CONSTRUCTING AN INDEX FOR CROSS-BORDER E-COMMERCE DEVELOPMENT LEVELS BASED ON ECOSYSTEM THEORY: EMPIRICAL INSIGHTS FROM RCEP COUNTRIES

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ABSTRACT

This study assesses the development levels of cross-border e-commerce among Regional Comprehensive Economic Partnership (RCEP) nations from 2013 to 2022. The study synthesizes global literature on e-commerce ecosystem theories, key influencing factors, and measurement approaches to construct a multidimensional indicator system. This system integrates the TIMG index to provide a comprehensive analysis of the digital economy's impacts. By employing principal component analysis in Stata, the study formulates a scoring methodology to evaluate e-commerce development across RCEP nations, highlighting trends over the decade. The results identify China, Japan, and Singapore as leading nations, followed closely by South Korea and Australia. New Zealand, Malaysia, Thailand, Indonesia, Vietnam, and the Philippines comprise the third tier, while Laos ranks at the lowest development level. The study emphasizes the critical roles of logistics and information flow in e-commerce development, providing valuable insights for future explorations within the RCEP framework.

Keywords: Cross-Border E-Commerce Development Index, RCEP, Cross-border E-commerce Ecosystem Theory, PCA, TIMG.

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1. INTRODUCTION

In recent years, the growth of traditional international trade has slowed, whereas cross-border e-commerce, fueled by advancements in information technology and the internet, has emerged as a vital driver of the digital economy (Zhang & Li, 2020). A report by Facts & Factors (2023) highlighted that the transaction volume of B2C cross-border e-commerce reached $785 billion in 2021 and is projected to exceed $793.8 billion by 2030, with a compound annual growth rate of 26.19% from 2022 to 2030. This remarkable growth underscores the growing significance of cross-border e-commerce in the global marketplace.

The Asia-Pacific region has played a central role in this expansion, achieving the highest annual e-commerce growth rate worldwide in 2019. Shimizu (2021) emphasized that the Belt and Road Initiative has substantially enhanced Southeast Asian cross-border e-commerce, projecting that its transaction volume will account for over 40% of the region's internet economy value by 2025. Moreover, the Regional Comprehensive Economic Partnership (RCEP), encompassing approximately one-third of the global economy, represents a pivotal milestone in economic integration and trade efficiency across the Asia-Pacific region (Su, 2022).

The RCEP agreement is anticipated to boost trade volumes and deepen economic integration within East Asia. It prioritizes digital connectivity, the strengthening of digital infrastructure, the advancement of paperless trading, and the protection of consumer data privacy, with the goal of fostering a favorable environment for e-commerce growth (Chiang et al., 2020). These initiatives are projected to facilitate cross-border e-commerce transactions, enhance customs and logistics efficiency, and ensure the seamless flow of goods and services across borders. Despite the promising expansion of cross-border e-commerce, particularly in the Asia-Pacific region, a significant gap persists in research that systematically measures and evaluates its development, particularly within the RCEP framework. The cross-border e-commerce ecosystem theory offers a holistic framework for analyzing the complex interactions and influencing factors within this sector. However, its empirical application within the RCEP context remains underexplored.

This study seeks to bridge this gap by formulating a comprehensive index to evaluate cross-border e-commerce development levels within RCEP countries. By conducting an extensive literature review, this study will examine the cross-border e-commerce ecosystem theory, pinpoint critical development factors, and evaluate the applicability and limitations of current measurement methods. This research aims to lay a robust theoretical foundation for constructing a cross-border e-commerce development index while providing valuable insights for future empirical studies in this domain.

2. LITERATURE REVIEW

The rapid rise of cross-border e-commerce as a vital component of the global trade ecosystem in the digital economy era necessitates a comprehensive understanding of its theoretical foundations and influencing factors. The concept of the cross-border e-commerce ecosystem originates from A.G. Tansley's introduction of the ecosystem concept in the 1930s, initially applied within biology and environmental science. Moore, J. F. (1999) later extended this concept into the business domain, introducing the business ecosystem framework, which includes core companies, consumers, market intermediaries, and suppliers. Frosch and Gallopoulos (1989) further advanced this concept into the industrial ecosystem, framing the economy as a cyclical system of material, energy, and information exchanges among stakeholders.

