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Evolution of Digital Economy Differences among SCO Member Countries: Analysis and Perspectives[1]

Rong LI [1)], **Catherine G. GOSPODARIK** [1, 2)]
[1)] *Belarusian State University, Minsk, Belarus*
[2)] *Financial University under the Government of the Russian Federation, Moscow, Russian Federation*

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Abstract. In the context of globalization and development of information technologies, the digital economy is increasingly recognized as a key indicator of national competitiveness. This research examines the spatial differences and patterns of the digital economy among SCO member states by analyzing indicators such as Internet penetration, e-commerce transactions, and digital infrastructure investment. Using the Theil index and exploratory spatial data analysis, the study reveals significant disparities in digital economic development and its spatial distribution characteristics among the member states. The findings indicate a clear stratification in the development levels of the digital economy, closely linked to the economic development levels and regional positions of each country. Despite the existence of this stratification, the overall distribution is relatively balanced. However, the pronounced imbalance in digital economy development affects not only individual member states' economic growth but also has significant implications for the broader regional economic landscape. By analyzing the relationships between digital development levels and regional economic indicators, this research explores how the digital economy reshapes regional economic patterns. Therefore, SCO countries are encouraged to prioritize the development of the digital economy in nations with strong resource endowments, foster industrial upgrading, and enhance economic cooperation. By deepening the interaction between the digital economy and regional economies, SCO member states can collaboratively address the challenges of digitalization and achieve mutually beneficial development.

Keywords: digital economy, regional pattern, spatial structure, regional economy, Shanghai Cooperation Organization

ИССЛЕДОВАТЕЛЬСКАЯ СТАТЬЯ

Цифровые разрывы между странами-членами ШОС

Жун ЛИ [1], Екатерина Г. ГОСПОДАРИК [1, 2]

[1] Белорусский государственный университет, г. Минск, Республика Беларусь

[2] Финансовый университет при Правительстве Российской Федерации, г. Москва, Российская Федерация

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Аннотация. В условиях глобализации и ускоренного развития информационных технологий цифровая экономика постепенно становится важным фактором национальной конкурентоспособности. В статье рассматриваются пространственные различия и закономерности развития цифровой экономики среди государств-членов ШОС через анализ таких показателей, как распространение Интернета, объем транзакций электронной торговли и инвестиции в цифровую инфраструктуру. Кроме того, в статье с помощью индекса Тейла и разведочного анализа пространственных данных анализируется эволюция региональной модели, что позволяет выявить цифровые разрывы и различия в пространственном распределении цифровой экономики. Цель исследования — создать теоретическую базу и разработать предложения по сокращению цифрового разрыва и развитию региональной экономической интеграции в рамках ШОС. Результаты показывают, что уровень развития цифровой экономики в странах-членах ШОС стратифицирован и демонстрирует значительные различия. Это расслоение тесно связано с уровнем экономического развития и региональным положением каждой страны. Несмотря на существование указанной стратификации, общее распределение относительно сбалансировано. Однако выраженный дисбаланс в развитии цифровой экономики влияет не только на экономический рост отдельных государств, но и на экономическую ситуацию во всем регионе. Государствам-членам ШОС рекомендуется приоритизировать развитие цифровой экономики при наличии значительного ресурсного потенциала, а также содействовать обновлению промышленности и укреплять экономическое сотрудничество. Углубляя взаимодействие между цифровой экономикой и региональными экономиками, государства-члены ШОС могут совместно справляться с вызовами цифровизации и достигать взаимовыгодного развития.

Ключевые слова: цифровая экономика, региональная модель, пространственная структура, региональная экономика, Шанхайская организация сотрудничества

1. Introduction

In the tide of globalization, the digital economy is gradually exerting a profound impact on the economic and social development of countries worldwide. Nations leverage the digital revolution to enhance economic growth. However, the effects of technological progress and digitalization vary across countries, depending on each country's development level and motivations (Hanna, 2016). The rise of the digital economy offers growth opportunities and helps narrow the development gap between regions and countries (Ballestar, 2021; Liu, 2022).

Analysis of Eurostat data from 2001 to 2016 shows that higher education levels and a greater number of patents have a positive impact on the digital economy indicators of both new and old EU member states (Hanna, 2016). Effective regional and national policies can help bridge the digital divide. In the EU, policy measures aimed at economic growth, improving education, boosting R&D spending, and preventing early school dropouts have successfully reduced regional disparities in digital access (Szeles & Simionescu, 2020).

A quantitative analysis of Denmark's ICT sector shows that regions with strong digital economy characteristics can better withstand the impact of the Internet bubble burst and experience faster development (Szeles, 2018). Research from Chinese scholars has shown that the digital economy significantly influences the green technology innovation of eastern Chinese cities, with a U-shaped effect on urban agglomerations, meaning that the digital economy must reach a certain level before enabling innovation in neighboring areas (Dian et al., 2024).

