

# Examining the Impact of ICT Access and ICT Use on Trade in Services: Focused on Selected Service Categories

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## Abstract

This paper examines the impact of ICT access and ICT use on exports and imports of the selected service categories over the period from 2005 to 2019 in Korea. By acknowledging that Korea is the frontrunner in the development of ICT, the study pays special attention to the role of ICT on exports and imports of service categories. In this regard, the aim of this study is to identify key determinants of exports and imports of services by employing the gravity model. The estimation results show that some coefficients of ICT access and ICT use have a significant positive effect on exports and imports of services respectively. However, contrary to expectations, unexpected signs and no significant effects are found in some categories. The reason for this is partly related to the use of disaggregated data instead of using aggregated data. Meanwhile, the interesting result of this study is that ICT use plays a more important role in increasing trade in service categories than ICT access does in many categories. The study also notes that there is a strong positive and significant relationship between exports and imports of service categories and macro-economic variables such as per capita GDP, trade openness and broad money. Up to recently, Korea remains to employ regulatory policies in individual service sectors compared to the other countries. Therefore, it is highly desirable for Korea to lift regulatory restrictions to provide a better environment for trade in services.

**Keywords:** ICT access, ICT use, Service exports and imports, Per capita GDP, Broad money

## 1 Introduction

According to the World Trade Organization (WTO), trade in services have grown faster than trade in goods for nearly thirty decades. Particularly, developing countries have played a more important role in this area and they are increasing their share of global service exports as well. In fact, services have always been traded for a long time. Among them, transportation services are the oldest and finance & insurance services are followed shortly after transportation services. It is also true that the development of communication technology has led to new types of services into the global economy. These services include a number of things: such as legal, engineering, other professional and computer & telecommunication services. In return, advances in telecommunications and computer technology have brought us to the 'Information Revolution'. In the process of this development, Information and Communications Technology (ICT) has brought positive contribution in increasing international trade in service sectors (or categories) as well.

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In this process, service sectors have emerged as the largest segment of most economies by contributing a growing share of Gross Domestic Product (GDP), creating a lot of employment, increasing unprecedented growth in global Foreign Direct Investment (FDI) and finally becoming a major driving force of the global economy. According to Organization for Economic Cooperation and Development (OECD), services are a critical part of the global economy by making more than two-thirds of the global GDP, enticing over three-quarters of FDI in advanced economies. In addition, services are employing the most workers and creating most of new jobs globally [18].

In this context, it is indisputable that trade in service sectors has played an crucial role in economic growth and has been a growing source of employment for a long time. However, it is also clearly apparent that service sectors have not been considered a major issue in international trade and trade policy until recently. This is because services are somewhat intangible and also considered non-tradable. The increase in service trade draws the exchange of ideas, know-how and technology, although it is often restricted by barriers such as domestic regulations. Therefore, the expansion of trade in services are crucial and indispensable for future economic development of all countries. For this reason, this research pays more attention to this point. Here, trade in services refers to the sale and delivery of an intangible product, called a service, between a producer and consumer. It means the value of services exchanged between residents and non-residents of an economy, including services provided through foreign affiliates established abroad. Figure 1 shows the world and Korea's trade in services, which is represented as a percentage of GDP. It turns out that Korea has continued to hold a higher share of service trade than the world has since 2005. However, recently the proportion has gradually decreased since the 2008 global financial crisis.

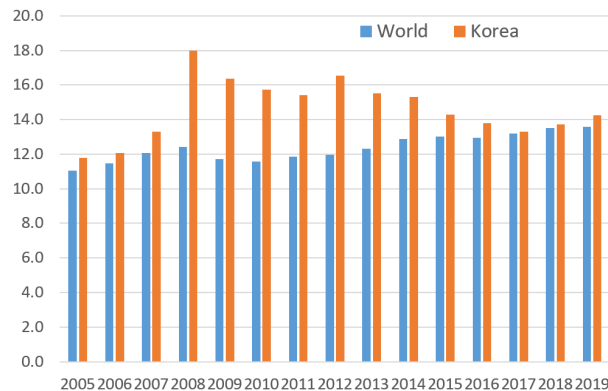


Figure 1: The World and Korea's trade in services(% of GDP)