Building on these foundational theories, the cross-border e-commerce ecosystem is now conceptualized as a network of interdependent organizations and individuals — businesses, government entities, and consumers—engaged in international trade via digital platforms. This ecosystem is marked by dynamic flows of goods, services, capital, and information, driven by technological advancements and the global reach of the internet. Core entities, such as e-commerce platforms, coordinate resources and activities, while key participants—producers, manufacturers, and consumers—create value through their interactions. Supporting entities, such as logistics and payment service providers, enhance the ecosystem's efficiency and connectivity (Liu, 2021; Hu, Lu, & Huang, 2009; Li, Zhang, Qu, & Zhao, 2018).

Recent studies have comprehensively traced the evolution of the ecosystem concept, from its ecological origins to its application in cross-border e-commerce, emphasizing the intricate network of interactions that characterize the modern cross-border e-commerce landscape (Zhang, 2021). This includes a multidimensional structure where entities exchange resources and support each other's growth, underscoring the ecosystem's potential for sustainable development.

The factors driving the growth of cross-border e-commerce are diverse. These factors include technological infrastructure, logistics efficiency, payment system security, and a supportive policy environment. The development of ICT and the internet has streamlined market entry, enabling sellers to reach global consumers with greater ease. Key drivers identified by scholars include national policies, ICT maturity, smartphone accessibility, and banking support for electronic transactions (Derindağ, 2022; Villa et al., 2018; Nazir & Muhammad Azam, 2020). Logistics, a critical component of the ecosystem, faces challenges such as high costs and inefficiencies, requiring policy support and infrastructure development (Zhang & Ma, 2015; Zhang et al., 2015).

Researchers have proposed various indicators and frameworks to effectively measure cross-border e-commerce development levels. These frameworks assess aspects such as marketing, payment processing, customs clearance, and logistics, reflecting the ecosystem's multifaceted nature. Recent studies have developed more comprehensive evaluation systems that incorporate multiple dimensions to fully capture the ecosystem's complexity (Yang Zheng & Yang, 2014; Li et al., 2020). However, there is still a need for detailed statistical measures to accurately assess the ecosystem's development level, particularly at regional and national levels.

As the digital economy evolves, understanding the dynamics of the cross-border e-commerce ecosystem is crucial for stakeholders. The integration of digital technologies with infrastructure, markets, and governance development plays a vital role in shaping the future of international trade and e-commerce (Wang et al., 2021; Timur et al., 2020). The digital economy, as defined by the Oxford Dictionary, refers to an economic system fundamentally based on digital technologies, emphasizing electronic transactions via the internet (OUP, 2021). This study aims to apply the cross-border e-commerce ecosystem theory to assess development levels within RCEP countries.

By applying the TIMG index, which evaluates global digital economy development across four dimensions—digital technology, digital infrastructure, digital markets, and digital governance—this research focuses on measuring information flow indicators within the cross-border e-commerce development framework. These indicators, along with other relevant metrics, are used to comprehensively evaluate the developmental status of cross-border e-commerce across RCEP nations.

3. METHODOLOGY

3.1. Statistical Analysis Method

Principal Component Analysis (PCA) is a statistical method that uses orthogonal transformations to convert a set of potentially correlated variables into a set of linearly uncorrelated variables, known as principal components. This method, developed by Pearson (1901) and Hotelling (1933), is widely used for dimensionality reduction and data interpretation. In the context of cross-border e-commerce and international trade, PCA can identify key factors affecting trade flow, economic performance, and development indicators. For example, Yushi and Borojo (2019) used PCA to examine the impact of institutional quality, border and transport efficiency, and physical and communication infrastructure on intra-Africa trade flows. Similarly, Chen (2021) proposed a PCA-based economic performance evaluation model to address the low accuracy of traditional models in evaluating Chinese enterprises' cross-border mergers and acquisitions. By reducing dimensionality and extracting key variables, PCA provides valuable data support and insights for decision-making in the cross-border e-commerce domain. Here, we outline the procedural steps and mathematical formulations integral to PCA, as commonly adopted in contemporary quantitative research. The steps and mathematical formulations integral to PCA are outlined as follows:

Data Standardization: To facilitate factor analysis, the data is first standardized using the range method. This transformation converts the data into a standardized normal distribution with a mean of 0 and a standard deviation of 1, eliminating unit differences between indicators and ensuring the data is analyzed on the same scale.

$$S_i \begin{cases} 0, & c_i \le c_{imin} \\ \frac{c_i - c_{imin}}{c_{imax} - c_{imin}}, & c_{imin} < c_i < c_{imax} \\ 1, & c_i \ge c_{imax} \end{cases} \quad (1)$$