The digital economy reflects national or regional competitiveness and modernization. Li and Cui (2024) developed a new mutual-information-based weighting method to quantify the centrality of indicators and applied Dagum's Gini coefficient decomposition method, kernel density estimation, and Moran's I to evaluate the digital economy's development in 110 cities along the Yangtze River Economic Belt from 2011 to 2020. Their data indicated a decreasing trend in digital economy development toward the west, with the lower Yangtze River showing the most robust growth and a clear decline in regional differences.

Other studies have used the entropy weight method and Exploratory Spatial Data Analysis (ESDA) to measure the Digital Economy Index across 31 Chinese provinces over ten years. Results revealed a booming growth trend in the regional economy, with decreasing gradient differences from the eastern coastal areas to the western inland regions. The digital economy positively impacts regional economic development, with its influence increasing annually (Fan et al., 2024).

Furthermore, research based on inter-provincial panel data in China has found that the flourishing digital economy significantly enhances inter-regional trade exchanges and domestic trade patterns. It promotes trade inflows and outflows, demonstrating positive spatial spillover effects. The digital economy lowers trade costs and stimulates market demand, although its role in resource allocation and technological innovation requires enhancement. The impact of the digital economy on inter-regional trade is particularly pronounced in less developed or non-border regions (Li et al., 2023).

Overall, research indicates that improvements in the quality of the digital economy positively affect social and economic life (Novak et al., 2021). Breakthroughs in digital technology are expected to significantly enhance the sustainable development capabilities of regions (Tang et al., 2021; Xu et al., 2024).

In Russian research, notable contributions include the work of Abdrahmanova et al. (2021), who developed a statistical measurement model for the digital economy that encompasses all stages of the life cycle of digital technologies and related products and services, from creation to utilization by organizations and the population. Their indicators facilitate an assessment of the processes and effects of digitalization and the resources of the digital economy in Russia compared to other countries from 2010 to 2020.

Yakimova and Khmura (2023) addressed the issue of measuring digital economic gaps resulting from the heterogeneity in the territorial distribution of capital and production. Their methodology was applied to 87 Russian regions, categorizing them into types: digital development leaders, developing regions, promising regions, underdeveloped regions, and recipient regions. Mirolyubova et al. (2020) organized the digital economy of regions by identifying the ICT core, the external ICT tier, and the digital sector beyond ICT. Additionally, Bukh and Heeks (2018) explored definitions and measurement methods of the digital economy across different countries.

Since the establishment of the Shanghai Cooperation Organization (SCO), economic and cultural exchanges among member states have intensified, extending to countries along the Belt and Road route. Seven countries bordering China serve as a gateway for its economic outreach to Central Asia, South Asia, and Europe. Particularly in South and Central Asia, the proximity to China positions these regions as critical areas for digital economy cooperation (Avdokushin, 2021). However, the overall development of the digital economy in South and Central Asia remains underdeveloped, with significant disparities among countries. These differences not only hinder the economic progress of individual nations but also impact the broader regional economic landscape.

For the SCO member states, which include key countries in South Asia, studying the disparities in digital economy development and their influence on regional patterns holds substantial theoretical and practical significance. However, academic research on the digital economies of SCO countries often lacks a focus on spatial differences and patterns. The overall economy of the SCO region is underdeveloped, with insufficient integration of the digital economy. Therefore, a systematic analysis of digital economy differentiation is essential to comprehend its spatial evolution and to promote its development within SCO member countries.

This paper relies on economic data from ten countries to apply the Theil Index and exploratory spatial data analysis (ESDA) methods. The aim is to investigate the spatial and temporal differences and patterns of the digital economy in South Asian countries. This research will help identify new trends in global economic development and offer fresh insights and strategies for sustainable economic growth.

2. Digital Economy in SCO Countries: A General Overview

The Shanghai Cooperation Organization (SCO) includes China, Russia, Kazakhstan, India, Pakistan, Kyrgyzstan, Tajikistan, Uzbekistan, Iran, and Belarus. The level of digital technology has become a crucial indicator of a country's overall economic status, and understanding this level provides valuable insights into the foundations of the digital economy within the SCO region. However, the development of the digital economy is influenced by various factors, including digital infrastructure, national policies, and the level of digital innovation.

To evaluate the digital economy of these countries, the China International Electronic Commerce Center published the "Belt and Road" Digital Economy Development Index Report in 2018. This index assesses the digital economy based on four dimensions: digital development environment, digital infrastructure, digital innovation level, and digital industry development. It calculates the digital economy index scores for 65 countries along the Belt and Road initiative. According to the report, the digital economy of the SCO countries is relatively underdeveloped, falling below the overall average of countries along the Belt and Road (see Table 1).

