



Measurement and International Comparison of the Competitiveness of Digital Service Trade Based on Entropy Method

Lan Liu^{1,2(✉)} and Wan Luo²

¹ Manufacturing Industry Development Research Center on Wuhan City Circle, Wuhan, China
liulan@jhun.edu.cn

² Business School of Jiangnan University, Wuhan, Hubei, China

Abstract. Digital service trade has become a new engine driving the growth of Global trade nowadays. Using the data of UNCTAD, this paper analyzes the development level and competitiveness of China's digital service trade. Based on entropy method, we select six countries of two types of economies for horizontal comparison. The study found that China's international competitiveness of digital service trade has improved year by year, but there is a large gap with developed economies such as Europe and the United States. In the future, we should take some countermeasures to lay a more solid foundation for the high-quality development of digital trade.

Keywords: digital service trade · competitiveness · entropy method

1 Introduction

It is generally believed that digital service trade refers to the trade of digital products and services delivered through network transmission. However, the understanding of specific service categories and scope is not unified, and there are still disputes about the definition of digital service trade. The US International Trade Commission (USITC2013) firstly defined digital trade as “commercial activities and international trade of products and services submitted through the Internet”. OECD believes that digital service trade refers to the trade of cross-border transmission and delivery through information communication networks, including e-books, software Data and database services, etc. The United Nations Conference on Trade and development (hereinafter referred to as “UNCTAD”) defines digital service trade as “all service trade delivered across borders through information and communication networks”. The Global Service Trade Development Index Report (2018) released by the Ministry of Commerce in China believes that digital service trade is the digital trade that eliminates the digitization of goods trade, which depends on embedding traditional services into different digital carriers for delivery and sales.

Some scholars have studied the measurement, development status and influencing factors of digital service trade. Because scholars choose different data and indicators in

the research, which usually leads to different results. For example, Fang (2020) analyzed the development of China's Digital Trade and developed an index system using the conceptual framework of OECD-WTO. According to the data of UNCTAD, Mei (2020) found that the export scale of global digital service trade has increased rapidly, and its proportion in global service trade has gradually increased from 43.4% in 2005 to about 50% in 2018. Lan and Dou (2019) used the "entropy method" to build a comprehensive evaluation system and compared the international competitiveness level of digital trade among the top ten countries in the total economic quantity from 2008 to 2017. Yue and Li (2020) investigated the international competitiveness of digital service trade based on the statistical framework of UNCTAD. On the whole, the existing research about China's digital service trade is still in the stage of preliminary exploration. They did not develop a unified evaluation index and did not make a further exploration on the segments of digital service trade, which cannot keep pace with the development and practice of digital service trade. Measuring and comparing the international competitiveness of China's digital service trade can help us more accurately study and judge the international situation and explore domestic advantages, and more actively participate in the formulation of international trade rules and global market competition, which has important theoretical and practical significance.

2 Analysis on the Development of Digital Service Trade

2.1 The Growth Rate of Digital Service Trade is Obvious

In recent years, the global digital economy has entered a new era of rapid development. Online R & D, design, production and delivery activities relying on digital technology are becoming more and more frequent, which has greatly promoted the development of digital service trade. The growth rate of digital service trade exceeds that of service trade and goods trade. From 2010 to 2020, the average annual growth rates of digital service trade, service trade and goods trade were 6.21%, 2.83% and 1.79% respectively. In 2020, the export scale of global digital service trade is expected to reach 3403.623 billion US dollars, accounting for 15.08% of the total export trade and 68.3% of the export of service trade. Digital service trade has become a new engine driving the growth of Global trade.

2.2 Developed Economies Have More Prominent Advantages in the Field of Digital Service Trade

Compared with the traditional goods trade, developed economies have more capital and technological advantages in digital service trade. Once the advantages are established, it will be difficult for transition economies and developing economies to surpass. In 2019, the export scale of digital service trade of the three major economies accounted for 1.29%, 22.56% and 76.15% of the global digital trade respectively. Developed economies accounted for the largest proportion, followed by developing economies and transition economies, the proportion of developed countries in digital service trade far exceeds that of service trade and goods trade (Table 1).

