

## Article

# Does Information-and-Communication-Technology Market Openness Promote Digital Service Exports?

Ziyu Yi <sup>1</sup>, Long Wei <sup>1,2,\*</sup> and Xuan Huang <sup>1</sup> 

<sup>1</sup> School of Economics, Wuhan University of Technology, Wuhan 430070, China; ziyu\_yi@whut.edu.cn (Z.Y.); huangxuan14@whut.edu.cn (X.H.)

<sup>2</sup> Hubei Science and Technology Innovation and Economic Development Research Center (STIED), Wuhan 430070, China

\* Correspondence: longwei@whut.edu.cn

**Abstract:** ICT has become an important support for the booming trade in services in the digital era. However, the extent to which trade activities can benefit from ICT will depend on the regulatory constraints and the market-openness level of the ICT market. This study empirically examines the impact of ICT market openness on digital service exports on the basis of bilateral trade data at the industry level from 2007 to 2019 from 50 countries. The results show that: (1) ICT market openness seeks the combination of effective regulation and moderate openness, which is mainly reflected in three policy areas: improving information interconnection and sharing, reducing access restrictions and promoting fair competition; (2) The ICT market openness in both exporting and importing countries can significantly boost digital service exports, but in different ways. Exporting countries expand digital service exports mainly by promoting fair competition, while importing countries have the most obvious positive impact on exports through the reduction of access restrictions; (3) The greater the gap between the ICT development levels, and the lower the bilateral risk levels between the two trading countries, the greater the marginal effect that ICT market openness will have on the promotion of digital service exports. Thus, improving market openness indicates an important direction for ICT regulatory reform, but the impact on digital service exports will vary by specific policy area and by trading-partner country.

**Keywords:** market openness; information and communication technology; trade in digital services; regulatory policy



**Citation:** Yi, Z.; Wei, L.; Huang, X. Does Information-and-Communication-Technology Market Openness Promote Digital Service Exports?. *Sustainability* **2022**, *14*, 4901. <https://doi.org/10.3390/su14094901>

Academic Editors: Nuno Crespo, Nadia Simoes and Nicole Palan

Received: 1 April 2022

Accepted: 18 April 2022

Published: 19 April 2022

**Publisher's Note:** MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.



**Copyright:**  2022 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

## 1. Introduction

The traditional service trade is undergoing a transformation and is becoming increasingly digital [1]. Information and communications technologies (ICTs) are the main enabling factor [2], and especially the emerging ICTs, such as artificial intelligence, blockchain, cloud computing and big data. Even with the ongoing shock to global trade from the coronavirus (COVID-19) pandemic, services that are delivered through the Internet and related ICTs are still showing strong resilience. Digital trade underpins the sustainable global trading system, and digitally deliverable services took up 63.55% of the total export of the service trade in 2020 (See Figure A1).

According to the USBEA's work [3], a digital service is primarily defined as a "Potentially ICT-enabled Service". ICTs refer to the technologies that provide and obtain information through the Internet and telecommunication networks, including broadcasting, wireless networks, mobile communications and other digital media [4]. The widespread adoption of ICTs effectively reduces the search costs [5], communication costs [6] and the transaction and transportation costs [7,8] that are related to international trade, and significantly spurs the exports of the service trade [4,9,10]. However, to what extent can the digital service trade benefit from ICTs? This will ultimately be contingent upon the

degree of regulatory restrictions and the market openness in the ICT sector with regard to the countries that are involved in trade [11].

The rapid penetration of digital trade enables new forms of trade protection. Conflicts occur among countries when digital regulations at the international level are inconsistent with the regulations at the national levels [12,13]. Governments prefer to adopt a wide range of domestic policies to protect the interests of domestic individuals and businesses by setting up cumbersome admission procedures, restricting Internet access and impeding the free data and other regulatory policies and measures. Given these intraborder digital trade restrictions and the pervasive nature of digitization in the global economy, how can exports be boosted by bolstering digital connectivity and tackling protectionism? This issue has become the focus of today's policymakers. Countries need to take a more "holistic" approach to ICT regulations in order to expand the globalization of digital services [14].

In this context, a global wave of ICT regulatory reforms has been set off in the digital era. Countries have further deepened and expanded their ICT/telecommunications-sector regulations both in domestic regulatory policymaking and in regional trade agreements (RTAs). The goal of ICT regulations has shifted from the industry-specific regulation of the telecommunications industry to comprehensive digital regulation that serves the development of the national economy and that promotes inclusiveness and openness. However, the net effect of a range of ICT regulations may be procompetitive or anticompetitive [15]. Liberalization can be a substitution for inefficient regulation in some cases, or a complement in others [16]. Thus, we believe the goal of effective ICT regulation is to seek a balance between expanding openness and strengthening supervision.

On the basis of the industry-level trade data of 50 countries from 2007 to 2019, this paper investigates the impact mechanism of ICT market openness on service trade exports, and it provides policy insights for creating a procompetitive regulation environment to promote the digital trade in services. We make several contributions to the existing literature. First, we construct an ICT-market-openness index that is based on the International Telecommunication Union (ITU)'s ICT Regulatory Tracker database, which, to some extent, overcomes the limitations of the time dimension and the sample size. The index is a score for a set of rules that support market openness. A total of 24 of the 50 indicators that were selected from the ICT Regulatory Tracker are grouped into three aspects: improving information interconnection and sharing, reducing access restrictions and promoting fair competition.

Second, there is an explosion of studies on the digital economy, but the definition of "digital services" is still unclear. This paper divides digital services into ICT services and ICT-enabled services by referring to the classification of trade-in-service activities by the United Nations Conference on Trade and Development (UNCTAD)'s Working Group on Trade in Services (TGServ) [2]. Thus, the internal relationship between ICT market openness and digital service exports is further clarified. It is important to note that the degree of the ICT market openness not only affects the exports of the ICT sectors, but it also has a knock-on effect on the export activities of the ICT-enabled services, as more and more service activities are searched, ordered, traded and delivered through the Internet and other ICT infrastructures.

Third, export decisions depend not only on the level of the market openness of the exporting countries, but also of the importing countries, which may have a significant impact on the decision of firms to export or not [17,18]. Accordingly, we evaluated the impact of the ICT market openness on digital service exports in our empirical study by taking into account the regulatory environments of both the exporting and importing countries. Then, the reliability of the regression results was further verified by a robustness test.

Finally, countries with different ICT development levels and different national risk levels hold different attitudes towards their ICT market openness. We empirically examine the moderating effects of the ICT development level and the country risk level on the impact of the ICT market openness on digital service exports. This work provides theoretical support and empirical evidence for different countries that can be used to formulate ICT

regulatory reform plans that are in line with their own development and that better promote high-quality market openness. The policy implication of this study is as follows: While the promotion of ICT market openness and fair competition is an important direction for ICT regulatory reform, the degree of ICT openness will vary by specific policy area and by trading-partner country.

The remainder of the paper is organized as follows: Section 2 provides the literature review and the impact mechanism of the ICT market openness on digital service exports; Section 3 presents the methodology, the variables and the data used; Section 4 analyzes and discusses the regression results; in Section 5, we further expand the study on the basis of the heterogeneity of the countries; and our overall conclusions and discussions are set up in Section 6.

## 2. Literature Review and Hypotheses

### 2.1. Openness, Regulation and the Service Trade

The ICT/telecommunications sector is the key basic sector that supports the development of the digital economy. Historically, the vast majority of the world's telecommunications markets have been monopoly markets, which are normally monopolized by the state-owned telecommunications enterprises of countries. Although most telecommunications markets have undergone the reform from monopoly to competition under the WTO negotiation, there has been no real effective competition in the global telecommunications market, as the telecommunications industry involves network security and national security, and especially the basic telecom businesses, which are the lifeblood of national economies. Countries still have strong supervision over the ICT market. However, the direction of the regulatory reform of ICT services in the digital era should be about compromise among the members and about gradually reducing the existing restrictions, opening up the ICT market and allowing competition among cross-border ICT services.