3. Methodology and Data

3.1. Data Source

This study uses GDP as the primary data source and selects two additional indicators closely related to the development of the digital economy. The first indicator is the Internet User Index (IUI), which reflects the penetration rate of the digital economy by indicating the proportion of the population that uses the Internet. The second indicator is ICT(BOP), defined by the World Bank, which measures the scale of services in the in-

Table 1

GDP and Digital Economy of SCO Countries

Ranking	Country	2008		2022	
		GDP-PPP, Billions of Dollars	Share of The World, %	GDP-PPP, Billions of Dollars	Share of The World, %
1	China	6241.3	9.90	16325.08	18.14
2	India	1312.42	2.08	2961.52	3.29
3	Russia	1298.06	2.06	1471.54	1.64
4	Iran	379.38	0.60	487.7	0.54
5	Pakistan	238.4	0.38	399.95	0.44
6	Kazakhstan	134.97	0.21	221.55	0.25
7	Uzbekistan	52.36	0.08	123.82	0.14
8	Belarus	49.46	0.08	57.25	0.06
9	Tajikistan	5.33	0.01	13.5	0.01
10	Kyrgyzstan	5.14	0.01	8.25	0.01

Source: World Bank Open Data Network

formation and communication technology sector across different countries and serves as a benchmark for assessing the level of digital economy development.

3.2. Research Methods

Jeffery G. Williamson's (1965) renowned "Inverted U" Theory posits that regional economic differences initially widen before eventually narrowing. According to this theory, such disparities are an unavoidable stage of economic development, with differences diminishing as economies mature. In contrast, Friedman's (1966) center-periphery theory suggests that objective differences in markets, resources, technology, and environment exist between regions. Stronger regions, benefiting from these advantages, gradually become central to the regional economic system. Additionally, Hirschman's (1949) "unbalanced growth theory" asserts that regional imbalances and disproportionate development can stimulate economic growth, leading to specific spatial distribution patterns (Gualerzi, 2015).

Consequently, regional differences and patterns remain a significant focus in regional economic research. This study will employ Theil's index and Exploratory Spatial Data Analysis (ESDA) to examine the spatial and temporal variability and patterns of digital economic development in SCO countries. Furthermore, the study employs a clustering method, adapting the approach used by Logacheva, N. M., and Petrova, A. K. (2021) to classify Russian regions according to the level of digital resources available in educational institutions.

4. The Theil Entropy

The Theil Entropy (Index) is a common indicator to measure the equilibrium (unbalanced) status of regional economic development and income distribution. There are two ways to calculate the Theil index, one is weighted by the proportion of income (recorded as coefficient *T*), and the other, by the proportion of population (Akita, 2003).

$$T = \sum_{i=1}^{n} x_i \log \frac{x_i}{y_i} \quad (1)$$

$$L = \sum_{i=1}^{n} x_i \log \frac{x_i}{p_i} \quad (2)$$

Theil index is divided into inter-regional Theil index and intra-regional Theil index. Taking the weighted calculation of income proportion as an example, the equation for calculating the Thiel index is as follows:

$$T = T_{Within} = T_{Between} = \sum_{i=1}^{n} \left(x_i \sum_{j=1}^{m} x_{ij} \log \frac{x_{ij}}{y_{ij}} \right) + \sum_{i=1}^{n} x_i \log \frac{x_i}{y_i} \quad (3)$$

Among them, n is the number of regions, m is the number of countries in region i, x_i is the share of regional measurement indicators in the whole region, y_i is the share of regional income in the whole region, and p_i is the share of regional population in the whole region. x_{ij} is the share of the indicator measured by country j in region i in the region, and y_{ij} is the share of the income of country j in region i in the region's income. The larger the Theil index, the greater the difference in this indicator (such as economic development, digital economy, etc.) between regions; the smaller the Theil index, the more balanced it is, and its numerical value range are [0,1] (Williamson, 1965).

5. Exploratory Spatial Data Analysis (ESDA)

Exploratory Spatial Data Analysis (ESDA) is a method frequently employed to examine spatial dependence and spatial heterogeneity. It can be categorized into global spatial autocorrelation and local spatial autocorrelation. Global spatial autocorrelation reflects the overall spatial distribution characteristics of the study area and is typically expressed using the global *Moran's I* index, which is defined as follows:

$$Moran's\ I = \frac{\sum_{n=1}^{i} \sum_{j=1}^{n} W_{ij} \left(Y_i - \bar{Y}\right)\left(Y_j - \bar{Y}\right)}{S^2 \sum_{i=1}^{n} \sum_{j=1}^{n} W_{ij}} \quad (4)$$

Among them, Y_i is the observation value of the i region, S^2 is the variance, $\bar{Y}$ is the average value of Y, i is the total number of regions, and W_{ij} is the binary spatial weight matrix, which represents the mutual proximity relationship of spatial objects. The value range of *Moran's I* statistic is generally between [–1, 1]. Less than 0 indicates negative correlation between regions, equal to 0 indicates no correlation, and greater than 0 indicates positive correlation (Anselin, 1995).