Covariance Matrix Computation: The covariance matrix is computed to elucidate the relationships between variables. If the data has been standardized, the covariance matrix and the correlation matrix converge. The element c_{ij} in the covariance matrix C is calculated as follows:

$$c_{ij} = \frac{1}{n-1}\sum_{k=1}^{n}(X_{ki} - \overline{X}_i)(X_{kj} - \overline{X}_j) \quad (2)$$

Here, n signifies the sample size, and $\overline{X_i}, \overline{X_j}$ are the sample means of variables X_i and X_j, respectively.

Eigenvalues and Eigenvectors Determination: The eigenvalues λ and corresponding eigenvectors v of the covariance matrix C are then ascertained by solving:

$$C\upsilon = \lambda\upsilon \tag{3}$$

This equation facilitates the identification of the principal components' directions.

Principal Component Selection: Principal components are selected based on descending order of their associated eigenvalues, λ , with the first k eigenvectors representing the dataset's primary axes of variance.

Principal Component Scores Calculation: Lastly, the projection of the dataset onto these principal components yields the principal component scores, calculated for the j^{th} component as:

$$PC_j = Z\upsilon_j \tag{4}$$

where Z denotes the matrix of standardized data, and υ_j corresponds to the j^{th} eigenvector.

Through these steps, PCA transforms the original dataset into a new set of orthogonal dimensions, ranked by their contribution to the total variance. This allows researchers to effectively reduce data dimensionality with minimal information loss, leading to a more concise representation of the dataset's structure.

3.2. Indicators and Data Sources

This study constructs an evaluation indicator system for the cross-border e-commerce ecosystem by integrating the cross-border e-commerce evaluation framework proposed by Huang (2019) and the national e-commerce model city evaluation system. The selected indicators reflect the multi-dimensional nature of the cross-border e-commerce ecosystem and ensure the objectivity and availability of data.

The indicator system is divided into primary and secondary indicators:

Table 1: Indicator Composition of CBECI System

Species	Primary Indicators	Secondary Indicators	Data Source
Leading Species	Scale of goods import and export transactions	Import volume of goods (LS1)	World Bank Database
		Export volume of goods (LS2)	World Bank Database
Key Species	Manufacturers and Consumers	Manufacturing value added (KS1)	World Bank Database
		Individuals using the Internet (KS2)	World Bank Database
Supporting Species	Logistics Performance	Ability to track and trace consignments (LP1)	World Bank Database
		Competence and quality of logistics services (LP2)	
		Ease of arranging competitively priced shipments (LP3)	
		Efficiency of customs clearance process (LP4)	
		Frequency with which shipments reach consignee within scheduled or expected time (LP5)	
		Quality of trade and transport-related infrastructure (LP6)	
	Information Flow	Digital technology (IF1)	Chinese Academy of Social Sciences (CASS)
		Digital Infrastructure (IF2)	
		Digital Market (IF3)	
		Digital Governance (IF4)	
	Cash Flow	Number of commercial banks (CF1)	International Monetary Fund Database
		Per capita net national income (CF2)	World Bank Database

3.3. Estimation Model

The cross-border e-commerce development level indicator system includes multiple indicators that influence various aspects of development, potentially leading to correlations among them. Directly introducing these indicators into the empirical model could result in multicollinearity issues and increase the model's complexity. To address this issue, PCA is employed to process the indicator system.

PCA extracts principal components to transform the data, deriving combinations of indicators and calculating the contribution of each. By extracting several principal components with higher contributions, this study aims to create a new set of mutually independent indicators that better reflect the overall situation, improving empirical testing accuracy by reducing redundant information and simplifying the empirical model. The basic formula for PCA is:

$$F_i = a_{1i}X_1 + a_{2i}X_2 + \cdots + a_{pi}X_p \quad (5)$$

Where $X_1, X_2, \cdots X_p$ are the individual indices, $a_{1i}, a_{2i}, \cdots a_{pi}$ are the constant vectors, and F_i represents the linear combination of P index vectors $X_1, X_2, \cdots X_p$ of data matrix X (i.e., comprehensive index vector).