"Market openness" refers to the regulatory environment in which foreign suppliers have the ability to "compete in the domestic market without encountering discriminatory, unduly onerous or restrictive conditions" [19]. Market openness has brought great benefits to service exports [11]. The improvement of the regulatory environment, which reduces the fixed costs of entering the market and the variable costs of servicing that market, is considered to be one of the important factors in the promotion of trade activity [20,21]. However, how do we measure ICT market openness? Some progress has been made in the quantitative research on service market openness from the perspective of regulation, which mainly includes four quantitative methods. First, the frequency index method that is proposed in [22] is used to measure the market openness in ICT/telecommunications [23]. Accordingly, the authors of [24] argue that telecommunication liberalization encompasses three factors: competition among telecommunications networks, openness to FDI and procompetitive regulation. The authors of [25] set up an index of telecommunications openness with scoring from three key aspects: market access, national treatment and regulatory principles (with an assigned value of 0 or 1), and they studied the impact of the trade liberalization of telecommunications services on the trade and investment of APEC countries. Second, they measured the level of service openness on the basis of the STRI database that was constructed by the World Bank [26,27]. The data are based on the following three modes of the service trade: cross-border payments, the commercial presence and the presence of natural persons. Third, by referring to the service market regulation index that was proposed by the OECD on the basis of the product-market-regulation (PMR) indicators, the openness of the service industry can be measured on the basis of the PMR database [28,29]. Fourth, the market openness index is constructed on the basis of the STRI database, which has been collected by the OECD since 2014. This quantitative approach has recently been favored by more and more studies [30–32]. These documents classify the policy measures that restrict market openness into foreign investment entry, the presence of natural persons, competition barriers, regulatory transparency and other discriminatory

policies, and thereby quantify the postborder trade restrictions in the telecommunications industry. The stricter the restrictions, the lower the level of the market openness.

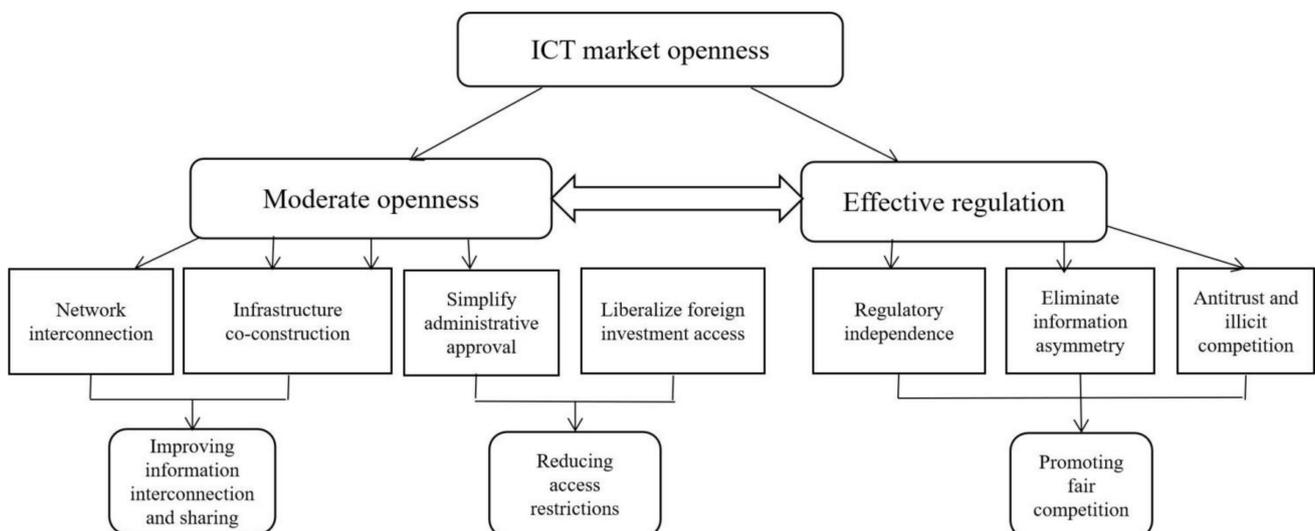
In terms of the impact of market openness on service trade exports, scholars generally believe that the regulatory measures within the border will evolve into trade barriers, which hinders the liberalization of the service trade. However, there may be differences between the effectiveness of the home-country and partner-country regulations on the trade in services. The authors of [33] believe that the regulatory level of the importing countries had no significant impact on the bilateral service trade, while the regulatory environment of the exporting countries had a significant inhibition effect on the service trade. The empirical results of [17] found that the regulatory policies of importing countries significantly restricted the trade in services, and that the higher the intensity of supervision, the greater the negative impact on the bilateral service trade. On the basis of the OECD-STRI database from 2008 to 2012, Nordås & Rouzet (2017) [32] conclude that either the importer's regulations or the exporter's regulations significantly hindered the bilateral service exports. Therefore, the following hypotheses are proposed in this paper.

**Hypothesis 1 (H1).** *The ICT-market-openness level of both the exporting and importing countries will have a significant impact on digital service exports.*

## 2.2. ICT-Market-Openness Index and Digital Services

On the basis of the above literature, this paper argues that the creation of an open and competitive regulatory environment is conducive to the digital service trade.

We propose that effective ICT market openness is a balance between the expansion of foreign investment access externally, and the promotion of fair competition internally. The government needs to build such a regulatory environment. On the one hand, it needs to reduce the access and operational barriers in the ICT market, and, on the other hand, it needs to strengthen the regulatory efficiency of the ICT regulatory departments in order to ensure fair competition in the market. Different types of regulatory policies focus on different areas (see Figure 1), and their impacts on digital service exports may be heterogeneous.



**Figure 1.** The ICT-market-openness index.

### (1) Improving information interconnection and sharing.

The core of all digital trade transactions is built on the physical infrastructure and the regulatory policies that guarantee information transmission and network connectivity. Therefore, restrictions on the access of firms to ICT services are horizontal measures that affect the ability of firms to participate in digital trade [11]. Greater ICT market openness

encourages the expansion of networks [24]. By encouraging the interconnection between networks and the co-construction of ICT infrastructures, the utilization and coverage of scarce resources and the efficiency of incumbent operators are improved [34,35], which thus helps the ICT-enabled sectors to lower the costs of services [36] and to improve the possibility of participating in export trade [9]. To be specific, the continuous expansion of the depth and scope of the ICT penetration, on the one hand, effectively reduces the cost of each link in the firms, and greatly reduces the costs of the search, communication, transaction and transportation that are related to international trade [10,37]. On the other hand, the entry barrier to new enterprises to the market is significantly reduced, and more small and medium-sized enterprises can participate in cross-border trade activities through information and network paths [38].

### (2) Reducing access restrictions.

For a long time, the ICT industries in developing countries had relatively strong monopolies [39]. Even after the telecom market reform, the state-owned telecom operators in developing countries still maintained dominant monopolies, which objectively resulted in low production efficiencies and the relatively lagging technology development of ICT firms [40]. High market-access costs or cumbersome licensing procedures become market-entry barriers for service enterprises [41]. In recent years, the supervision of telecommunications departments in various countries has been liberalized, and the phenomenon of market structure concentration has been gradually alleviated [26]. According to the ITU, about 60 percent of countries have introduced uniform licensing or general licensing systems, which enable enterprises to participate in the provision of ICT networks and services through a simple licensing process, which significantly reduces the potential market-entry barriers and operating costs of ICT services, which thus facilitates enterprises to use ICT services to improve their productivity. The further liberalization of foreign investment access has allowed domestic companies the technology-spillover effect and learning effect of absorption and has allowed foreign companies to internalize the forefront of technology and services, as well as the use of ICT to improve their service efficiency and service quality, in order to increase the export of the service trade. On the other hand, when a large number of foreign enterprises enter the domestic market, they will occupy the original market profit space of local enterprises. If competition can be guaranteed between providers, it will induce a positive efficiency effect [32,42], as those domestic enterprises will carry out technological innovation in order to improve their ability to compete with foreign suppliers.