Local spatial autocorrelation examines the degree of correlation between a specific area and its adjacent areas within a region. The Local Moran's I index (MRI), also known as LISA (Local Indicator of Spatial Association), is utilized to analyze the clustering characteristics of observation values in local areas. The equation for calculating the Moran's I index is as follows:

$$I = \frac{Y_i - \bar{Y}}{S} \sum_{j=1}^{n} W_{ij} (Y_j - \bar{Y}) \quad (5)$$

The Local Moran's I index categorizes the degree of correlation between regions into four types. The High-High (H-H) area indicates that a region has high detection values, and its surrounding areas also exhibit high values. In contrast, the High-Low (H-L) area denotes that a region has high detection values while its surrounding areas have low values. The Low-High (L-H) area signifies that a region has low detection values, but its surrounding areas are high. Finally, the Low-Low (L-L) area indicates that both the region and its surrounding areas have low detection values.

6. Analysis of Differences in Digital Economic Development among SCO Member States

Given the positive correlation between the digital economy and total GDP, the Theil Index (*T*) is employed to examine the disparities in the digital economy among SCO member states. The analysis categorizes these countries based on their level of economic development and geographic location. Most SCO member countries, excluding China, India, and Russia, have smaller economies. Therefore, a geographic division into three regions is proposed:

Region I: India, Pakistan, and Iran, which border the Arabian Sea.

Region II: Russia, Belarus, and Kazakhstan, situated in the European region.

Region III: China, Uzbekistan, Kyrgyzstan, and Tajikistan, located in Central Asia.

This division allows for a more focused spatial analysis, with the ten countries grouped into these three major regions. Initially, the differences in income-based Internet population share (IUI) and ICT service exports (ICT(Bop)) were calculated separately. Subsequently, the GDP, IUI, and ICT (Bop) data for the SCO member countries were substituted into Equation (3) to compute the intra-regional variation (TWR), inter-regional variation (TBR), and total regional variability (Theil). Figures 1 and 2 illustrate these findings, where intra-regional variation refers to variance within Regions I, II, and III, inter-regional variation pertains to variance between these regions, and total regional variability is the sum of TWR and TBR.

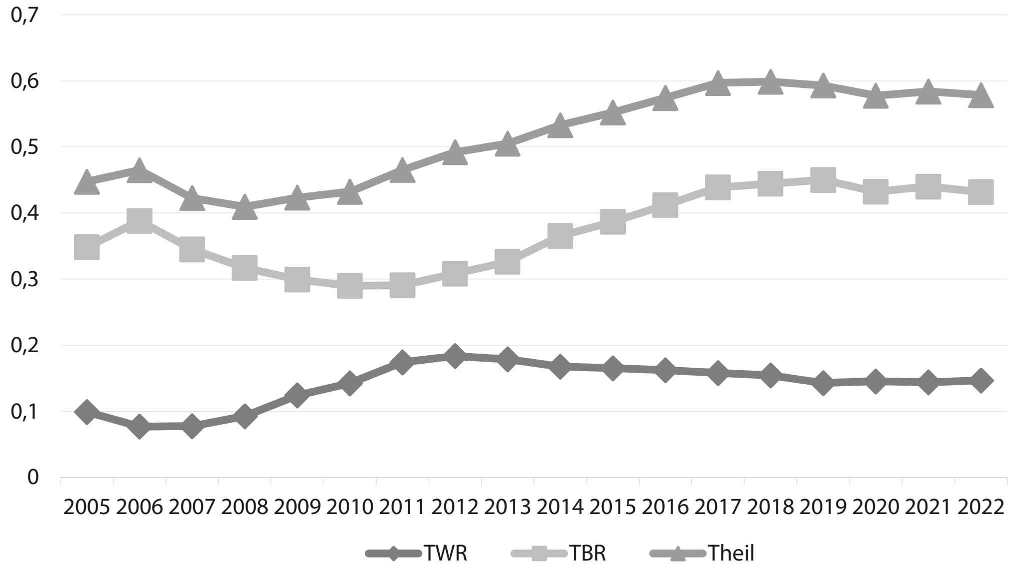


Fig. 1. *Internet User (IUI) Differentiation Based on Revenue*
Source: Compiled by the authors