Source: World Bank, World Development Indicator, 2021

In sequence, the indicator of service trade is measured in million US dollars for service exports and imports. According to the statistics, trade in services include the following services, such as transport (both freight and passengers), travel, communications(postal, telephone, satellite, etc.), construction, insurance and financial, computer and information, royalties and license fees, other business (operational leasing, technical and professional services, etc.), cultural and recreational, but government services are not included in the list. Figure 2 shows Korea's trade in services in terms of exports and imports in 2019. According to the International Trade Administration (ITA) [13], Korea exported 96.3 billion dollars of services. The top services exported by Korea were transportation (\$21.7 billion) in 2018 and followed by other business, travel and construction services. Exports of transportation services in 2019 were the most as in 2018 and followed by other business, travel, construction and telecommunication. On the other hand, Korea imported a total of 118 billion dollars of services in 2018. The top services imported by Korea were other business in 2018, followed by transportation, travel and construction. In 2019,

Korea imported other business (34.7 billion), transportation (\$29.7 billion), travel (\$29.4 billion) and telecommunication (\$3.4 billion) respectively.

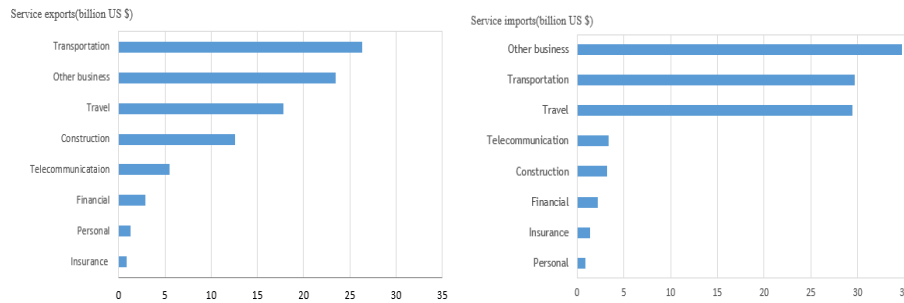


Figure 2: Korea's service exports and imports in the global economy  
Source: Statistics on trade in services, WTO

It is taken for granted that continuous ICT development has contributed a great deal to the expansion of service trade. Theoretically speaking, the development of ICT has a strong positive effect on international trade by reducing information costs across international borders [15]. The study results show that the development of ICT plays an important role in increasing EU trade. Many other previous studies also clearly show the importance of the ICT's role in increasing service exports with the help of improvements in productivity [2, 25]. Considering the strength status of ICT development in Korea and the ever-expanding service trade in the global economy up to recently, this study attempts to identify the major determinant of selected service categories by applying the gravity model.

Given these primary intentions, the rest of this paper is organized as follows. Section 2 looked into ICT Index, which is also called as IDI (ICT Development Index). ICT Index are classified into three sub-indices labeled as ICT access, ICT use, and ICT skills. In addition, it also examines closely EBOPS 2010 service category classification including code names and description. Section 3 reviews previous literatures focused on examining the impact of ICTs on international trade and trade in services and presents the theoretical framework for this study. Section 4 specifies the model and describes the data used in this study. Section 5 presents and discusses the empirical results of this study. Finally, Section 6 concludes the findings of this study and refers to some policy implications as well as future research.

## 2 ICT Development Index (IDI) and Service Categories

ICT is a much broader term compared to information technology (IT) in that it emphasizes the role of integration of telecommunications and computers that allow for users to easily access and utilize information. By enlarging the scope of IT, ICT encompasses both the internet-enabled sphere and the mobile one, which are powered by wireless network. It also utilizes economic, societal and interpersonal transactions and interactions. Therefore, it is certain that ICT has greatly caused many changes on how people work, communicate, live, and trade. With the help of ICT development, it is easy to notice that trade in services is relatively high and steadily increasing every year.-

In this regard, Korea has attracted great attention. Figure 3 shows that Korea has had a very good reputation as a global leading ICT country and is ranked first among the world's 60 most innovative economies in the Bloomberg Index of Most Innovations 2021. It denotes that Korea is the most innovation country in encompassing a post-pandemic digital society. It is also surprising that an East Asian country has been in the first place in the Bloomberg's Annual Innovation Index for the seventh times in a row. In addition, Singapore ranked in second place.

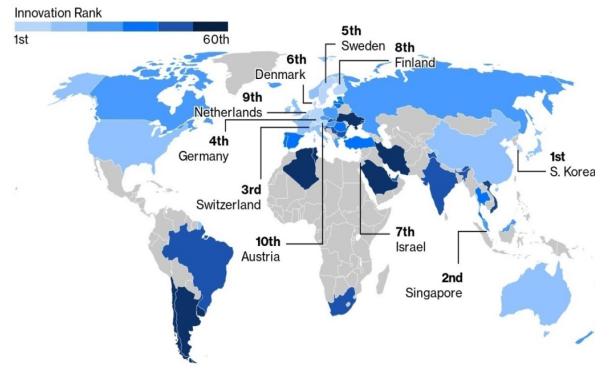


Figure 3: World's 60 Most Innovative Economies 2021.