### (3) Promoting fair competition.

The WTO first established regulatory standards in the Telecommunication Reference Document, which requires the member countries to strengthen the competition in the telecommunications market and to further promote trade liberalization. However, it is difficult to effectively deal with monopolies and unfair competition in the market only by lowering the threshold of the ICT market access and by expanding market openness. Competition in the sector still faces the risk of uncertain or discriminatory regulations [43]. An independent ICT/telecommunications regulatory authority can reduce the government control over the ICT industry and is a key requirement to improve the market allocation efficiency, to ensure fair competition and to avoid discrimination [24]. By separating the regulatory functions from government agencies and service providers, the independence of the regulatory functions enables regulatory decisions to be made in a more fair, impartial and open manner [15]. At the same time, effective market regulation can also eliminate the information asymmetry between service trade suppliers and consumers, and between the existing enterprises and new entrants into the market, and can help to avoid market failure [44]. A perfect market supervision system will encourage more small and medium-sized enterprises (SMEs) to participate in market competition, and the newly entered SMEs can undertake the production links where the original enterprises have no obvious comparative advantages [45]. The resulting resource-allocation effect will adjust the market

structure and make it more reasonable and efficient, which will thus drive more digital service trade exports.

**Hypothesis 2 (H2).** *ICT market openness promotes the export of digital services by improving the regulatory environment through three policy areas: “improving information interconnection and sharing”, “reducing access restrictions” and “promoting fair competition”. Under the different policy areas, the impacts of the ICT market openness of both exporting and importing countries on digital service exports are heterogeneous.*

### 3. Methodology and Data

#### 3.1. Methodology

With reference to the model setup of [7], this paper uses the logarithmic gravity model with multilateral-trade-resistance variables to test the impact of the ICT market openness on the export of digital services. The benchmark model settings are as follows:

$$\ln X_{ij} = \alpha_0 + \beta_1 \ln Y_i + \beta_2 \ln Y_j + \beta_3 \ln t_{ij} + \beta_4 \ln \Pi_i + \beta_5 \ln P_j + \varepsilon_{ij} \quad (1)$$

where  $t_{ij}$  represents the cost of the bilateral trade between country  $i$  and country  $j$ ; and  $\Pi_i$  and  $P_j$  are the variables that capture the internal and external multilateral resistances, respectively. Since the multilateral-resistance term cannot be directly observed, the fixed effect (FE) of the home country and the partner country is widely used for the control in the general research. Then, on the basis of Equation (1), we regard the liberalization of the ICT regulatory environment to be an important factor that affects trade costs, and we construct a gravity model to study the impact of the ICT market openness on the export of digital services, as shown in Equation (2):

$$\ln Digital\_EX_{ijrt} = \beta_0 + \beta_1 \ln Openness_{it}^{ICT} + \beta_2 \ln Openness_{jt}^{ICT} + \beta_3 \sum \ln Control_{ijt} + \mu_i + \mu_j + \mu_r + \mu_t + \varepsilon_{ijrt} \quad (2)$$

where  $i$  and  $j$  represent the national and partner countries, respectively,  $r$  represents the digital service sector and  $t$  represents the year. The explanatory variable,  $Digital\_EX_{ijrt}$ , is the trade export volume of the  $r$  sector of country  $i$  to the  $j$  partner country. The core explanatory variables,  $Openness_{it}^{ICT}$  and  $Openness_{jt}^{ICT}$ , represent the ICT market openness of the exporting countries and importing countries, respectively. See Table 1 for the specific index construction.  $\sum Control_{ijt}$  is the set of control variables, including the GDP, bilateral distance, common language, contiguity, the presence of RTAs and other traditional gravity-model control variables of the two countries. Then, add the variables  $\mu_i$ ,  $\mu_j$ ,  $\mu_r$  and  $\mu_t$  to represent for the exporter, importer, industry and the time fixed effect respectively in order to further alleviate the endogenous problems of the model;  $\varepsilon_{ijrt}$  is the error term of the model estimation.

**Table 1.** Quantitative framework of ICT-market-openness index.

Policy Field	Policy Type	Specific Indicators
Improving information interconnection and sharing (IS)	Network interconnection	Unbundled access to the local loop required Secondary-spectrum trading allowed Band migration allowed
	Infrastructure co-construction	Infrastructure sharing for mobile operators permitted Infrastructure sharing mandated Co-location/site sharing mandated

Table 1. Cont.

Policy Field	Policy Type	Specific Indicators
Reducing access restrictions (RR)	Simplify administrative approval	Types of licences provided
		License exempt
	Liberalize foreign investment access	Foreign participation/ownership in facilities-based operators
		Foreign participation/ownership in spectrum-based operators
		Foreign participation/ownership in local service operators
		Foreign participation/ownership in international service operators
Promoting fair competition (PC)	Regulatory independence	Separate telecom/ICT regulator
		Public consultations mandatory before decisions
Promoting fair competition (PC)	Antitrust and illicit competition	Dispute-resolution mechanism
		Appeals to decisions
		Existence of competition authority
Promoting fair competition (PC)	Eliminate information asymmetry	Legal concept of dominance or SMP
		Criteria used to determine dominance or SMP
		Operators required to publish reference interconnection offer (RIO)
		Interconnection prices made public
		Quality of service monitoring required

Source: On the basis of the theoretical framework of this paper, the authors used the ITU's ICT Regulatory Tracker to sort out the data.

### 3.2. Data

#### 3.2.1. Explained Variable

On the basis of the classification of the service trade activities by the UNCTAD's Working Group on Trade in Services (TGServ), this paper defines a digital service as a "potentially ICT-enabled service". Therefore, we hold that the export of a digital service (Digital\_EX) includes the export of an ICT service (ICT\_EX) and an ICT-enabled service (ICT\_enabled\_EX). ICT-enabled services refer to services that provide remote execution, delivery, evaluation and consumption support through ICTs [2]; services that are involved in the movement of physical objects or humans, such as construction and transportation services; or services that require face-to-face contact, such as maintenance, processing and other services, which are ultimately provided in physical form and cannot be delivered remotely through ICT networks. Even if these services inevitably use ICT in the digital era, they are not included in the statistical caliber of the digital services in this paper.

The export data of the service trade that are used in this paper are selected from the Balanced Trade in Services (BaTIS) database, which was jointly constructed by the OECD and the WTO. BaTIS provides data for the 12 main EBOPS 2010 service categories from 2005 to 2019 on the basis of the sixth edition of the Balance of Payments and International Investment Position Manual (BPM6). According to the research purpose of the paper, ICT services refer to telecommunication, computer and information services, and ICT-enabled services mainly include insurance and pension services, financial services, intellectual property royalties, other business services and personal culture and entertainment services.

#### 3.2.2. Core Explanatory Variable

The ICT-market-openness indexes of the exporting countries (Openness\_ex) and the importing countries (Openness\_im) are the core explanatory variables. This paper adopts

the coding method of the ITU's ICT Regulatory Tracker, which filters and processes the indicators on the basis of the principles of the GATS Telecom Reference Document and the work of [15] in order to construct the ICT-market-openness index. A total of 24 out of 50 regulatory indicators were judged as being the most relevant to the promotion of openness and competition in the ICT markets. Each indicator is assigned a score from 0 to 2, and these are summed up to produce the country's total score. The higher the index score, the more open the ICT market.

The ITU's ICT Regulatory Tracker is a benchmark that has experienced five generations of evolution, from the first-generation regulation (G1 benchmark), which encourages the improvement of the efficiency and service of state-owned monopoly telecom business operations, to the fifth generation of cross-sectoral collaborative regulation (G5 benchmark), which was proposed to achieve better global digital connectivity and faster digital transformation.

In order to clarify whether the different opening paths that are proposed in the theoretical hypothesis have heterogeneous impacts on digital service exports, this paper selects 24 indexes and divides them into three policy areas: "improving information interconnection and sharing (IS)", "reducing access restrictions (RR)" and "promoting fair competition (PC)" (see Table 1 for specific contents). The IS index is mainly reflected in the co-construction of the ICT infrastructure and the interconnection of networks; the RR index mainly covers the access barriers of the FDI and the relaxation of the regulatory licensing procedures; and the PC index mainly includes ensuring the independence, impartiality and transparency of the ICT regulators, as well as the prevention of a market monopoly and unfair competition. Finally, the overall ICT openness index is obtained by summing up the subindexes, and its logarithm is used for the regression.