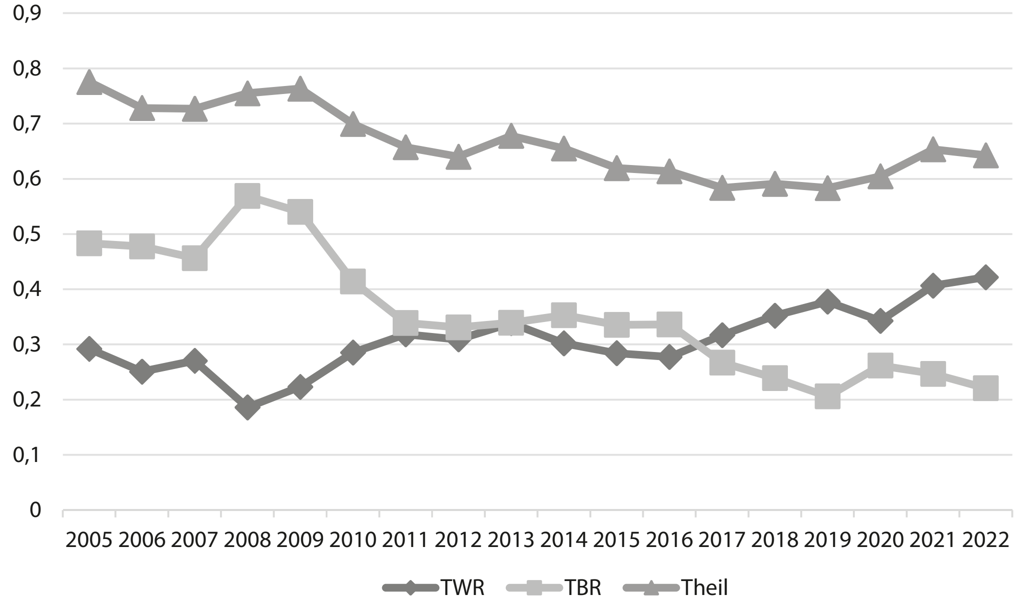


Fig. 2. *ICT(Bop) Differentiation Based on Revenue*
Source: Compiled by the authors
**On the TWR and TBR comparisons, the relatively high TBR means that the current indicator differences mainly exist between regional groups, while the indicator differences within regional groups are relatively small.*

The findings illustrated in Figures 1 and 2 are as follows:

— Theil Index Trends (2005–2022): The Theil index for ICT (IUI) in SCO countries remained below 0.6 from 2005 to 2022, indicating that differences in ICT (IUI) among these countries are narrowing. In contrast, the Theil index for ICT(Bop) within and between groups is relatively high, typically ranging from 0.3 to 0.35, with the total Theil index reaching approximately 0.775. This suggests a significant disparity in the distribution of ICT(Bop) across SCO member countries, highlighting substantial developmental differences. The contrasting results can be attributed to the different stages of digital economic development represented by the Internet user population and ICT service exports. Internet usage reflects the initial stage of digital economic development, while ICT service exports represent a more advanced stage, showcasing the competitiveness of a country's digital products and services. The data for ICT(Bop) indicates that the digital economies of SCO member countries vary considerably. Some countries exhibit high Internet penetration, while others lag behind, resulting in substantial disparities in ICT(Bop), although none have achieved a high level of development. As the digital economy evolves and mobile networks advance, the Internet population among TWRs in SCO member countries is gradually decreasing.

— Fluctuations in ICT (Bop) Differences (2008–2022): Between 2008 and 2022, ICT(Bop) differences among SCO member countries fluctuated, initially rising and then stabilizing. This trend indicates that IUI differences are stabilizing. This fact is consistent with the natural progression of Internet development, which cannot grow indefinitely (with a maximum value of 100 %). In countries with underdeveloped Internet, the growth rate of Internet users has increased significantly over the past decade due to

Table 2

The Composition of Digital Economy Variations among SCO Member Countries

Year	ICT(IUI) differences					ICT(Bop) Difference				
	TWR	TWR contribution rate, %	TBR	TBR contribution rate, %	Theil	TWR	TWR contribution rate, %	TBR	TBR contribution rate, %	Theil
2005	0,099	22	0,348	78	0,447	0,292	38	0,483	62	0,775
2006	0,077	17	0,388	83	0,465	0,251	34	0,477	66	0,728
2007	0,078	18	0,345	82	0,423	0,270	37	0,456	63	0,727
2008	0,093	23	0,317	77	0,410	0,186	25	0,569	75	0,755
2009	0,124	29	0,299	71	0,423	0,223	29	0,540	71	0,763
2010	0,143	33	0,290	67	0,432	0,285	41	0,414	59	0,699
2011	0,174	37	0,291	63	0,465	0,318	48	0,339	52	0,657
2012	0,184	37	0,308	63	0,492	0,309	48	0,331	52	0,640
2013	0,179	35	0,326	65	0,505	0,339	50	0,339	50	0,678
2014	0,168	31	0,365	69	0,533	0,302	46	0,353	54	0,655
2015	0,165	30	0,387	70	0,552	0,284	46	0,335	54	0,619
2016	0,162	28	0,412	72	0,574	0,277	45	0,336	55	0,614
2017	0,158	26	0,439	74	0,597	0,317	54	0,267	46	0,584
2018	0,154	26	0,444	74	0,599	0,352	60	0,239	40	0,591
2019	0,143	24	0,450	76	0,593	0,377	65	0,206	35	0,583
2020	0,145	25	0,432	75	0,578	0,343	57	0,262	43	0,604
2021	0,144	25	0,440	75	0,584	0,407	62	0,247	38	0,653
2022	0,147	25	0,432	75	0,579	0,422	66	0,221	34	0,643

Source: Created by the authors. * TWR — Within-region Theil Index, representing differences within regions; TBR — Between-region Theil Index, indicating variations between regions.

rapid advancements in information technology. Conversely, in countries with developed Internet infrastructure, the growth rate of Internet users has slowed.