Table 1. Proportion of digital service trade in service trade of three economies (export)

| | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|----------------------|------|------|------|------|------|------|------|------|------|------|
| Transition economies | 32.2 | 33.4 | 34.2 | 35.0 | 36.2 | 37.4 | 38.0 | 37.6 | 38.1 | 39.3 |
| Developing economies | 27.7 | 27.1 | 28.0 | 29.2 | 29.3 | 29.1 | 28.1 | 27.8 | 28.0 | 30.0 |
| Developed economies | 53.9 | 54.7 | 55.0 | 55.3 | 56.1 | 56.7 | 57.6 | 57.5 | 57.4 | 58.2 |

2.3 The Scale of China's Digital Trade is Rising, But Its International Market Share is Low

In recent years, with the accelerated integration of digital technology and service trade, the degree of digital delivery of China's service trade has been continuously improved, and the proportion of digital service trade in service trade has increased significantly. From 2010 to 2019, the total export volume of China's digital service trade continued to increase, reaching the highest value of US \$151.05 billion in 2019. The proportion of China's total digital trade exports in the total global digital trade exports has exceeded 4.50% in 2019. However, compared with the United States, which accounts for 16.73% of the global digital trade exports, China's digital trade exports account for a lower proportion in the international market.

2.4 China's Intellectual Property Services and ICT Services Play an Important Role

According to the classification of the expanded balance of payments service classification (EBOPS), the UNCTAD subdivided digital services trade into six categories. In 2020, China's six segments of digital service trade, sorted from large to small by export scale, were other business services, ICT services, intellectual property services, insurance services, financial services and personal entertainment services. The export was US \$75.446 billion, US \$59.034 billion, US \$8.879 billion, US \$5.45 billion, US \$4.268 billion and US \$1.297 billion respectively, The average annual growth rates of intellectual property services, ICT services, personal entertainment services, insurance services, financial services and other commercial services are 17.47%, 16.13%, 16.06%, 9.22%, 8.60% and 5.30%. The main driving force for the growth of digital service trade is intellectual property services, ICT services and personal entertainment services.

3 Measurement and International Comparison of Competitiveness of Digital Service Trade

3.1 Analysis of Four Indexes of Competitiveness

We select six countries (America, Japan, Germany, India, China and Brazil) from different economies, and uses four competitiveness indexes TCA, RCA, MS and MI to measure the international competitiveness of digital service trade.

Table 2. TCA index of digital service trade of six major economies from 2010–2019.

| | | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|----------------------|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| Developed economies | America | 0.210 | 0.236 | 0.249 | 0.260 | 0.260 | 0.260 | 0.247 | 0.255 | 0.274 | 0.264 |
| | Japan | -0.050 | -0.041 | -0.053 | -0.110 | -0.081 | -0.090 | -0.064 | -0.057 | -0.065 | -0.050 |
| | Germany | 0.038 | 0.025 | 0.036 | 0.035 | 0.065 | 0.069 | 0.067 | 0.077 | 0.073 | 0.060 |
| Developing economies | China | -0.089 | -0.090 | -0.093 | -0.108 | -0.017 | 0.040 | -0.018 | -0.014 | 0.032 | 0.056 |
| | India | 0.312 | 0.350 | 0.357 | 0.394 | 0.415 | 0.412 | 0.373 | 0.339 | 0.344 | 0.339 |
| | Brazil | -0.299 | -0.277 | -0.283 | -0.309 | -0.277 | -0.302 | -0.281 | -0.298 | -0.278 | -0.284 |

3.1.1 Trade Competitive Advantage Index

Trade Competitive Advantage index (TCA) indicates the proportion of the balance of a country's import and export trade in its total import and export trade. Table 2 shows TCA indexes of digital service trade of six major economies from 2010–2019. In 2019, the TC value of developed countries (such as the United States and Germany) is greater than 0, and their digital service trade is competitive. While the TCA value of India is also greater than 0, which does not reflect significant differences with developed economies. China's TCA index was negative from 2010–2017, but basically maintained an upward trend and became positive from 2018. It can be seen that the overall international competitiveness of China's digital trade is weaker than that of developed countries, but the gap is slowly narrowing.

3.1.2 Revealed Comparative Advantage Index

Revealed Comparative Advantage index (RCA) refers to the proportion of the share of certain commodities or service in the total exports of a country relative to the share of such commodities or service in the total exports in the world, which can reflect the international competitiveness and global supply capacity of a country's service industry. $RCA > 1$ means that the country has a comparative advantage in the export of this commodity; $RCA < 1$ indicates that the country has no comparative advantage in the export of this commodity in the international market. Table 3 calculates the RCA index of digital service trade of six major economies from 2010 to 2019. Only the RCA value of Japan, the United States and India is greater than 1, indicating that the export of digital service trade is more important to developed countries than other services. China's RCA value is low and there is a large gap with developed economies.