### 3.2.3. Control Variables

There are many factors that affect the digital service trade. Therefore, in order to clarify the impact of the ICT market openness on the export of digital services, control variables need to be included in order to ensure the effectiveness of the regression model and to avoid the deviation that is caused by missing variables. The following control variables are selected in this paper:

- (1) The market sizes of the exporter (GDP<sub>ex</sub>) and the importer (GDP<sub>im</sub>). A large number of studies believe that the market scale will affect bilateral trade, and the GDP is a common variable that is used to measure the economic scale. In this paper, the logarithm of the domestic GDP and the GDPs of the trading-partner countries is used as the control variable, and the data is from the UNCTAD database;
- (2) The bilateral geographical distance between two economies (Distance). As an observable trade cost, the impact of distance on trade still exists in the Internet era [46]. This paper uses the population-weighted distance to measure the geographical distance between China and its partner countries, and it takes the pair value for the regression analysis;
- (3) Whether there is a common language (Comlag). A common language is conducive to the communication and business relations between enterprises, and it reduces the information costs that are caused by enterprise information asymmetry [47];
- (4) Whether there is a colonial relationship (Colony). This indicator reflects the institutional distance between two economies. When there is a colonial relationship, both countries can benefit from the trade relations that were established during the colonial period, which is more conducive to bilateral digital service trade. The data comes from the CEPII database;
- (5) The existence of a digital RTA (RTAs) between two economies. We adopt the data from the Trade Agreements Provisions on Electronic Commerce and Data (TAPED) database [48]. Moreover, we take the signing of a digital RTA between two countries as the control variable, and we set the effective year of the RTA as 1. Since a lag exists in the effect of the RTAs, the RTA with one-stage lag is used for the regression.

### 3.2.4. Moderator Variables

- (1) The gaps between the levels of the national ICT development of the exporters and importers (Diff\_IDI) may affect the relationship between market openness and digital service exports. The use of ICT and the Internet effectively reduces the search, communication, transaction and transportation costs that are related to the service trade, and it promotes bilateral trade activities [10]. However, in order to maintain national security, the government may adopt a strict ICT regulatory environment when the ICT gap between countries is too large, which will have a negative effect on the trade between two countries.

The ICT-development-index (IDI) data that are used in this paper come from the annual report on the measurement of the information society that was issued by the ITU, in which the data for 2009 and 2014 are missing. The level of ICT development is measured by the weighted summation of the ICT access and the use and skill indicators of a country, and the weights of the ICT access, the ICT use and the ICT skills in the IDI are 0.4, 0.4 and 0.2, respectively. Although the core measurement method of the IDI has remained unchanged, the measurement standard is slightly adjusted every year to reflect the dynamic nature of the ICT department, and so the data of the same year in different reports are different. Therefore, if there was a gap between the national values in the same year and the reports in different years, we selected the data in the latest report for the research and analysis. Then, the absolute value of the difference between the exporting and importing countries was used to calculate the ICT-development-level gap between the two countries:  $(Diff\_IDI_{ijt} = \ln(|IDI_{it} - IDI_{jt}|))$ .

- (2) In this paper, we believe that the country risk level will affect the promotion effect of the ICT market openness on the digital service trade. According to [25], the impact of the ICT/telecommunications market openness on trade and investment depends on a country's risk rating. When a country has great potential risks, its trade activities will face greater uncertainty, and the trade cost will increase accordingly. Therefore, we take the average of the country risk index of the exporter and the importer to measure the bilateral country risk level (Bi\_Risk). The country risk index in this paper adopts the International Country Risk Guide (ICRG), which was prepared by the PRS group. Through the weighted sum of the country's risk scores for the political, financial and economic aspects, the country's comprehensive risk level is obtained. The higher the score, the lower the risk. Table 2 shows the descriptive statistics of the main variables.

**Table 2.** Descriptive statistics of main variables.

Variables	Observations	Mean	S.D.	MAX	MIN
Explained variable					
Digital_EX	187,623	1.2893	3.0520	10.9241	−13.8155
Explanatory variables					
Openness_ex	191,100	3.5846	3.9926	3.8712	0.6931
Openness_im	191,100	3.5846	3.9926	3.8712	0.6931
Control variables					
GDP_ex	191,100	13.0140	1.4927	16.8853	9.4853
GDP_im	191,100	13.0140	1.4927	16.8853	9.4853
Distance	191,100	8.4459	1.0551	9.8800	4.9519
Comlag	191,100	0.0653	0.2471	1	0
Colony	191,100	0.0073	0.0854	1	0
RTAs	191,100	0.4909	0.4999	1	0
Moderator					
Diff_IDI	132,288	2.9245	1.335	4.9079	−4.6052
Bi_RISK	161,700	5.0141	0.0625	5.2024	4.8074

Note: Except for dummy variables, all variables in the table are data statistics in logarithmic form.

## 4. Results and Robustness Check

### 4.1. Estimated Results of the Benchmark Model

In Table 3, the impact of the ICT market openness on digital service exports is estimated. All the regression models include the sample of 50 countries in the period 2007–2019. Since the fixed-effect model cannot estimate the variables that do not change with time in the regression process, the least-squares dummy-variable method was used to control the fixed effects and to carry out the regression. In the regression, the fixed effects of the exporting country, the importing country, the industry and the year were controlled.

**Table 3.** Benchmark model results.

	Exporter Openness		Importer Openness		Bilateral Openness	
	(1)	(2)	(3)	(4)	(5)	(6)
Openness_ex	0.522 *** (34.12)	0.193 *** (12.56)			0.381 *** (23.04)	0.166 *** (10.50)
Openness_im			0.515 *** (33.59)	0.155 *** (10.03)	0.369 *** (22.26)	0.116 *** (7.29)
GDP_ex		0.469 *** (21.20)		0.535 *** (25.58)		0.455 *** (20.46)
GDP_im		0.758 *** (36.31)		0.723 *** (32.68)		0.702 *** (31.62)
Distance		−0.979 *** (−168.37)		−0.979 *** (−168.31)		−0.980 *** (−168.48)
Comlag		0.315 *** (21.44)		0.315 *** (21.44)		0.315 *** (21.44)
Colony		0.894 *** (23.24)		0.895 *** (23.24)		0.894 *** (23.24)
RTAs		0.0882 *** (8.31)		0.0890 *** (8.38)		0.0862 *** (8.12)
Constant	−3.039 *** (−45.72)	−8.067 *** (−24.59)	−3.012 *** (−45.28)	−8.331 *** (−25.39)	−3.864 *** (−50.82)	−7.467 *** (−22.08)
Exporter FE	Yes	Yes	Yes	Yes	Yes	Yes
Importer FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	187,623	187,623	187,623	187,623	187,623	187,623
R2	0.740	0.797	0.740	0.797	0.741	0.797

Note: Unless otherwise specified, all fixed effects are controlled in subsequent regression. The regression is processed by a robustness test, and the *t*-values of the coefficients are in parentheses. \*, \*\* and \*\*\* denote significance at the 10%, 5% and 1% level respectively.

Columns (1), (3) and (5) report the regression results of the impact of the ICT market openness of the exporting countries, the importing countries, and the bilateral openness of the digital service exports, respectively. The regression results of Columns (2), (4) and (6) show that the model is still robust after the addition of control variables. The empirical results show that the regression coefficients of the ICT openness of the exporting, importing and bilateral countries are significantly positive. This shows that enhanced ICT market openness can effectively promote digital service exports. Among them, the openness level of the exporter has a higher promotion effect on digital service exports than the effect of the importer.

Further analysis of the control variables shows that the regression results of all the control variables are significant, and that the coefficients meet the expectations. The

improvement in the economic-development levels of the two countries, the common language, the colonial relationship and the signing of an RTA with digital terms between the two countries are all conducive to the export of digital services between the two countries. The distance variable shows a significant negative impact, which indicates that the farther the distance between the countries, the more unfavorable this is to the digital service trade between the two countries.

#### 4.2. Robustness Tests

In the benchmark regression, this paper effectively reduces the potential endogenous problems that are caused by missing variables by controlling the fixed effects of the country, industry and year. However, the choice of variables and estimation methods, and the possible reverse causal relationship between ICT openness and digital service exports, may also lead to endogenous problems, which may bias the estimation results. In order to evaluate the robustness of the above results, we used an alternative measurement of the variables and alternative methods for estimation.