— Trends in ICT (Bop) (2009–2022): From 2009 to 2022, the ICT(Bop) among SCO member countries exhibited significant fluctuations, initially declining before rising again. A notable decline occurred from 2009 to 2012 and from 2013 to 2019, after which a slow recovery began, although the overall gap is narrowing.

Additionally, the ICT(Bop) difference index reveals that the contribution rates of intra-group differences and inter-group differences to the total difference vary significantly. This indicates clear disparities within and between the three major regions, with inter-group differences being predominant and reflecting a low degree of integration among different regions. While intra-group differences are relatively small, they are expanding, suggesting a high degree of regional integration. Although geographical space significantly influences digital economic development, the variations in digital economic development among SCO member states are still related to the geographical location and level of Internet development in each region. The contribution rates of intra-group and inter-group differences to the total difference in the ICT(Bop) difference index are not markedly different, with intra-group differences primarily driving the overall disparity. The differences within the three major regions far exceed those between them, constituting the main factor in the total difference. However, the overall ICT(Bop) difference remains substantial. Furthermore, as ICT export volumes from SCO member states increase, the impact of intra-group differences becomes more pronounced, reaching a contribution rate of 66 % by 2022. This underscores the significant gaps in digital economic development within the SCO, which primarily drive the overall disparity. While geographical location does exert some influence, it is not the dominant factor (see Table 2).

In summary, the analysis of the IUI and ICT(Bop) difference indices shows spatial disparities in the digital economy development across SCO member countries and regions. These differences are primarily reflected in the proportion of ICT(Bop). The inter-group and intra-group differences in the three major regions have relatively similar contribution rates, which together contribute to the IUI disparities.

7. Analysis of the Spatio-Temporal Pattern of Digital Economic Development in SCO Member Countries and Regions

Global auto correlation analysis

The Theil Index analysis reveals uneven digital economy development among SCO member states. To further investigate the spatial distribution patterns of the digital economy in these countries, we will conduct exploratory spatial data analysis. Global autocorrelation analysis will provide a macroscopic view of the overall spatial distribution characteristics of the digital economy within the SCO member regions, helping to determine whether spatial correlation exists. We will use IUI and ICT(Bop) data from 10 countries to calculate the index over several years. In the calculation of the index using Equation (4), the spatial weight matrix represents each country's adjacency, assigning a value of 1 for adjacent countries and 0 for non-adjacent ones.

First, Moran's I index is calculated using IUI as the observed variable and tested for significance. The p-value and z-value obtained through replacement are shown in Table 3. Aside from the positive correlation observed in 2011–2013, the other years show no significant correlation, indicating that SCO countries exhibit a pattern of random distribution — agglomeration — random distribution in terms of IUI, with random distribution being the dominant trend overall.

Next, Moran's I index is calculated using ICT(Bop) as the observed variable and tested for significance, as shown in Table 3. The results pass the significance test, with Moran's I index consistently around –0.05 across all years. This indicates a negative spatial correlation among SCO member countries in terms of ICT(Bop), meaning that countries with higher ICT(Bop) are adjacent to those with lower ICT(Bop), and vice versa, reflecting a discrete distribution. Additionally, the Moran's I value has remained relatively stable over the past 15 years, indicating that this pattern of discrete distribution has not changed. The degree of dispersion has neither intensified nor diminished, nor has there been any tendency toward agglomeration.

Local spatial autocorrelation studies

Since the global analysis shows that IUI is mostly insignificant, we focus on local autocorrelation analysis for ICT(Bop). Three time points—2005, 2014, and 2022—are selected to observe the spatial-temporal evolution. The Moran's I scatter plots (Fig. 3 (a) (b) (c)) generated using software indicate that changes after 2014 are not significant. In Figure 3, the horizontal axis represents the descriptive variable, while the vertical axis represents the spatial lag vector.