3.1.3 International Market Share Index

International market share (MS) refers to the proportion of a country's total exports of certain goods or services in the world's total exports. It is used to reflect the changes in the international market share of a country's exports of certain goods or services. Using the data of UNCTAD database, Table 4 calculates the MS index of digital service trade of six major economies from 2010 to 2019. It is not difficult to see that the market share of digital trading countries in the United States is the largest. In 2019, its international

Table 3. RCA index of digital service trade of six major economies in 2010–2019

| | | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|----------------------|---------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Developed economies | America | 1.866 | 1.885 | 1.865 | 1.805 | 1.731 | 1.673 | 1.667 | 1.739 | 1.700 | 1.671 |
| | Japan | 0.740 | 0.811 | 0.822 | 0.791 | 0.949 | 0.934 | 0.956 | 0.946 | 0.950 | 1.004 |
| | Germany | 0.840 | 0.850 | 0.905 | 0.903 | 0.890 | 0.873 | 0.874 | 0.893 | 0.881 | 0.862 |
| Developing economies | China | 0.337 | 0.379 | 0.341 | 0.341 | 0.359 | 0.320 | 0.328 | 0.339 | 0.398 | 0.407 |
| | India | 2.484 | 2.283 | 2.451 | 2.364 | 2.169 | 2.279 | 2.211 | 2.080 | 2.084 | 2.164 |
| | Brazil | 0.732 | 0.744 | 0.825 | 0.772 | 0.887 | 0.817 | 0.773 | 0.700 | 0.645 | 0.632 |

Table 4. MS index of digital service trade of six major economies in 2010–2019

| | | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|----------------------|---------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Developed economies | America | 18.02 | 17.58 | 18.01 | 17.40 | 16.96 | 17.62 | 17.60 | 17.77 | 16.80 | 16.73 |
| | Japan | 3.47 | 3.43 | 3.33 | 2.82 | 3.34 | 3.41 | 3.71 | 3.60 | 3.46 | 3.64 |
| | Germany | 6.47 | 6.43 | 6.48 | 6.50 | 6.58 | 6.50 | 6.72 | 6.78 | 6.56 | 6.27 |
| Developing economies | China | 3.07 | 3.49 | 3.32 | 3.45 | 3.80 | 3.69 | 3.59 | 3.63 | 4.29 | 4.50 |
| | India | 4.43 | 4.42 | 4.69 | 4.60 | 4.29 | 4.48 | 4.46 | 4.33 | 4.32 | 4.63 |
| | Brazil | 0.88 | 0.96 | 1.00 | 0.91 | 0.97 | 0.85 | 0.80 | 0.76 | 0.69 | 0.65 |

market share was 16.73%, which has a strong competitive advantage, while China only occupied 4.5% of the international market.

3.1.4 Market Volatility Index

Market volatility index (MI) also known as “michaely volatility index”, refers to the difference between the proportion of a country’s service exports in total domestic exports and the proportion of imports in total domestic imports. Compared with TC, RCA and MS indexes, MI index measures the international market competitiveness of the commodity by comprehensively investigating the import change factors of the commodity. According to Table 5, it can be found that in 2019, only the United States, China and India have positive MI, which are 0.114, 0.002 and 0.165 respectively, and China’s MI index is only 0.002, with weak competitive advantage, but in a gradual upward trend.

3.2 Calculation of International Competitiveness by Entropy Method

The above four indicators have their own emphasis and have certain limitations. In order to better evaluate the international competitiveness of digital service trade. From the perspective of information theory, entropy is a measure of information uncertainty, and it refers to the degree of dispersion of data. The higher the degree of dispersion, the smaller the entropy, and the lower the data availability; On the contrary, the lower the