4. RESULTS AND DISCUSSION

4.1. Data Suitability Testing

To ensure that the variables meet the strong correlation requirement for principal component analysis, this study conducted the Kaiser-Meyer-Olkin (KMO) test and Bartlett's test of sphericity on the standardized data. The results, presented in Table 2, indicate a KMO value of 0.856, which exceeds the commonly accepted threshold of 0.7. The significance level of Bartlett's test of sphericity is 0.000, indicating that the selected indicators are highly appropriate for PCA.

Table 2: Summary of Bartlett's Test and KMO Measure

Measure	Value
Bartlett's Test of Sphericity χ^2	3967.174
Degrees of Freedom (df)	120
p-value	< .001
Kaiser-Meyer-Olkin (KMO)	0.856

Source: Data processed, STATA 18

4.2. Factor Analysis

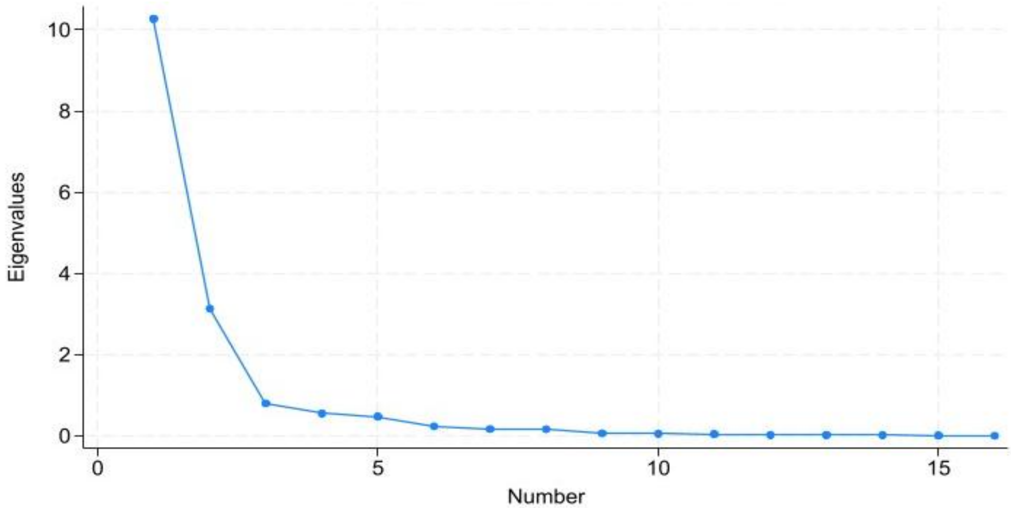
The factor analysis results, presented in Table 3, reveal that the eigenvalues of the first two components are both greater than 1, suggesting that these principal components are highly reliable. The cumulative variance contribution of these two components reaches 83.78%, indicating that the current indicator system satisfactorily explains a significant portion of the variance in the development level of cross-border e-commerce.

Table 3: Total Variance Explanation

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	10.2716	7.1391	0.6420	0.6420
Comp2	3.1325	2.3329	0.1958	0.8378
Comp3	0.7996	0.2533	0.0500	0.8877
Comp4	0.5463	0.0746	0.0341	0.9219
Comp5	0.4717	0.2376	0.0295	0.9514
Comp6	0.2341	0.0660	0.0146	0.9660
Comp7	0.1681	0.0062	0.0105	0.9765
Comp8	0.1619	0.1037	0.0101	0.9866
Comp9	0.0582	0.0088	0.0036	0.9903
Comp10	0.0494	0.0069	0.0031	0.9933
Comp11	0.0425	0.0213	0.0027	0.9960
Comp12	0.0212	0.0029	0.0013	0.9973
Comp13	0.0182	0.0050	0.0011	0.9985
Comp14	0.0133	0.0042	0.0008	0.9993
Comp15	0.0091	0.0069	0.0006	0.9999
Comp16	0.0022	.	0.0001	1.0000

Source: Data processed, STATA 18

Figure 1: Scree Plot of Eigenvalues



Source: Data processed, STATA 18

Table 4: Loadings Matrix

	Comp1	Comp2
LS1	0.1243	0.5090
LS2	0.1291	0.5042
KS1	0.0935	0.5221
KS2	0.2523	-0.1552
LP1	0.2998	-0.0337
LP2	0.3040	-0.0390
LP3	0.2535	0.0503
LP4	0.2881	-0.1154
LP5	0.2813	-0.0550
LP6	0.3053	-0.0182
IF1	0.2962	0.0057
IF2	0.2683	0.0684
IF3	0.2571	0.1897
IF4	0.2823	-0.1898
CF1	0.1754	-0.1753
CF2	0.2394	-0.2464