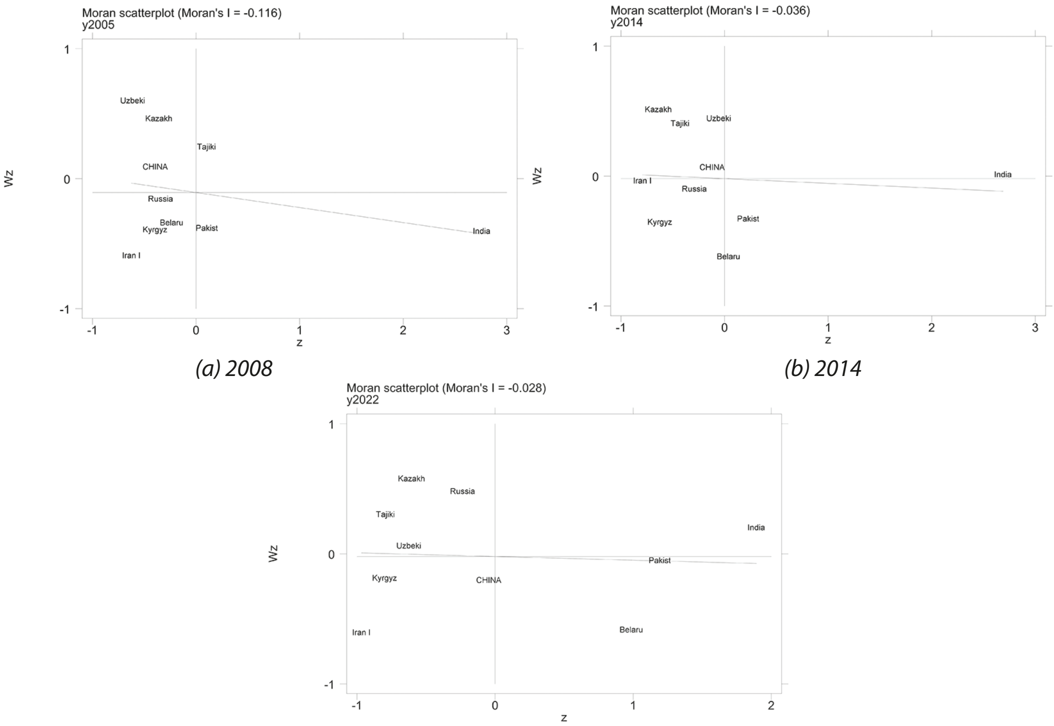
Figure 3 illustrates changes in the spatial distribution pattern of ICT(Bop) from 2005 to 2022. While the ICT(Bop) of each country has increased from 2014 to 2022, the growth rates have varied. The Moran's I scatter plot shows shifts in the distribution of high-high (H-H), high-low (H-L), low-high (L-H), and low-low (L-L) clusters. Additionally, the LISA cluster analysis reveals that over time, countries like China, India, and Belarus have

Table 3

Moran's I Index for ICT(Bop), IUI, 2008–2019

Year	Calculation of Moran's I Index by ICT(Bop)			Calculation of Moran's I Index by IUI			
	I	***z***	***p*-value***	***I***	***z***	***p*-value***	***p*-value***
2005	–0.116	–0.044	0.482	–0.048	0.309	0.379	Insignificant
2006	–0.095	0.149	0.441	–0.118	–0.036	0.486	Insignificant
2007	–0.088	0.219	0.414	–0.132	–0.104	0.459	Insignificant
2008	–0.020	0.664	0.253	–0.090	0.107	0.457	Insignificant
2009	–0.032	0.620	0.268	–0.076	0.187	0.426	Insignificant
2010	–0.058	0.626	0.266	–0.019	0.464	0.321	Insignificant
2011	–0.042	0.735	0.231	0.087	0.963	0.168	Significant
2012	–0.016	0.890	0.187	0.088	0.966	0.167	Significant
2013	–0.062	0.397	0.346	0.059	0.818	0.207	Significant
2014	–0.036	0.638	0.262	–0.023	0.426	0.335	Insignificant
2015	–0.057	0.447	0.327	–0.045	0.316	0.376	Insignificant
2016	–0.094	0.122	0.452	–0.050	0.293	0.385	Insignificant
2017	–0.087	0.156	0.438	–0.074	0.181	0.428	Insignificant
2018	–0.078	0.192	0.424	–0.095	0.078	0.469	Insignificant
2019	–0.073	0.210	0.417	–0.115	–0.020	0.492	Insignificant
2020	–0.068	0.220	0.413	–0.081	0.150	0.440	Insignificant
2021	–0.049	0.315	0.376	–0.070	0.206	0.419	Insignificant
2022	–0.028	0.414	0.340	–0.064	0.240	0.405	Insignificant

Source: created by the authors.



(a) 2008 *(b) 2014*

(c) 2022

Fig. 3. *Moran's I Scatter-plot for ICT(Bop) in the SCO Member States Region*
Source: Compiled by the authors

shifted quadrants. India now shows a higher ICT(Bop), with neighboring countries also exhibiting higher values, indicating a positive correlation. The spatial distribution of ICT(Bop) among SCO member states features H-H, H-L, L-H, and L-L patterns. Although the digital economy in SCO member states has not formed a clear clustering effect, from 2014 to 2022, there has been gradual spatial diffusion and spillover effects in the region's digital economy development.

8. Discussion and Conclusion

Digital economy aggregation strengthens intra-industry connections, promotes the flow of technology, knowledge, and capital, facilitates resource complementarity, and enhances industrial efficiency. At the same time, the development of the digital economy depends on the significant benefits of industrial aggregation, and its high-quality growth will inevitably lead to further industrial clustering.