Source: Bloomberg, ILO, IMF, WB, OECD, World Intellectual Property Organization, United Nations Educational, Scientific and Cultural Organization

With its cutting edge ICT infrastructure boasting the world's fastest internet speeds, Korea is stimulated to keep its reputation as a global ICT frontrunner by investing more heavily into innovative technologies, such as the 5G network, Artificial Intelligence (AI), and Big Data. Keller insists that "technological change increases the importance of services even further". In addition, he argues that "improvements in digital technologies and ICT make it easier to trade services across borders" [12]. According to the International Trade Centre (ITC), services consist of the largest sector in the global economy, which makes up 46% of exports, 60% of global employment and 70% of global GDP, measured in value-added terms in 2021. Recently, it is not easy to operate businesses without efficient services, such as telecommunication, internet, finance and transportation [10]. As those services are becoming increasingly tradable with the help of the advancement in technology, trade in services is continuously increasing continuously and supplying significant opportunities for many countries.

Pratt [20] suggests that "within the ICT market, the advancement of ICT capabilities has made the development and delivery of various technologies cheaper for ICT vendors and the customers, while also providing new market opportunities". She also maintains that "for businesses, advances within ICT have brought a slew of cost savings, opportunities and conveniences". Further, she claimed that "the impact range from highly automated business processes that have cut costs, to the big data revolution where organizations are turning the vast trove of data generated by ICT into insights that derive new products and services, and also to ICT-enabled transactions such as internet shopping and telemedicine and social media that give customers more choices in how they shop, communicate and interact". On the other hand, Gervais and Jensen [9] estimate and identify trade costs for service and manufacturing industries by applying the gravity model. By using trade cost, they divide industries into two categories labeled as tradable and non-tradable industries. Finally, the study insists that trade liberalization brings about potential welfare benefits in the service sector.

Considering the importance of ICT development in service trade, the development of a country's ICT can be explained in three stages. Figure 4 shows that ICT has three stages in its evolution towards an information society. The first stage is ICT readiness, which reflects the level of networked infrastructure and access to ICTs. The second stage is ICT intensity, which reflects the level of use of ICTs in the society. Finally, the third stage is ICT impact, which reflects the result/outcomes of efficient and effective ICT use. All three stages are closely linked to each other. In relation to this, the ICT Development Index (IDI) ranks and compares the level of ICT access, ICT use, and ICT skills across various countries around the world. In this context, the IDI is attracting more and more attention recently.

The IDI, which has been published annually by the International Telecommunications Union (ITU)

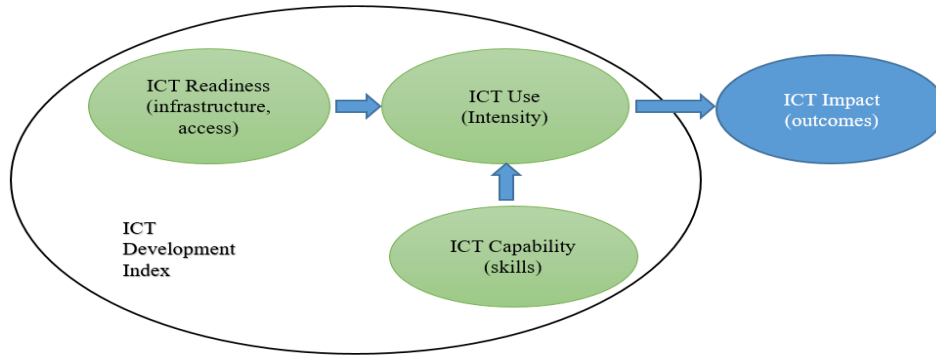


Figure 4: Three stages in the evolution towards an information society  
Source: ITU(2021)

since 2009, is a composite index that combines 11 categories into one benchmark measure. It is used to monitor and compare developments in information and communication technology (ICT) between countries over time. Therefore, the index is designed to be global and reflect changes taking place in countries at different levels of ICT development. In the end, based on the three stages of ICT development, the IDI is divided into the following three sub-indices, and a total of 11 indicators.

Table 1: ICT Development Index: indicators and weights.

