630
West	0.201	0.294	0.315	0.384	0.410	0.458	0.548	0.551
Northeast	0.352	0.435	0.490	0.524	0.534	0.555	0.571	0.587

4.3. Analysis of the Degree of Relative Development

Table 5 shows the results of the relative degree of development of each province in China. In temporal terms, there is a tendency for China's overall development type to transform from a lagging digital economy to a synchronized and coordinated one. Compared with 2014, among the types of digital economic and retail development in China's provinces, in 2021, there was a significant increase in the number of synchronized and coordinated provinces and a decrease in the number of provinces with lagging digital economies. China had far more provinces with lagging digital economies than cities lagging in retail development in the period 2014–2021, which also indirectly indicates that digital economy lag is the main factor affecting the coupling and harmonization of the two.

In spatial terms, the digital economy and retail show diversified development in China's provinces. The development of the digital economy and retail in Beijing, Shanghai, Shandong, Jiangsu, Zhejiang, Shananxi, and Guangdong is at the optimal coupling stage, XI. Fujian, Hubei, Hunan, Chongqing, and Sichuan are at the stage of coordinated coupling; all are characterized by backward digital economies, and the development of the relationship between the two is not synchronized. The mid-west and northeast regions have a lower level of digital economic and retail development; they are mostly in the friction coupling stage, and only Nei Mongol and Tibet are at the stage of antagonistic coupling. In general, the level of China's digital economy lags behind the level of retail development.

Table 5. *Stages of the coupling of the development of the digital economy and retail by province.*

Region	Province	2014	2015	2016	2017	2018	2019	2020	2021
East	Beijing	VII	X	X	X	X	XI	XI	XI
	Tianjin	IV	IV	IV	VII	VII	VII	VII	VII
	Shanghai	VII	VII	VII	VII	XI	XI	XI	XI
	Hebei	IV	IV	VII	VII	VII	VII	VII	VIII
	Shandong	IV	IV	IV	IV	IV	IV	XI	XI
	Jiangsu	VII	VII	VII	XI	XI	XI	XI	XI
	Zhejiang	VII	VII	VII	XI	XI	XI	XI	XI
	Fujian	VII	VII	VII	VII	VII	VII	X	X
	Hainan	IV	IV	IV	IV	VII	VII	VII	VII
	Guangdong	VIII	VIII	XI	XI	XI	XI	XI	XI
Middle	Shanxi	I	IV	IV	IV	IV	IV	IV	VII
	Henan	IV	IV	IV	IV	VII	VII	VIII	VIII
	Hubei	IV	IV	IV	VII	VII	VII	VII	X
	Hunan	IV	IV	IV	IV	VII	VII	VII	X
	Anhui	IV	IV	IV	IV	VII	VII	VIII	VIII
	Jiangxi	IV	IV	IV	IV	VII	VII	VII	VII
West	Nei Mongol	I	IV	IV	IV	IV	IV	IV	IV
	Xinjiang	IV	IV	IV	IV	IV	IV	VII	VII
	Xizang	I	I	I	I	IV	IV	IV	IV
	Ningxia	I	IV	IV	IV	IV	IV	IV	VII
	Shananxi	IV	IV	IV	IV	IV	X	X	XI
	Gansu	I	I	IV	IV	IV	IV	VII	VII
	Qinghai	I	I	IV	IV	IV	IV	VII	VII
	Chongqing	IV	IV	IV	IV	VII	VII	VIII	X
	Sichuan	IV	IV	IV	VII	VII	VII	VIII	X
	Guizhou	I	I	I	IV	IV	IV	IV	VII
	Guangxi	I	IV	IV	IV	IV	IV	VII	VII
	Yunnan	IV	IV	IV	IV	IV	VII	VII	VII
Northeast	Heilongjiang	IV	IV	IV	IV	VII	VII	VII	VII
	Jilin	IV	IV	IV	IV	IV	IV	VII	VII
	Liaoning	IV	IV	IV	IV	VII	VII	VII	VII

4.4. Spatial Auto-correlation Analysis of the Degree of Coupled Coordination

In order to analyze the spatial correlation characteristics and changes in spatial agglomeration of the coupled coordination degree of the development of the digital economy and retail industry in China, this paper applies Moran's index to test its spatial correlation and evolution characteristics. The results of the global spatial auto-correlation analysis are shown in Table 6. The global Moran's index is positive in all years, and all of them are significant at the 1% level. The results show that there was a significant positive spatial correlation between the digital economy and the development of the retail industry's composite system in China from 2014 to 2021.

Table 6. *Global Moran's index.*

Year	Moran's index	P-value	Z-value	Significance level
2014	0.475	0	4.125	1%
2015	0.442	0	4.013	1%
2016	0.712	0	6.106	1%
2017	0.458	0	4.114	1%
2018	0.431	0	3.924	1%
2019	0.433	0	3.947	1%
2020	0.464	0	4.106	1%
2021	0.427	0	3.746	1%