1. Based on the analysis of the Theil Index, the following conclusions can be drawn about regional digital economy differences among SCO member countries: First, the regional Internet population share varies significantly, while differences in ICT exports are small, indicating that the digital economy in SCO countries is largely underdeveloped. A higher Internet population share is essential for digital economy growth, but the large Theil Index for Internet penetration highlights significant disparities among regions. Additionally, the overall ICT export levels in these countries are low, with no notable dif-

ferences in development, reflecting consistent underperformance. Therefore, the digital economy in the SCO region remains at an early, underdeveloped stage.

2. Based on exploratory spatial data analysis, the following conclusions are drawn about the spatial evolution of the digital economy in SCO member regions: Global spatial autocorrelation analysis, using ICT(Bop) as the observed variable, reveals a negative correlation in digital economy development, indicating a dispersed distribution. Countries with higher development levels are located near those with lower levels, and there is no clustering effect. This spatial dispersion suggests that the digital economy in SCO member countries still has considerable room for growth.

The development of the digital economy typically follows a pattern where disparities initially increase and later decrease, with leading countries driving others toward balanced growth. However, the digital economy in SCO member states is constrained by significant differences, particularly in the low Internet penetration rates across many countries, which hampers broader progress.

To accelerate the digital economy's integration into socio-economic development, it is essential to leverage mobile devices and the mobile Internet to create an accessible, grounded digital economy. Efforts should focus on: maximizing the potential of e-commerce to boost trade; learning from Southeast Asia by integrating the tourism industry with the digital economy; and expanding areas like the sharing economy and digital services to increase public engagement.

Internet infrastructure is the backbone of this transformation. By using resources from international institutions like the World Bank and the Asian Investment Bank, it is crucial to improve network infrastructure in South Asia to foster interconnectivity.

While the overall digital economy in the SCO region lags behind, countries like China, India, and Russia, with stronger economic outputs and higher Internet penetration, can spearhead the growth of the digital economy. These countries, along with several Central Asian nations, are positioned to form high-low digital development zones. According to the Blue Book of the Global Information Society (2022), China, Russia, and India show the greatest potential for further development of the digital economy, which can serve as the foundation for broader regional progress.

Promoting industrial upgrades through digital transformation is key. The SCO member states must "change lanes" by transitioning from traditional to smart economies, leveraging their unique strengths in industries like agriculture, textiles, and entertainment. Digital technology can enhance industrial upgrading, service innovation, and trade diversification. Moreover, talent and technology investments are fundamental to unlocking the full potential of the digital economy, ensuring sustained growth.

Breaking from traditional development models, the SCO countries must embrace industrial clustering and cooperation. Close collaboration with China, which leads in areas like e-commerce, smart cities, 5G, and cloud computing, can drive technology transfers and foster innovation. Strengthening exchanges at the levels of the government, industry, and individual levels will ensure the flow of ideas, technologies, and best practices across the region.

Finally, SCO countries should focus on deepening regional cooperation in the digital economy. By formulating inclusive and cooperative policies, sharing technological achievements, and fostering coordinated efforts in product and service exports, the region can build a platform for win-win collaboration, driving industrial efficiency and the benefits of digital economy aggregation.

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About the authors

Rong Li — PhD candidate, Belarusian State University; https://orcid.org/0009-0001-5064-8446 (4, Nezavisimosti Avenue, Minsk, 220030, Belarus; e-mail: econ.lirong@qq.com).

Catherine G. Gospodarik — Cand. Sci. (Econ.), Associate Professor, Head of the Department of Analytical Economics and Econometrics, Faculty of Economics, Belarusian State University; Associate Professor of the Department of Business Analysis, Financial University under the Government of the Russian Federation; https://orcid.org/0000-0002-5593-7728 (4, Nezavisimosti Avenue, Minsk, 220030, Belarus; e-mail: gospodarik@bsu.by; 49, Leningradsky Avenue, Moscow, 125167, Russian Federation; e-mail: eggospodarik@fa.ru).

Информация об авторах

Ли Жун — аспирант, Белорусский государственный университет; https://orcid.org/0009-0001-5064-8446 (Республика Беларусь, 220030, г. Минск, пр-т Независимости, 4; e-mail: econ.lirong@qq.com).

Господарик Екатерина Геннадьевна — кандидат экономических наук, доцент, заведующая кафедрой аналитической экономики и эконометрики факультета экономики, Белорусский государственный университет; доцент кафедры бизнес-аналитики, Финансовый университет при Правительстве Российской Федерации; https://orcid.org/0000-0002-5593-7728 (Республика Беларусь, 220030, г. Минск, пр-т Независимости, 4; e-mail: gospodarik@bsu.by; Российская Федерация, 125167, г. Москва, пр. Ленинградский, 49; e-mail: eggospodarik@fa.ru).

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