##### 4.2.1. Alternative Measurement of Variables

Firstly, this paper tested the robustness by changing the methods for the measurement of the explanatory variables. For the indicator of the explanatory variable (the ICT market openness), the OECD's services trade restrictiveness index (STRI) of the telecommunications sector can be used for an alternative analysis, and the data range is 2014–2019. As an indicator to measure the level of the trade restrictions within a country's borders, the STRI can effectively reflect a country's openness to foreign capital entry, natural person flow, competition barriers, regulatory transparency and other aspects. The higher the STRI, the lower the ICT market openness in the country. Columns (1)–(3) of Table 4 report the regression results of the exporting country's STRI (STRI\_ex), the importing country's STRI (STRI\_im) and the bilateral STRI (taking both exporter and importer into account), respectively, as the surrogate variables. The estimated results are still robust, which further verifies the positive effect of ICT market openness on digital service exports.

Columns (4)–(6) in Table 4 report the regression results of the one-stage lag of the openness index. Because of the existence of the hysteretic effect, the impact of the improvement in the ICT openness on trade is difficult to fully reflect in the current period. After substituting the explanatory variables, the ICT market openness still significantly boosted the digital service exports. The robustness test results are consistent with those of the benchmark model, which further proves the robustness of the estimation results.

**Table 4.** Robustness test results.

	Replace with the Service Trade Restrictiveness Index			Replace with the Lag Term of Openness			Replace with PPML Estimation		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
STRI_ex	−0.840 *** (−53.63)		−0.868 *** (−54.37)						
STRI_im		−0.197 *** (−13.20)	−0.128 *** (−7.99)						
L_open_ex				0.212 *** (12.83)		0.181 *** (10.59)			
L_open_im					0.165 *** (10.18)	0.118 *** (7.01)			
Openness_ex							0.326 *** (7.40)		0.284 *** (6.40)
Openness_im								0.218 *** (6.46)	0.174 *** (5.10)

Table 4. Cont.

	Replace with the Service Trade Restrictiveness Index			Replace with the Lag Term of Openness			Replace with PPML Estimation		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
GDP_ex	1.033 *** (210.84)	0.471 *** (5.95)	1.023 *** (203.21)	0.444 *** (17.68)	0.511 *** (21.22)	0.429 *** (17.05)	0.711 *** (11.78)	0.764 *** (13.93)	0.677 *** (11.21)
GDP_im	0.523 *** (6.36)	0.938 *** (199.31)	0.937 *** (184.51)	0.718 *** (30.06)	0.688 *** (27.26)	0.665 *** (26.27)	0.715 *** (9.88)	0.691 *** (8.88)	0.654 *** (8.54)
Distance	−1.113 *** (−110.71)	−0.948 *** (−105.91)	−1.055 *** (−123.76)	−0.983 *** (−146.31)	−0.982 *** (−146.21)	−0.983 *** (−146.41)	−0.456 *** (−47.64)	−0.455 *** (−47.53)	−0.456 *** (−47.81)
Comlag	0.715 *** (25.79)	0.717 *** (28.72)	1.039 *** (38.32)	0.313 *** (22.35)	0.313 *** (22.35)	0.312 *** (22.33)	0.331 *** (12.94)	0.332 *** (12.97)	0.331 *** (12.95)
Colony	0.617 *** (8.75)	0.624 *** (8.72)	0.457 *** (6.51)	0.889 *** (20.47)	0.889 *** (20.45)	0.889 *** (20.45)	0.177 *** (3.66)	0.178 *** (3.66)	0.175 *** (3.61)
RTAs	0.0280 (1.41)	0.0812 *** (4.49)	0.0518 *** (2.82)	0.0884 *** (8.16)	0.0898 *** (8.28)	0.0857 *** (7.90)	0.218 *** (10.30)	0.219 *** (10.30)	0.215 *** (10.19)
Constant	−9.978 *** (−8.55)	−8.728 *** (−7.77)	−16.90 *** (−129.61)	−7.262 *** (−19.12)	−7.573 *** (−19.80)	−6.675 *** (−17.12)	−11.58 *** (−10.19)	−11.63 *** (−9.88)	−10.69 *** (−9.00)
FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	79,905	79,905	79,905	173,206	173,206	173,206	191,100	191,100	191,100
R2	0.579	0.620	0.547	0.797	0.797	0.797	0.858	0.858	0.858

Note: The *t*-values of the coefficients are in parentheses. \*, \*\* and \*\*\* denote significance at the 10%, 5% and 1% level respectively.

#### 4.2.2. Alternative Estimation Test Method

We further used Poisson pseudo-maximum likelihood (PPML) estimation to test the robustness of the results. The regression results are reported in Columns (7)–(9) of Table 4. As the fixed-effect model will delete the zero-value variables when the logarithmic transformation is performed, sample loss and heteroscedasticity may be caused. The PPML estimation can effectively solve the heteroscedasticity problem by retaining the zero value. Refer to the method of [49] to further complete the PPML estimation. The regression results in Columns (7)–(9) show that the statistical significance of each variable is still strong, and that the sign and relative size of the coefficient are consistent with the results of the benchmark regression, which confirms the robustness of the regression results.

## 5. Further Discussion

### 5.1. Heterogeneity Analysis of ICT Openness in Different Regulatory Domains

The impact of the openness in different ICT regulatory domains on digital service exports is heterogeneous. By analyzing the empirical results, we can clarify the effective paths of ICT market openness to promote digital service exports. Columns (1)–(3) of Table 5 report the regression results of the IS index, while Columns (4)–(6) and (7)–(9) report the regression results of the RR index and the PC index, respectively. Moreover, the study finds that improving the regulatory environment in all three areas could significantly increase digital service exports.

The coefficients of the three different regulatory domains that promote ICT market openness in exporting countries are further analyzed. Among the three subindexes, the coefficient of the PC index is the largest (0.175), the coefficient of the IS is ranked second (0.140) and the coefficient of the RR index is the smallest, with only 0.086. This result shows that, for the exporting countries, the regulatory policies that aimed to promote fair competition were the most beneficial measures to increasing digital service exports, while regulatory policies that reduce market-access restrictions have the least impact on boosting the country's digital service exports.

**Table 5.** Heterogeneity analysis of ICT openness in different regulatory domains.

	IS			RR			PC		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
IS_ex	0.171 *** (12.72)		0.140 *** (9.85)						
IS_im		0.093 *** (7.01)	0.093 *** (7.01)						
RR_ex				0.100 *** (5.32)		0.086 *** (4.53)			
RR_im					0.137 *** (7.60)	0.125 *** (6.90)			
PC_ex							0.193 *** (12.56)		0.175 *** (9.47)
PC_im								0.138 *** (9.47)	0.108 *** (7.28)
GDP_ex	0.487 *** (21.52)	0.514 *** (24.03)	0.461 *** (20.04)	0.528 *** (22.65)	0.538 *** (25.58)	0.504 *** (21.31)	0.477 *** (21.35)	0.543 *** (25.84)	0.463 *** (20.64)
GDP_im	0.734 *** (34.74)	0.745 *** (33.14)	0.706 *** (30.89)	0.782 *** (37.76)	0.756 *** (32.76)	0.740 *** (31.60)	0.764 *** (37.02)	0.738 *** (33.77)	0.715 *** (32.57)
Distance	−0.972 *** (−149.26)	−0.970 *** (−148.68)	−0.962 *** (−146.86)	−0.971 *** (−148.76)	−0.976 *** (−149.03)	−0.969 *** (−147.08)	−0.979 *** (−151.01)	−0.979 *** (−150.91)	−0.979 *** (−151.05)
Comlag	0.313 *** (23.20)	0.315 *** (23.34)	0.316 *** (23.40)	0.321 *** (23.88)	0.318 *** (23.54)	0.323 *** (23.96)	0.315 *** (23.45)	0.316 *** (23.45)	0.315 *** (23.44)
Colony	0.608 *** (13.50)	0.713 *** (15.36)	0.340 *** (6.93)	0.778 *** (17.65)	0.817 *** (18.17)	0.674 *** (14.12)	0.895 *** (21.39)	0.895 *** (21.37)	0.894 *** (21.38)
RTAs	0.101 *** (9.59)	0.110 *** (10.37)	0.124 *** (11.71)	0.099 *** (9.34)	0.101 *** (9.51)	0.107 *** (10.00)	0.090 *** (8.57)	0.091 *** (8.64)	0.089 *** (8.46)
Constant	−7.779 *** (−22.51)	−8.182 *** (−23.59)	−7.307 *** (−19.94)	−8.789 *** (−25.95)	−8.646 *** (−25.65)	−8.238 *** (−22.93)	−8.028 *** (−24.03)	−8.415 *** (−25.28)	−7.408 *** (−21.38)
FEs	Yes								
Observations	180,104	180,104	180,104	180,104	180,104	180,104	180,104	180,104	180,104
R2	0.799	0.799	0.800	0.798	0.797	0.798	0.797	0.797	0.797

Note: The *t*-values of the coefficients are in parentheses. \*, \*\* and \*\*\* denote significance at the 10%, 5% and 1% level respectively.