	Indicators	Weights (indicators)	Weights (subindices)
ICT Access	1.Fixed-telephone subscriptions per 100 inhabitants	0.20	40
	2.Moblie-celluar telephone subscriptions per 100 inhabitants	0.20	
	3.International internet bandwidth (bit/s) per internet user	0.20	
	4.Percentages of households with a computer	0.20	
	5.Percentages of households with Internet Access	0.20	
ICT Use	6.Percentages of Individuals using the Internet	0.33	40
	7.Fixed-broadband subscriptions per 100 inhabitants	0.33	
	8.Active mobile-broadband subscriptions per 100 inhabitants	0.33	
ICT Skills	9.Adult literacy rate	0.33	20
	10.Secondary gross enrollment ratio	0.33	
	11.Tertiary gross enrollment ratio	0.33	

Source: ITU.

Table 1 shows the three sub-indies, which are ICT access, ICT use and ICT skills. First, the ICT access sub-index captures ICT readiness, and includes five infrastructures and access indicators. Secondly, the ICT use sub-index captures ICT intensity and includes three intensity, and usage indicators. Finally, the ICT skills sub-index seeks to capture capabilities or skills which are important for ICTs. It includes three proxy indicators. Because these are proxy indicators, the skills sub-index is given less weights in

the computation of the IDI compared to the other two sub-indices.

Meanwhile, Table 2 shows the results of the top ten countries of the IDI through 2010 to 2017, and indicates that levels of ICT development are very different across the countries. The IDI results show that most of countries increased their values between 2010 and 2017. The top ten countries of the IDI shows some common characteristics, which aid to explain why those countries have high levels of ICT access and ICT use. Basically, those countries have highly liberalized and competitive ICT markets and people of those countries have the skills to take advantage of ICTs as well.

Table 2: ICT Development Index (IDI).

2017 Rank	Country	2017 Value	2016 Rank	2016 Value	2015 Rank	2015 Value	2013 Rank	2013 Value	2010 Rank	2010 Value
1	South Korea	8.94	1	8.80	1	8.93	1	8.86	1	8.64
2	Iceland	8.88	2	8.78	3	8.86	4	8.64	3	8.19
3	Switzerland	8.74	4	8.66	7	8.56	13	8.11	12	7.60
4	Denmark	8.71	3	8.68	2	8.88	2	8.85	4	8.18
5	United Kingdom	8.65	5	8.53	4	8.75	5	8.50	10	7.62
6	Hong Kong	8.61	6	8.47	9	8.52	9	8.28	13	7.41
7	Netherlands	8.49	10	8.40	8	8.53	7	8.38	7	7.82
8	Norway	8.47	7	8.45	10	8.49	6	8.39	5	8.16
9	Luxembourg	8.47	9	8.41	6	8.59	10	8.26	8	7.82
10	Japan	8.43	11	8.32	11	8.47	11	8.22	9	7.73

Source: ITU, Measuring the Information Society Report 2019, 2020, 2021.

In particular, Korea reaches its highest IDI value in 2017 with an IDI value of 8.94, which illustrates continued growth in ICT access and ICT use. Korea also has sustained in being a long-time front runner with the highest IDI value since 2010. The remaining top ten countries include mostly European countries and covers additional countries from Asia and the Pacific, such as Hong Kong and Japan. Table 2 denotes that most of the top ten countries have an IDI value of more than eight in 2017. Among the top ten countries, the United Kingdom is the country with the highest increase in rank between 2010 and 2017.

Moreover, Table 3 presents and covers exports and imports of services of the world from 202 reporting economies from 2005 to 2019, broken down by service categories according to the availability of the source data. In addition to total services, the eight main service categories, specified in Extended Balance of Payment Service (EBOPS) 2010 [14], have been selected for this study. It also presents a few memorandum items derived from the standard components. Especially, commercial services is used in the WTO context and excludes government goods and services n.i.e. because “services supplied in the exercise of government authority”, that is neither on a commercial basis nor in competition with other suppliers, are excluded from the General Agreement on Trade in Services (GATS).

As a matter of fact, Korea tends to achieve high performance in both the ICT access and ICT use sub-indices. In addition, Korea has increased trade in commercial services over the last decade. Recognizing the crucial role of service trade in leading to economic growth, employment and inflow of FDI opportunities, the study fulfills to examine the role of ICT on exports and imports of trade in service categories in Korea. Previously, many studies were focused on aggregated trade in service, and did not estimate the effect of ICT respectively for each service category. On the other hand, this study applies disaggregated service categories (or commercial services) to identify whether ICT access and ICT use have an unusual and differential effect on Korea’s exports and imports for these selected service categories.

Table 3: EBOPS 2010 Categories Classification: code names and hierarchy.