Table 5. MI index of digital service trade of six major economies in 2010–2019

| | | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|----------------------|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| Developed economies | America | 0.090 | 0.092 | 0.094 | 0.093 | 0.097 | 0.103 | 0.106 | 0.110 | 0.112 | 0.114 |
| | Japan | -0.012 | -0.001 | 0.002 | -0.004 | 0.000 | -0.015 | -0.021 | -0.017 | -0.014 | -0.011 |
| | Germany | -0.004 | -0.005 | -0.007 | -0.006 | -0.003 | -0.004 | -0.007 | -0.002 | 0.000 | -0.002 |
| Developing economies | China | -0.011 | -0.009 | -0.010 | -0.011 | -0.004 | -0.003 | -0.007 | -0.004 | 0.001 | 0.002 |
| | India | 0.148 | 0.137 | 0.156 | 0.156 | 0.155 | 0.176 | 0.166 | 0.153 | 0.157 | 0.165 |
| | Brazil | -0.050 | -0.046 | -0.048 | -0.045 | -0.041 | -0.065 | -0.084 | -0.087 | -0.068 | -0.067 |

degree of dispersion, the greater the entropy, and the greater the data effectiveness. Using entropy method, we can determine the weight of four indicators, and then calculate the entropy value based on the weight, then measure the international competitiveness of digital service trade.

3.2.1 Data Standardization

The above four indicators are positive indicators, that is, the larger the calculated data, the greater the international competitiveness of the measured digital trade. Firstly, we need to normalize the evaluation indexes and eliminate meaningless data such as zero and negative values. Usually, $X'_{ij} = \frac{X_{ij} - \min\{X_j\}}{\max\{X_j\} - \min\{X_j\}}$, X_{ij} is the value of the j -th competitiveness index in the i -th year, $\min\{X_j\}$ and $\max\{X_j\}$ are Minimum and maximum values respectively. Generally, all the indexes after data standardization are shifted by a minimum unit, i.e. $X'_{ij} = X_{ij} + \delta$, but in order not to break the internal law of the original data, it is necessary to take δ as small as possible, here we take $\delta = 0.001$.

3.2.2 Calculate the Weight of Digital Trade Comprehensive Competitiveness Index

According to the entropy method, $W_i = d_j / \sum_{j=1}^n d_j$, Where, $d_j = 1 - e_j$; $e_j = -\frac{1}{\ln m} \sum_{i=1}^m (Y_{ij} \times \ln Y_{ij})$; $Y_{ij} = \frac{X'_{ij}}{\sum_{i=1}^m X'_{ij}}$. m is the number of evaluation years, n is Number of indicators, By substituting X'_{ij} into the above formula, we can calculate the weight of the four major trade competitiveness indices from 2010 to 2019, as shown in Table 6.

3.2.3 Calculate the Competitiveness Index of Digital Service Trade

Using the index weight determined by entropy method, the comprehensive index of digital service trade competitiveness can be calculated, $S_{ij} = W_i \times X'_{ij}$. Table 7 shows the ranking and change trend of digital trade competitiveness of the United States, Germany, Japan, China, India and Brazil from 2010 to 2019.

As is shown in Table 7, China’s competitiveness in digital service trade has risen steadily. By 2019, China has ranked second, indicating that China’s digital service trade

Table 6. Weight of various indicators of competitiveness of digital service trade

| | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|-----|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| MI | 0.271 | 0.277 | 0.275 | 0.245 | 0.222 | 0.212 | 0.273 | 0.341 | 0.312 | 0.287 |
| TC | 0.320 | 0.316 | 0.348 | 0.358 | 0.356 | 0.363 | 0.347 | 0.313 | 0.267 | 0.235 |
| MS | 0.219 | 0.221 | 0.213 | 0.261 | 0.304 | 0.317 | 0.280 | 0.217 | 0.218 | 0.207 |
| RCA | 0.191 | 0.186 | 0.163 | 0.135 | 0.117 | 0.108 | 0.101 | 0.129 | 0.203 | 0.271 |

Table 7. Evaluation and ranking of competitiveness of digital service trade in six countries

| | | | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|----------------------|---------|---------|------|------|------|------|------|------|------|------|------|------|
| Developed economies | America | Score | 3.18 | 3.26 | 3.43 | 3.83 | 3.93 | 4.01 | 4.24 | 4.21 | 4.36 | 4.57 |
| | | ranking | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | Japan | Score | 1.26 | 1.55 | 1.46 | 1.39 | 1.48 | 1.76 | 1.97 | 2.08 | 2.20 | 2.22 |
| | | ranking | 5 | 3 | 4 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| | Germany | Score | 2.00 | 2.02 | 2.24 | 2.84 | 2.89 | 2.26 | 2.19 | 2.63 | 2.33 | 2.31 |
| | | ranking | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 2 | 4 | 4 |
| Developing economies | China | Score | 1.32 | 1.48 | 1.53 | 1.70 | 2.08 | 2.11 | 2.28 | 2.43 | 2.82 | 3.01 |
| | | ranking | 3 | 4 | 3 | 3 | 3 | 3 | 2 | 3 | 2 | 2 |
| | India | Score | 1.29 | 1.47 | 1.35 | 1.43 | 1.58 | 1.81 | 2.08 | 2.40 | 2.56 | 2.98 |
| | | ranking | 4 | 5 | 5 | 4 | 4 | 4 | 4 | 4 | 3 | 3 |
| | Brazil | Score | 0.13 | 0.20 | 0.23 | 0.37 | 0.59 | 0.63 | 0.75 | 0.89 | 0.93 | 0.99 |
| | | ranking | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |

is developing rapidly and is in the process of transformation from quantity to quality. In 2020, the scale of digital service trade accounted for 68.3% of service trade, but there is still a large gap with developed economies such as the United States. As the leader of global digital trade, the United States occupies the forefront of the world in terms of the scale of digital trade. In 2020, US digital service trade exports accounted for 16.7% of global digital trade exports. It is worth noting that Germany is one of the countries with the best infrastructure construction in the world, however, with a large loss of scientific and technological talents, the international competitiveness of German digital service trade has gradually declined. India has developed rapidly in the technology intensive digital service industry. Telecommunications, computer and information service trade are the basis and important part of the development of India's digital economy, and its share in the international market is much higher than that of other industrial sectors. The development of digital trade in Japan is flat, and the growth rate in total is slow. Due to its low participation in the division of labor system of the global value chain, Japan is gradually surpassed by China.

4 Countermeasures to Enhance China's the Competitiveness of Digital Service Trade

Firstly, China should participate in trade negotiations actively and establish and improve the rule system of digital service trade. At present, due to the differences in the development level of service trade in different economies, there are contradictions in the demands for trade rules. In the future, China should actively participate in bilateral and multilateral dialogues and regional trade negotiations, gradually change from the recipient of the results of previous global trade rules to the promoter and setter of international trade rules.

Secondly, China should speed up the construction of basic information and digital facilities. We must speed up the construction of digital infrastructure, such as strengthening the network coverage, improving the network speed, and promoting the development and application of AI, big data, blockchain, internet of things, 5g services and other technical services.

Thirdly, we should strengthen information security and intellectual property protection. In the process of information transmission and trade delivery, we always encounter different degrees of network attacks. In order to prevent information damage in the process of transaction, we need to adopt technical means such as encryption, authorization restriction and physical isolation for the data, as well as timely backup of the data, so as to build a more secure and confidential system, formulate China's unique digital trade legal system framework.

Fourthly, we should introduce policies to support small and medium-sized enterprises engaged in digital service trade. At present, for the small and medium-sized enterprises, there is a shortage of digital talents, and the cost of employing digital talents is high. The government can increase the policy support system to attract overseas talents to return home. At the same time, it can provide enterprises with preferential policies such as tax relief to help small and medium-sized enterprises transform and upgrade their industrial structure.

5 Conclusion

Digital service trade is not only an important part of digital trade, but also the focus of digital trade rules negotiation. China's international competitiveness of digital service trade has improved year by year, but there is a large gap with developed economies such as Europe and the United States. In the future, We should take some countermeasures to lay a more solid foundation for the high-quality development of digital trade.

Acknowledgements. Manufacturing Industry Development Research Center on Wuhan City Circle Director Fund Project (W2021Y04).

References

- Fang Y (2020) Exploratory analysis on the development of China's Digital Trade – based on the conceptual framework and index system of OECD-WTO. *Res Customs Econ Trade* 41(04):95–109
- Lan Q, Dou K (2019) An empirical research on the international competitiveness of China's Digital Trade based on "Diamond Model" (3):44–54
- Lopez GJ, Ferenca J (2018) Digital trade and market openness. *OECD Trade Policy Paper*, no. 217
- Mei G (2020) Development status and trend prospect of global digital service trade. *Globalization* (04):62–77+134
- OECD (2018) Towards a handbook on measuring digital trade: status update [R/OL], 24 October 2018
- Yue Y-S, Li R (2020) Comparison of international competitiveness of digital service trade and its enlightenment to China China's circulation economy 34(4):12–20

Open Access This chapter is licensed under the terms of the Creative Commons Attribution-NonCommercial 4.0 International License (<http://creativecommons.org/licenses/by-nc/4.0/>), which permits any noncommercial use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license and indicate if changes were made.

The images or other third party material in this chapter are included in the chapter's Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the chapter's Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder.