By analyzing the regression coefficients of the three subindexes of the importing countries, it was found that the coefficient of the RR index ranks the highest among the three (0.125), the PC index comes next (0.108) and the IS index is the least important (0.093). This shows that trade-importing countries have the greatest promotion effect on digital service exports through the reduction of access restrictions, which contrasts with the results of this index for exporting countries. Therefore, Hypothesis 2 can be proven through the above analysis. The promotion paths of the ICT openness in exporting countries and importing countries to expand digital service exports are different. To be specific, policies to improve information interconnection and sharing have a positive impact on both importing and exporting countries. Moreover, exporting countries rely more on regulatory policies that promote fair competition to improve the trade-promotion effect of ICT market openness, while importing countries improve the ICT market openness mainly through regulation policies that reduce access restrictions to increase exports.

## 5.2. Heterogeneity Analysis of National ICT-Development-Level Gaps

The impact of regulatory reform on the volume of trade in services may vary, depending on the level of the economic development [30]. Countries with different ICT development levels hold different attitudes towards the openness degrees of their ICT markets. Will the gap between the countries' ICT development levels affect the promotion effect of ICT openness on digital service exports? To answer this question, the interaction term Diff\_IDI\*Openness\_ex for the exporting country, and the interaction term Diff\_IDI\*Openness\_im for the importing country, were introduced on the basis of the benchmark model. Then, the explanatory variables, the moderator variable and the cross-multiplication terms were centralized, and the logarithm was taken for the regression

to eliminate the multicollinearity of the model. After controlling the fixed effects, we investigated whether the IDI gaps between the exporter and the importer would affect the impact of the ICT market openness on the digital service exports. The regression results are reported in Table 6.

**Table 6.** Heterogeneity analysis of national ICT-development-level gap.

	Exporter Openness	Importer Openness	Bilateral Openness
	(1)	(2)	(3)
Diff_IDI*Openness_ex	0.0220 *** (3.22)		0.0195 *** (2.79)
Diff_IDI*Openness_im		0.0425 *** (2.76)	0.0320 ** (2.04)
Openness_ex	0.195 *** (9.71)		0.158 *** (7.64)
Openness_im		0.192 *** (9.68)	0.151 *** (7.42)
Diff_IDI	−0.0346 *** (−4.56)	−0.0395 *** (−5.21)	−0.0393 *** (−5.17)
GDP_ex	0.384 *** (13.78)	0.438 *** (16.51)	0.370 *** (13.25)
GDP_im	0.678 *** (26.06)	0.623 *** (22.42)	0.606 *** (21.72)
Distance	−0.989 *** (−123.56)	−0.989 *** (−123.55)	−0.990 *** (−123.65)
Comlag	0.316 *** (19.45)	0.317 *** (19.50)	0.316 *** (19.44)
Colony	0.899 *** (17.85)	0.904 *** (17.89)	0.900 *** (17.84)
RTAs	0.0777 *** (5.95)	0.0786 *** (6.01)	0.0762 *** (5.83)
Constant	−5.103 *** (−11.48)	−5.087 *** (−11.42)	−3.960 *** (−8.45)
FEs	Yes	Yes	Yes
Observations	129,870	129,870	129,870
R2	0.797	0.797	0.797

Note: The *t*-values of the coefficients are in parentheses. \*, \*\* and \*\*\* denote significance at the 10%, 5% and 1% level respectively.

According to the regression results, the regression coefficients of Diff\_IDI are significantly negative, which indicates that, when there is a large gap between the ICT development levels of the two trading countries, bilateral digital service exports will be hindered. The coefficients of the interaction terms, Diff\_IDI\*Openness\_ex and Diff\_IDI\*Openness\_im, are both significantly positive, which means that, when the national ICT-development-level gap between the two countries is large, it is more conducive to release the service-export-promotion effect of the ICT market openness. This may be due to the fact that, when there is a large gap between the national IDIs of the two countries, the countries with lower IDIs tend to implement stricter ICT regulatory policies in order to ensure the security of their information transmission and to maintain the competitiveness of their firms, which thus hinders the digital service trade between the countries. However, the large gap in the IDI also means that the two sides of the trade undertake different segments in the global value chain, complement each other in the production process of products and thus have great trade potential. In this way, when the ICT market becomes more open, the optimization of the business environment will turn this trade potential into actual trade gains, which will make the trade-boosting effects of the ICT market openness more significant, while, when the ICT development level of the exporter and importer are similar, the countries may be in the same segments of the global value chain, which results in intensified competition among the countries and affects the actual effect of the market openness.

### 5.3. Heterogeneity Analysis of Bilateral Country Risk Level

As a national strategic sector, the development of the ICT market may face national security issues. Therefore, governments must face a fundamental balance when choosing ICT regulatory reform measures. That is, they must trade off between the reduction in the trade costs brought on by the market openness and the possible risks, such as network and information security issues in an open environment [1]. Therefore, a strong security guarantee is an important prerequisite for ICT market openness. If an economy has obvious economic, financial and political risk exposure, this will affect the government's regulatory decision to promote market openness. We now explore whether the results reported by the benchmark model vary across the bilateral country risk levels (Bi\_RISK). The calculation method of the indicators is described in detail in Section 3.2.4. Similarly, all the variables were processed by logarithm after centralization. Table 7 reports the regression results.

**Table 7.** Heterogeneity analysis of bilateral country risk levels.

	Exporter Openness	Importer Openness	Bilateral Openness
	(1)	(2)	(3)
Bi_RISK*Openness_ex	1.785 *** (12.38)		1.584 *** (10.94)
Bi_RISK*Openness_im		0.617 *** (3.41)	0.317 * (1.77)
Openness_ex	0.482 *** (50.95)		0.451 *** (46.91)
Openness_im		0.495 *** (23.13)	0.330 *** (15.37)
Bi_RISK	9.355 *** (108.43)	9.969 *** (113.74)	9.630 *** (109.11)
GDP_ex	0.969 *** (326.88)	0.957 *** (320.34)	0.966 *** (325.33)
GDP_im	0.360 *** (13.72)	0.243 *** (8.37)	0.176 *** (6.12)
Distance	−1.064 *** (−176.75)	−1.069 *** (−177.87)	−1.064 *** (−176.93)
Comlag	0.682 *** (41.20)	0.705 *** (42.28)	0.683 *** (41.28)
Colony	0.972 *** (20.73)	0.762 *** (16.40)	0.959 *** (20.42)
RTAs	0.167 *** (13.81)	0.240 *** (20.07)	0.161 *** (13.35)
Constant	−7.342 *** (−21.12)	−5.620 *** (−14.57)	−4.889 *** (−12.80)
FEs	Yes	Yes	Yes
Observations	158,670	158,670	158,670
R2	0.726	0.723	0.726

Note: The *t*-values of the coefficients are in parentheses. \*, \*\* and \*\*\* denote significance at the 10%, 5% and 1% level respectively.

The interaction terms, Bi\_RISK\*Openness\_ex and Bi\_RISK\*Openness\_im, of the country risk index, and the ICT openness of both trading parties, are significantly positive at the level of 1%. This shows that the lower the risk level of bilateral countries, the more active the improvement in the ICT market openness in the promotion of bilateral digital service exports. The lower the national risk level, the more perfect the overall institutional environment of the country, which provides a stronger guarantee for the implementation of the regulatory reform for opening up the ICT market. Therefore, both importing and exporting countries need to ensure national political, economic and financial security in order to fully release the trade-promotion potential of ICT openness and to realize the high-quality development of the digital service trade.