The local spatial auto-correlation model is used to further test the spatial agglomeration characteristics of the coupled coordination degree of the digital economy and retail development, and to show the spatial evolution characteristics of the degree of coupled coordination via a Moran scatter plot. The results are shown in Table 4. On the whole, the provinces with positive correlations account for 70.96% and 87.09% of the total sample, indicating that the local spatial heterogeneity of the degree of coupling and coordination between the digital economy and retail development in China is decreasing, and that the degree of spatial agglomeration is increasing. From a regional point of view, the provinces are mainly distributed in the first and third quadrants, and the high–high agglomerations are mainly distributed in the eastern region; meanwhile, the low–low agglomerations are concentrated in the mid-west and the northeastern regions, which illustrates that there is a spatial agglomeration characteristic of "high–high, low–low" in the degree of coordination of the coupling between China's digital economy and the development of the retail industry. The high–high and low–low agglomerations have a strong spatial correlation, and the inter-region influence is relatively strong. Compared with 2014, the number of high–high concentration areas in 2021 increased by three provinces, Anhui, Hubei, and Henan; this was mainly due to their proximity to high–high concentration areas in the east. The coupling and coordination between the digital economy and the development of the retail industry have been steadily increasing under the impetus of the neighboring provinces. The low–low agglomeration area increased only in Heilongjiang, Ningxia. The results show that China's eastern region exhibits strong spatial correlations, with obvious spatial spillover effects; meanwhile, the spatial spillover effect is not obvious in the mid-west and northeastern regions due to the lack of provinces with a high level of coupled coordination of the digital economy and retail development.

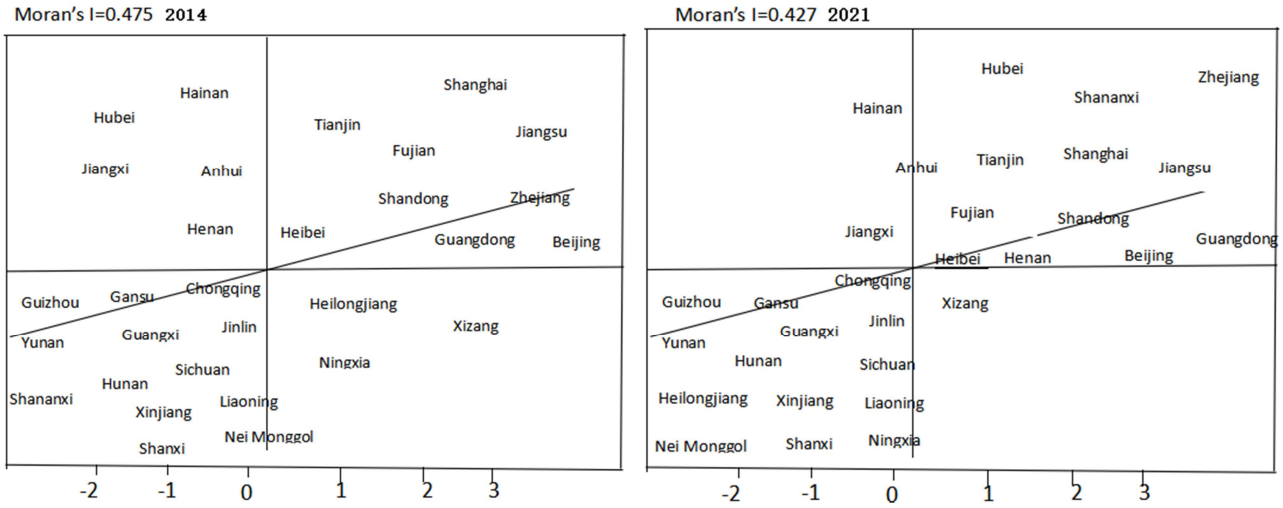

Figure 1. *Moran scatter-plot (2014, 2021).*

5. Conclusions

Based on the panel data for the digital economy and the high-quality development of the retail industry in 31 provinces of China from 2014 to 2021, we empirically studied the relationship between the digital economy and the development of the retail industry and drew the following conclusions:

China's digital economy and the level of retail development both exhibit an upward trend year by year, with the digital economy rising faster than the level of retail development.

The development of China's digital economy and the development of the retail industry are uneven. Both are

characterized by a high level of development in the east and a relatively low level of development in the central and western regions.

The degree of coupling coordination between China's digital economy and retail development shows a steady upward trend. Overall, the digital economy and the development of the retail industry are in the grinding coupling stage. The coupling coordination level in the eastern region is much higher than in other regions; the degree of coupling coordination in the mid-west and northeastern provinces is mostly in the grinding coupling stage, or even in the antagonistic coupling stage.

In terms of the degree of relative development, the long-term digital economic level of most provinces in China lags behind the development of the retail industry. Beijing, Shanghai, Hebei, Shandong, Jiangsu, Zhejiang, Henan, Hubei, Anhui, Tianjin, Fujian, and Guangdong are in the synchronization and coordination stage.

The results of the spatial auto-correlation of the degree of coupling coordination show that the coupled and coordinated development of the digital economy and retail development exhibits strong spatial agglomeration and spatial correlation characteristics. Additionally, the coupling coordination and spatial linkage pattern is more pronounced in the eastern region, whereas a benign spatial linkage pattern has not yet been formed in the mid-west and northeastern regions.

Thus, the government should further promote the integrated development of the digital economy and retail. From the perspective of retail enterprises, companies should further integrate digital technology with their own business, thereby enhancing the contribution of digital technologies to retail performance. The digital development of retail enterprises is closely correlated with the support of the government, so the government should introduce more supporting policies to facilitate the digital development of the retail industry and provide necessary guidance for industrial transformation. Second, the innovative development of the digital economy should be further promoted. The digital transformation of the retail industry requires digital technology that is suitable for industrial development; therefore, R&D investment in digital technology should be further boosted to integrate technology into industrial development and lay a solid foundation for the development of the retail industry. Third, an industry-wide data sharing mechanism should be established. As evidenced by the current status of the development space of the existing retail industry, there is a sizeable gap between the East and the West. Rules should be formulated at the industrial level to form a mechanism for sharing digital technology in order to break technical barriers and provide a better technical environment. This is necessary for the development of underdeveloped areas and will provide technical support for their high-quality development.

Data Availability

All data in this paper are available through the authors.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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