Source: Data processed, STATA 18

4.3. Principal Component Scores Calculation

The coefficients for the linear combinations $Comp_1$ and $Comp_2$ are calculated by dividing each indicator's component value by the square root of the eigenvalue of the corresponding principal component. The equations for $Comp_1$ and $Comp_2$ are as follows:

$$Comp_1=0.0388*LS_1+0.0403*LS_2+0.0292*KS_1+0.0787*KS_2+0.0935*LP_1+0.0949*LP_2+0.0791*LP_3+0.0899*LP_4+0.0878*LP_5+0.0953*LP_6+0.0924*IF_1+0.0837*IF_2+0.0802*IF_3+0.0881*IF_4+0.0547*CF_1+0.0747*CF_2 \quad (6)$$

$$Comp_2=0.2876*LS_1+0.2849*LS_2+0.2950*KS_1-0.0877*KS_2-0.0190*LP_1-0.022*LP_2+0.0284*LP_3-0.0652*LP_4-0.0311*LP_5-0.0103*LP_6+0.0032*IF_1+0.0386*IF_2+0.1072*IF_3-0.1072*IF_4-0.099*CF_1-0.1392*CF_2 \quad (7)$$

The comprehensive score formula is:

$$Comp=(0.642*Comp_1+0.1958*Comp_2)/0.8378 \quad (8)$$

$Comp_1$ and $Comp_2$ represent the scores of RCEP member countries under the influence of two principal components, respectively, while Comp denotes the composite score. The coefficients for Comp are normalized, resulting in the establishment of a composite scoring model:

$$CBECI=0.0946*LS1+0.0962*LS2+0.0903*KS1+0.0381*KS2+0.0651*LP1+0.0654*LP2+0.0654*LP3+0.0517*LP4+0.058*LP5+0.0684*LP6+0.0695*IF1+0.0712*IF2+0.0846*IF3+0.0406*IF4+0.0177*CF1+0.0232*CF2 \quad (9)$$

4.4. Measuring Results of Cross-border E-commerce Development Level

By substituting the variables from the indicator system into the composite score formula Y, the development level data for cross-border e-commerce among the 12 RCEP countries are obtained, as shown in Table 5.

Table 5: Development level of cross-border e-commerce in RCEP countries

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
AUS	0.5743	0.5714	0.5718	0.5710	0.5699	0.5702	0.5723	0.5753	0.5822	0.5884
CHN	0.6022	0.6258	0.6342	0.6505	0.6744	0.7108	0.7216	0.7388	0.8078	0.8217
IDN	0.3186	0.3121	0.3074	0.3041	0.3337	0.3740	0.3728	0.3748	0.3845	0.3919
JPN	0.6266	0.6347	0.6370	0.6452	0.6543	0.6724	0.6703	0.6662	0.6671	0.6649
KOR	0.5430	0.5493	0.5643	0.5724	0.5655	0.5671	0.5715	0.5840	0.6025	0.6151
LAO	0.0817	0.0578	0.0397	0.0214	0.0873	0.1363	0.1334	0.1284	0.1236	0.1187
MYS	0.4709	0.4657	0.4603	0.4525	0.4400	0.4304	0.4493	0.4733	0.4997	0.5224
NZL	0.5112	0.4936	0.4765	0.4594	0.5034	0.5470	0.5350	0.5254	0.5211	0.5165
PHL	0.2689	0.2700	0.2721	0.2667	0.2809	0.3002	0.3198	0.3471	0.3661	0.3847
SGP	0.5899	0.6038	0.6181	0.6376	0.6364	0.6307	0.6441	0.6651	0.6922	0.7149
THA	0.3806	0.3730	0.3673	0.3652	0.3922	0.4180	0.4313	0.4421	0.4532	0.4605
VNM	0.2937	0.2896	0.2808	0.2796	0.3096	0.3651	0.3762	0.3879	0.3947	0.3999

Source: Data processed, STATA 18

Overall, under the current indicator system, a noticeable gap exists in the development levels of cross-border e-commerce between lower-middle-income countries and upper-middle-income to high-income countries. As illustrated in Table 6, Laos, the Philippines, and Vietnam, which are ranked at the lower end, are all classified as lower-middle-income countries.