## 6. Conclusions

By matching the ITU's ICT regulatory database with the OECD's BaTIS database, this paper obtained the industry-level data of 50 countries from 2007 to 2019, with a total of 191,100 samples for the empirical study. We make an in-depth study on the relationship between the ICT market openness and digital service trade exports. We believe that high-quality ICT market openness seeks the combination of effective regulation and moderate openness. In this way, the ICT-market-openness index is constructed as a score that indicates the number of ICT regulatory policies that are adopted by a country that support openness, which mainly include the regulatory rules in three policy areas: "improving information interconnection and sharing", "promoting fair competition" and "reducing access restrictions".

The results indicate that ICT market openness generates a positive effect on digital service exports. According to the classification criteria of TGServ, digital service is divided into ICT service and ICT-enabled services. Thus, our work found that the higher the openness of the ICT market, the more obvious the promotion of ICT service exports. Moreover, as services become increasingly searched, ordered and transacted through ICTs, ICT openness will also have a knock-on effect on ICT-enabled digital service exports. The findings also indicate that ICT market openness in both exporting and importing countries positively promotes digital service exports, but the effect paths are heterogeneous. Exporting countries are more likely to promote the export of digital services by "promoting fair competition", while importing countries mainly adopt "reducing access restrictions" as the path of ICT market openness to increase exports. Further research shows that the different ICT development levels and risk levels of trading countries will affect the effect of the ICT openness on the digital service exports. Specifically, the greater the gap between countries in the ICT development levels, the more obvious the export-promotion effect of the ICT openness. Similarly, the lower bilateral risk levels in both countries would be more conducive to realizing the benefits of ICT openness.

Therefore, improving market openness and competition is an important direction for countries in order to reform the ICT regulatory environment, but the degree of the ICT market openness varies with specific regulatory areas and with trading partners.

Accordingly, we put forward the following policy recommendations. First, governments should actively promote global ICT regulatory cooperation. While ensuring national security, countries should ease restrictions on foreign ownership, promote ICT infrastructure connectivity and ensure fair market competition in order to expand the globalization of digital services. Second, governments may focus on strengthening infrastructure construction and technological innovation in the field of new-generation ICTs that are represented by artificial intelligence (A), block chain (B), cloud computing (C) and big data (D) (known as "ABCD"). In this way, they can improve the levels of the digital applications of firms so that different countries can equally seize the opportunities of market openness in the digital era and further expand the space of the global trade market. Finally, the government should continue to deepen the reform of streamlining administration, delegating power, combining regulation and optimizing services in the ICT sector, and they should orderly promote high-level market openness and in-depth regulatory reform. By promoting the transformation of the ICT market from the management mode of "strict access and loose regulation" to "easy access and strict regulation", the combination of the effective control and the moderate openness of the ICT sector can be realized.

Finally, with the rapid development of digital trade, ICT regulation is increasingly transforming into comprehensive digital regulation that serves national economic development and that promotes inclusiveness and openness. Our current research is limited to ICT regulation. Therefore, future research can further conduct quantitative and empirical research on the comprehensive digital openness framework and can systematically evaluate the impact of national digital regulation and of opening policy on digital trade.

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

**Funding:** This work was supported by the National Social Science Foundation of China (Grant No. 19ZDA054). The authors are responsible for any errors in the paper.

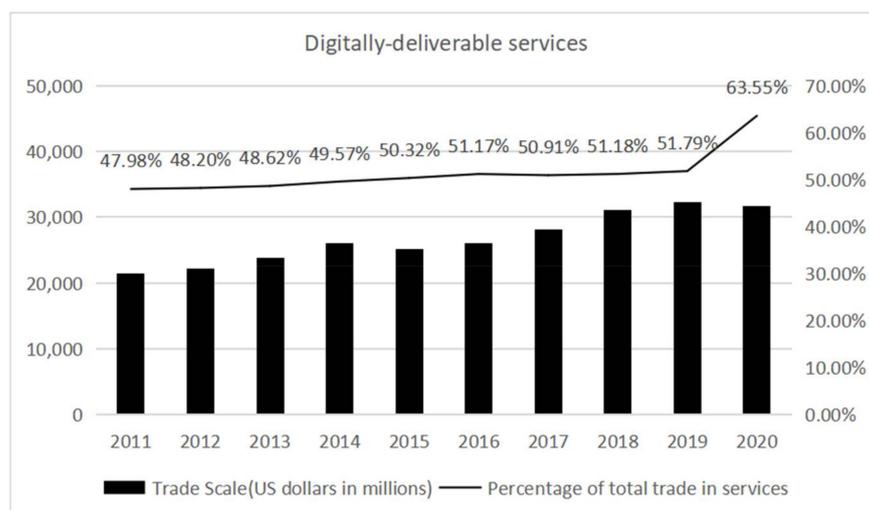
**Institutional Review Board Statement:** Not applicable.

**Informed Consent Statement:** Not applicable.

**Data Availability Statement:** For the specific principles and coding methods of the ICT Regulatory Tracker, see: ITU, [www.itu.int/go/tracker](http://www.itu.int/go/tracker) (accessed on 22 December 2021). For the digital-service-trade data, visit: OECD, <https://www.oecd.org/sdd/its/balanced-trade-statistics.htm> (accessed on 22 December 2021). The ICT Regulatory Tracker coding method can be downloaded at: <https://app.gen5.digital/ICTRegulatoryTracker.pdf> (accessed on 22 December 2021). Other data are available upon request.

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

## Appendix A



**Figure A1.** Trade scale and proportion of digitally deliverable services. Source: The data used in the calculations were provided by the United Nations Conference on Trade and Development (UNCTAD).

## References

1. Staiger, R.W. *Does Digital Trade Change the Purpose of a Trade Agreement?* (No. w29578); National Bureau of Economic Research: Cambridge, MA, USA, 2021. Available online: [https://www.nber.org/system/files/working\\_papers/w29578/w29578.pdf](https://www.nber.org/system/files/working_papers/w29578/w29578.pdf) (accessed on 22 December 2021).
2. UNCTAD. *International Trade in ICT Services and ICT-Enabled Services: Proposed Indicators from the Partnership on Measuring ICT for Development*; UNCTAD Technical Notes on ICT for Development; UNCTD: Geneva, Switzerland, 2015. Available online: [https://unctad.org/system/files/official-document/tn\\_unctad\\_ict4d03\\_en.pdf](https://unctad.org/system/files/official-document/tn_unctad_ict4d03_en.pdf) (accessed on 22 December 2021).
3. Barefoot, K.; Curtis, D.; Jolliff, W.; Nicholson, J.R.; Omohundro, R. *Defining and Measuring the Digital Economy*; US Department of Commerce Bureau of Economic Analysis: Washington, DC, USA, 2018; Volume 15. Available online: <https://www.bea.gov/sites/default/files/papers/defining-and-measuring-the-digital-economy.pdf> (accessed on 22 December 2021).
4. Luong, T.A.; Nguyen, T.H. The impact of ICT on service trade. *Singap. Econ. Rev.* **2021**, *66*, 1073–1086. [[CrossRef](#)]
5. Allen, T. Information Frictions in trade. *Econometrica* **2014**, *82*, 2041–2083. [[CrossRef](#)]
6. Fink, C.; Mattoo, A.; Neagu, I.C. Assessing the impact of communication costs on international trade. *J. Int. Econ.* **2005**, *67*, 428–445. [[CrossRef](#)]
7. Anderson, J.E.; Van Wincoop, E. Gravity with Gravitas: A Solution to the border puzzle. *Am. Econ. Rev.* **2003**, *93*, 170–192. [[CrossRef](#)]