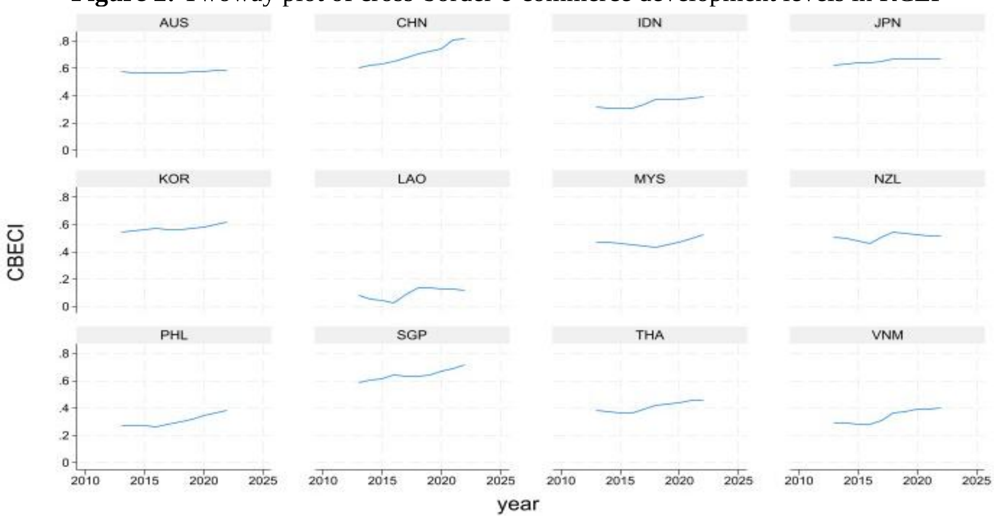
Table 6: Ranking of cross-border e-commerce development level in RCEP countries

	2013	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
AUS	4	4	4	5	4	4	4	5	5	5
CHN	2	2	2	1	1	1	1	1	1	1
IDN	9	9	9	9	9	9	10	10	10	10
JPN	1	1	1	2	2	2	2	2	3	3
KOR	5	5	5	4	5	5	5	4	4	4
LAO	12	12	12	12	12	12	12	12	12	12
MYS	7	7	7	7	7	7	7	7	7	6
NZL	6	6	6	6	6	6	6	6	6	7
PHL	11	11	11	11	11	11	11	11	11	11
SGP	3	3	3	3	3	3	3	3	2	2
THA	8	8	8	8	8	8	8	8	8	8
VNM	10	10	10	10	10	10	9	9	9	9

Source: Compiled based on STATA 18 calculation results

Based on the time trend analysis in Figure 2, the development levels of cross-border e-commerce among RCEP countries have generally shown growth from 2013 to 2022. China, in particular, has consistently led with an increasing annual growth rate. Singapore ranks at the forefront of cross-border e-commerce development. Developed countries such as Japan and Australia have experienced slow growth but maintain a relatively high level overall. Malaysia, New Zealand, and Laos have experienced slower development speeds with fluctuating trends. Despite some setbacks in certain years, they have shown potential for growth. Vietnam, Thailand, and the Philippines have lower levels of cross-border e-commerce development but are steadily making progress.

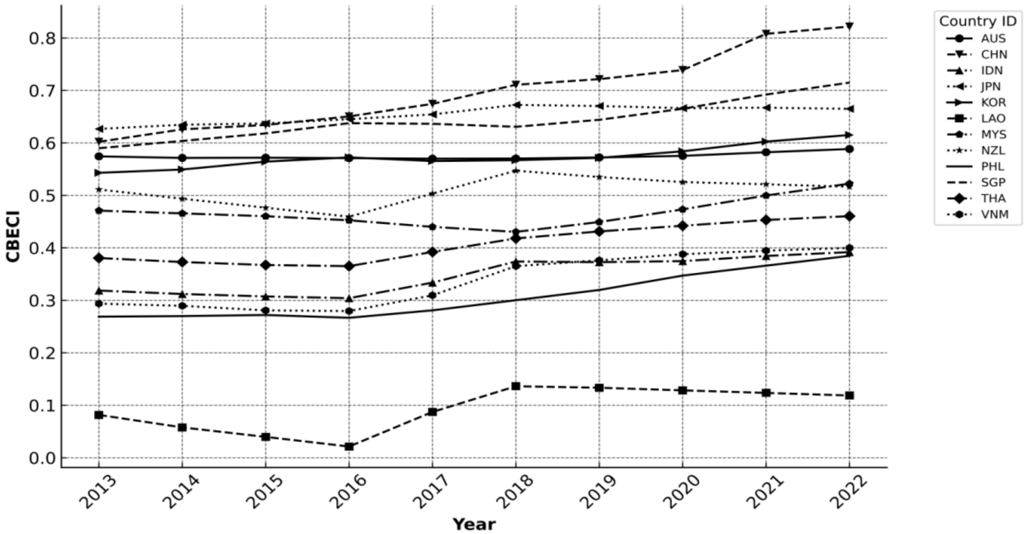
Figure 2: Twoway plot of cross-border e-commerce development levels in RCEP



Source: Data processed, STATA 18

From the perspective of country differences, as shown in Figure 3, China has successfully overtaken Japan to become the leader in cross-border e-commerce development, demonstrating its significant trade potential. Countries such as Singapore, Japan, South Korea, and Australia continue to hold leading positions, indicating their high levels of cross-border e-commerce development. Observing the disparities in cross-border e-commerce development between China and countries such as Laos and the Philippines, as shown in Figure 3, reveals significant differences among RCEP member states.

Figure 3: Line chart of cross-border e-commerce development level in RCEP countries 2013-2022



Source: Data processed, STATA 18

4.5. Discussion

In this study, Principal Component Analysis (PCA) was used to construct an index for evaluating the development level of cross-border e-commerce in RCEP countries, with indicator weights reflecting their impact on the index. This section discusses the results in the context of the theoretical background reviewed earlier and provides supporting arguments based on prior research to justify the findings and further explore insights.

From the perspective of the cross-border e-commerce ecosystem, the total weights for Leading Species, Key Species, and Supporting Species are 0.1908, 0.1284, and 0.6808, respectively. The results indicate that the development level of Supporting Species accounts for 68.08% of the cross-border e-commerce development level, providing empirical evidence for the critical role of "Supporting Species in promoting cross-border e-commerce development," which aligns with the findings of Li (2018).

Looking at the primary indicators, the weights for the Scale of goods import and export transactions, Manufacturers and Consumers, Logistics Performance, Information Flow, and Cash Flow are 19.08%, 12.84%, 37.41%, 26.58%, and 4.08%, respectively. These results first support Zhang's (2021) argument that the cross-border e-commerce ecosystem is a complex ecological network comprising logistics, business flows, capital flows, and information flows. Secondly, the highest proportion of logistics underscores its crucial role in the development level of cross-border e-commerce, consistent with the counter-argument by Zhang & Ma (2015) that lagging logistics hinders the development of cross-border e-commerce. Next, the TIMG index, representing information flow, ranks second only to logistics, aligning with Zhang and Li (2020) assertion that "the digital economy is the foundation for the development of cross-border e-commerce and digital trade."

At the secondary indicator level, the weights for Import volume of goods, Export volume of goods, and Manufacturing value added all exceed 9%, validating, to some extent, He and Wang's (2019) statement that "GDP influences cross-border e-commerce trade." Import and export volumes of goods and Manufacturing value added reflect GDP. On the other hand, the smallest proportions for the two secondary indicators of Cash Flow suggest a relatively minor impact of capital flows on the development level of cross-border e-commerce. This may be related to the limitations of the selected indicators. This viewpoint is yet unsupported by literature. Current research only provides insights into the relationship between capital flows and economic activity, without directly discussing the impact of cash flow on the development level of cross-border e-commerce.

From a national perspective, China, with its gradually perfected cross-border e-commerce infrastructure and vast market size and consumer base, ranks first in global cross-border e-commerce development. This ranking is likely due to the rapid improvement of logistics and network infrastructure, as well as enhanced customs efficiency, aligning with the reality and reflecting the comprehensiveness and authenticity of the constructed cross-border e-commerce development level index system. Singapore, as the most economically developed country in RCEP, ranks at the forefront, supported by its advanced financial services, manufacturing sector, and open trade and investment policies.

The results show that as time progresses, the development level of cross-border e-commerce in all countries continues to grow, with varying speeds but a positive trend overall, in line with Shen's (2023) discussion. However, this study finds that the development levels of cross-border e-commerce in Australia and South Korea are on par, differing from previous research (Shen, 2023), possibly due to differences in the datasets of G20 and RCEP countries. This also highlights areas for further exploration in future research.