8. Goldfarb, A.; Tucker, C. Digital economics. *J. Econ. Lit.* **2019**, *57*, 3–43. [CrossRef]
9. Nath, H.K.; Liu, L. Information and Communications Technology (ICT) and services trade. *Inf. Econ. Policy* **2017**, *41*, 81–87. [CrossRef]
10. Rodríguez-Crespo, E.; Martínez-Zarzoso, I. The effect of ICT on trade: Does product complexity matter? *Telemat. Inform.* **2019**, *41*, 182–196. [CrossRef]
11. González, J.L.; Ferencz, J. *Digital Trade and Market Openness*; OECD Trade Policy Papers, No. 217; OECD Publishing: Paris, France, 2018. [CrossRef]
12. Castro, D.; Atkinson, R.D. Beyond Internet Universalism: A Framework for Addressing Cross-border Internet Policy. *ITIF* **2014**, 1–24. [CrossRef]
13. Lendle, A.; Olarreaga, M.; Schropp, S.; Vézina, P. There Goes Gravity: Ebay and the Death of Distance. *Econ. J.* **2016**, *126*, 406–441. [CrossRef]
14. Van der Marel, E. Digital-based Services Globalization and Multilateral Trade Cooperation. *Glob. Policy* **2021**, *12*, 392–398. [CrossRef]
15. Montenegro, L.O.; Araral, E. Can Competition-enhancing Regulation Bridge the Quality Divide in Internet Provision? *Telecommun. Policy* **2020**, *44*, 101836. [CrossRef]
16. Fiorini, M.; Hoekman, B. EU Services Trade Liberalization and Economic Regulation: Complements or Substitutes? *Rev. Int. Organ.* **2020**, *15*, 247–270. [CrossRef]
17. Nicoletti, G.; Scarpetta, S. Regulation, productivity and growth: OECD Evidence. *Econ. Policy* **2003**, *18*, 9–72. [CrossRef]
18. Kox, H.; Lejour, A. The effects of the services directive on Intra-EU trade and FDI. *Rev. Écon. Fr.* **2006**, *57*, 747–769. [CrossRef]
19. OECD. OECD Market Openness Principles. OECD Innovation Policy Platform. 2010. Available online: <http://www.oecd.org/innovation/policyplatform/48137680.pdf> (accessed on 22 December 2021).
20. Portugal-Perez, A.; Wilson, J.S. Export Performance and Trade Facilitation Reform: Hard and Soft Infrastructure. *World Dev.* **2012**, *40*, 1295–1307. [CrossRef]
21. Gervais, A.; Jensen, J.B. The Tradability of Services: Geographic Concentration and Trade Costs. *J. Int. Econ.* **2019**, *118*, 331–350. [CrossRef]
22. Hoekman, B. Tentative First Steps: An Assessment of the Uruguay Round Agreement on Services. 1995. Available online: <https://ssrn.com/abstract=636162> (accessed on 22 December 2021).
23. Warren, T. The Impact on Output of Impediments to Trade and Investment in Telecommunications Services. In *Impediments to Trade in Services: Measurement and Policy Implications*; Routledge: New York, NY, USA, 2000; pp. 85–100.
24. Varoudakis, A.; Rossotto, C.M. Regulatory Reform and Performance in Telecommunications: Unrealized Potential in the MENA Countries. *Telecommun. Policy* **2004**, *28*, 59–78. [CrossRef]
25. Lim, E.K.; Chen, Z. The impact of trade liberalization in telecommunications services: The case of APEC Countries. *Telecommun. Policy* **2012**, *36*, 274–281. [CrossRef]
26. Borchert, I.; Gootiiz, B.; Mattoo, A. Guide to the Services Trade Restrictions Database. World Bank Policy Research Working Paper, No. 6108. 2012. Available online: <https://ssrn.com/abstract=2096025> (accessed on 22 December 2021).
27. Van der Marel, E.; Shepherd, B. Services Trade, Regulation and Regional Integration: Evidence from Sectoral Data. *World Econ.* **2013**, *36*, 1393–1405. [CrossRef]
28. Veenendaal, P.; Rojas-Romagosa, H.; Lejour, A.; Kox, H.L. A Value-Added Trade Perspective on Recent Patterns in World Trade. In *Global Trade Slowdown: A New Normal?* Hoekman, B., Ed.; VoxEU Book, CEPR: London, UK, 2015. [CrossRef]
29. Crozet, M.; Milet, E.; Mirza, D. The Impact of Domestic Regulations on International Trade in Services: Evidence from Firm-level Data. *J. Comp. Econ.* **2016**, *44*, 585–607. [CrossRef]
30. Benz, S. *Services Trade Costs: Tariff Equivalents of Services Trade Restrictions Using Gravity Estimation*; OECD Trade Policy Papers, No. 200; OECD Publishing: Paris, France, 2017. [CrossRef]
31. Fontagné, L.; Mitaritonna, C. Assessing Barriers to Trade in the Distribution and Telecom Sectors in Emerging Countries. *World Trade Rev.* **2013**, *12*, 57–78. [CrossRef]
32. Nordås, H.K.; Rouzet, D. The impact of services trade restrictiveness on trade flows. *World Econ.* **2017**, *40*, 1155–1183. [CrossRef]
33. Kox, H.; Lejour, A.M. *Regulatory Heterogeneity as Obstacle for International Services Trade*; Cpb Netherlands Bureau for Economic Policy Analysis: The Hague, The Netherlands, 2005. Available online: [https://www.fep.up.pt/conferences/earie2005/cd\\_rom/session%20i/i.g/kox\\_lejour.pdf](https://www.fep.up.pt/conferences/earie2005/cd_rom/session%20i/i.g/kox_lejour.pdf) (accessed on 22 December 2021).
34. Oltra-Badenes, R.; Gil-Gomez, H.; Guerola-Navarro, V.; Vicedo, P. Is it possible to manage the product recovery processes in an ERP? Analysis of Functional Needs. *Sustainability* **2018**, *11*, 4380. [CrossRef]
35. Toader, E.; Firtescu, B.; Roman, A.; Anton, S. Impact of information and communication technology infrastructure on economic growth: An empirical assessment for the EU countries. *Sustainability* **2018**, *10*, 3750. [CrossRef]
36. Boylaud, O.; Nicoletti, G. *Regulation, Market Structure and Performance in Telecommunications*; Economics Department Working Paper, No. 237; OECD Publishing: Paris, France, 2000. [CrossRef]
37. Limao, N.; Venables, A.J. Infrastructure, geographical disadvantage, transport costs, and Trade. *World Bank Econ. Rev.* **2001**, *15*, 451–479. [CrossRef]

38. Woetzel, J.; Orr, G.; Lau, A.; Chen, Y.; Chang, E.; Seong, J.; Qiu, A. China's Digital Transformation: The Internet's Impact on Productivity and Growth. McKinsey Global Institute. 2014. Available online: <https://www.mckinsey.com/~{} /media/McKinsey/Industries/Technology%20Media%20and%20Telecommunications/High%20Tech/Our%20Insights/Chinas%20digital%20transformation/MGI%20China%20digital%20Executive%20summary.ashx> (accessed on 22 December 2021).
39. Wallsten, S. Regulation and internet use in developing countries. *Econ. Dev. Cult. Chang.* **2005**, *53*, 501–523. [[CrossRef](#)]
40. Castelnovo, P.; Del Bo, C.F.; Florio, M. Quality of institutions and productivity of State-Invested Enterprises: International evidence from major telecom companies. *Eur. J. Political Econ.* **2019**, *58*, 102–117. [[CrossRef](#)]
41. Casalini, F.; González, J.L. *Trade and Cross-Border Data Flows*; OECD Trade Policy Papers, No. 220; OECD Publishing: Paris, France, 2019. [[CrossRef](#)]
42. Konan, D.E.; Van Assche, A. Regulation, market structure and service trade liberalization. *Econ. Model.* **2007**, *24*, 895–923. [[CrossRef](#)]
43. Makhaya, G.; Roberts, S. Telecommunications in developing countries: Reflections from the South African experience. *Telecommun. Policy* **2003**, *27*, 41–59. [[CrossRef](#)]
44. Francois, J.; Wooton, I. Market structure and market access. *World Econ.* **2010**, *33*, 873–893. [[CrossRef](#)]
45. Kox, H.; Nordås, H. *Services Trade and Domestic Regulation*; OECD Trade Policy Papers, No. 49; OECD Publishing: Paris, France, 2007. [[CrossRef](#)]
46. Freund, C.L.; Weinhold, D. The effect of the internet on international trade. *J. Int. Econ.* **2004**, *62*, 171–189. [[CrossRef](#)]
47. Melitz, J.; Toubal, F. Native language, spoken language, translation and trade. *J. Int. Econ.* **2014**, *93*, 351–363. [[CrossRef](#)]
48. Burri, M.; Polanco, R. Digital trade provisions in preferential trade agreements: Introducing a new dataset. *J. Int. Econ. Law* **2020**, *23*, 187–220. [[CrossRef](#)]
49. Correia, S.; Guimarães, P.; Zylkin, T. Fast Poisson estimation with high-dimensional fixed effects. *Stata J.* **2020**, *20*, 95–115. [[CrossRef](#)]