Laos ranks lowest in cross-border e-commerce development due to its economic development level and relatively backward e-commerce infrastructure, consistent with Song's (2021) findings on the lower e-commerce development levels in Myanmar, Laos, and Cambodia among ASEAN countries. These disparities may stem from variations in economic levels, infrastructure development, and logistics speed and efficiency among the countries.

5. CONCLUSION

5.1. Summary of Findings

This study developed an index to evaluate the development levels of cross-border e-commerce among RCEP member countries using Principal Component Analysis (PCA). The key findings from this research can be summarized as follows:

Firstly, the suitability of the data for PCA was confirmed by the results of the Kaiser-Meyer-Olkin (KMO) and Bartlett's test. The KMO value of 0.856 was well above the accepted threshold of 0.7, and Bartlett's test had a significance level of 0.000, demonstrating that the data was appropriate for factor analysis. This ensures that the data could effectively be used to identify underlying patterns in cross-border e-commerce development.

Secondly, two principal components were identified in the analysis, which together explained 83.78% of the variance in the dataset. These components represent the key factors influencing cross-border e-commerce development, particularly logistics performance and information flow. The identification of these principal components highlights the critical factors that shape the development of cross-border e-commerce within the region.

Thirdly, the Composite Cross-Border E-Commerce Index (CBECI) that was constructed successfully captured the variations in development levels among the 12 RCEP countries. This index revealed significant disparities in development levels, with a clear divide between lower-middle-income countries and upper-middle-income to high-income countries. This finding emphasizes the varying stages of development across the region and the need for targeted interventions in lower-income countries.

Finally, the country rankings showed that China, Singapore, Japan, and South Korea consistently ranked at the forefront of cross-border e-commerce development. China, in particular, led in terms of growth rate. On the other hand, Laos, the Philippines, and Vietnam exhibited lower levels of development, although they demonstrated potential for improvement. This underscores the unequal progress within the region and the potential for growth in countries lagging behind.

5.2. Implications

The findings of this study provide several important implications for policymakers and future research.

First, the significant role of logistics and information flow in cross-border e-commerce development suggests that policymakers should prioritize improvements in digital infrastructure and logistics systems. Strengthening customs procedures, promoting digital payment solutions, and ensuring cybersecurity will create a more conducive environment for e-commerce growth, particularly in lower-income countries. These measures are crucial for improving the efficiency and security of cross-border transactions, fostering greater participation in the global e-commerce market.

Second, the disparities in development levels among RCEP countries highlight the importance of regional cooperation. Countries with higher e-commerce development should share best practices and provide technical and financial support to lower-income nations. Coordinating policies, improving logistics networks, and harmonizing trade regulations can foster economic integration and elevate cross-border e-commerce across the region. This collaborative approach will help bridge the development gap and create a more balanced e-commerce ecosystem in RCEP.

5.3. Limitations

While this study makes important contributions, there are several limitations that should be addressed in future research.

First, the data used in this study is limited to the past decade, which might not fully capture long-term trends. Extending the time frame to include more historical data could help identify more stable and enduring patterns in cross-border e-commerce development. Longer-term data will provide a more comprehensive understanding of how the e-commerce ecosystem has evolved and how it might continue to develop in the future.

Second, the exclusion of certain RCEP member countries from the analysis could limit the generalizability of the findings. The absence of some countries from the dataset means that the conclusions drawn from the study may not be fully representative of the entire RCEP region. Future research should aim to include all RCEP countries to ensure a more holistic understanding of the regional e-commerce landscape and to enhance the robustness of the results.

5.4. Future Research

To address these limitations, future research should:

Extend Data Timeframe: Future studies should expand the time frame for analyzing cross-border e-commerce development to ensure the stability and robustness of the findings. This will help to capture longer-term trends and assess the ongoing impact of digital economy policies and e-commerce strategies.

Include More Countries: To gain a more complete and representative view of the region's cross-border e-commerce landscape, future studies should include all RCEP member countries. This will improve the generalizability of the findings and provide a more comprehensive understanding of the factors influencing cross-border e-commerce development across the region.

This study offers a comprehensive evaluation of cross-border e-commerce development levels among RCEP member countries. The findings emphasize the crucial role of logistics and information flow in shaping e-commerce growth. By addressing the gaps and challenges identified, policymakers and stakeholders can enhance the cross-border e-commerce ecosystem, promoting more balanced and inclusive growth across the RCEP region.

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