<b>Code</b>	<b>EBOPS 2010 category description</b>	<b>Type</b>	<b>Derivation</b>
S:	Total services	Standard	-
SA	Manufacturing services on physical inputs owned by others	Standard	-
SB	Maintenance and repair services n.i.e	Standard	-
SC	Transport	Standard	-
SD	Travel	Standard	-
SE	Construction	Standard	-
SF	Insurance and Pension services	Standard	-
SG	Financial services	Standard	-
SH	Charges for the use of intellectual property n.i.e.	Standard	-
SI	Telecommunications, computers and information services	Standard	-
SJ	Other business services	Standard	-
SK	Personal, cultural, and recreational services	Standard	-
SL	Government goods and services n.i.e.	Standard	-
<b>Memorandum Items:</b>			
SOX:	Commercial services	Derived	<b>S-SL</b>
SOX1	Other commercial services	Derived	SE+SF+SG+SH+SI+SJ+SK
SPX1	Other services	Derived	SE+SF+SG+SH+SI+SJ+SK+SL
SPX4	Goods-related services	Derived	SA+SB

### 3 Literature Review

Many economic literatures have attempted to examine the role of ICTs on international trade and trade in services over the last two decades. Most of previous studies show that there is a strong positive and significant impact of ICTs on service trade. In this light, an important concern of this study is to identify distinctively the impact of ICT access and ICT use on trade in eight services categories in Korea. Regarding this objective, this study reviews and discusses previous studies by distinguishing them in terms of areas of interest. In this context, main research areas of study can be divided into three categories by examining the impact of ICT on macroeconomic variables and trade in services.

First, many previous papers attempt to identify the impact of ICTs on macro-level variables such as economic growth, productivity, international trade and employment. Secondly, recent studies are more focused on examining the impact of ICTs on aggregated trade in services. Thirdly, a few studies gradually assess the impact of ICTs on disaggregated trade in services. In addition, to analyze the influences of ICTs on trade in services, most of the studies have mainly used the gravity model, which

was first introduced by Tinbergen in 1962 [24]. The gravity model is often applied to assess whether the development of ICT, in terms of ICT access and ICT use, give rise to increasing international trade in services. Consequently, this study also utilizes the gravity model to analyze the impact of ICT on trade in service categories.

First of all, Vemuri and Siddiqi [26] investigate the impact of ICT and internet penetration on international trade by using an extended gravity model with balanced panel data for 64 countries, which indicates many stages of economic development, from 1985 and 2005. The study results indicate that ICT infrastructure and internet penetration stimulate bilateral trade volume and economic development among trade partners. In 2011, Ahmad et al. [1] identifies the effect of the development of ICT infrastructure on trade in Malaysia by using panel data of 36 trading partners in a gravity model framework. The empirical results suggest that ICT infrastructure plays an important role in increasing Malaysian exports to its trading partners. In addition, Bankole et al. [4] explore the impact of ICT investment on human development. The results indicate that the four dimensions of ICT investment in terms of hardware, software, internal spending and telecommunication have a positive impact on human development. On the other hand, Yushkovo [29] estimates the impact of the internet on total exports of goods for 40 countries. The results show that the internet usage has a positive impact on the export flows among these countries.

Furthermore, Osnago and Tan [19] examine the impact of internet adoption on bilateral trade and the empirical results reveal that the internet has a positive impact on bilateral trade. In 2017, Alderete [3] assess the role of ICT with respect to the socioeconomic development of countries. This study uses the concept of ICT access, ICT use and ICT skills for the year 2013 including 163 countries. The results indicate that ICT use and ICT skills stimulate the effect of ICT access on socioeconomic development. In 2018, Xing [27] examines the role of ICT on export performance using panel data of 21 developed and developing countries and 30 OECD countries. The study results reveal that the efficient use of ICT and better access of ICT can enhance bilateral trade among them. Further, Morrar et al. [16] estimate the effect of the growth of ICT on service sector productivity in Palestine and suggest that ICT use in terms of internet use is the most important factor for labor productivity among service firms. Recently, Solomon and Klyton [22] examine the impact of the usage of digital technology on economic growth for 39 African countries over the period of 2012-2016 by applying Generalized Methods of Moments (GMM) methods. They divide the usage of digital technology into three categories such as individual, business, and government. The study results indicate that only the individual usage category has a positive impact on economic growth.

Moreover, the paper reviews previous studies, which are more interested in examining the impact of ICT on trade in services, regarding exports and imports respectively. First, Freund and Weinhold [7] analyze exports and imports of fourteen service categories between the US and 31 countries in 2002. The study results denote that the internet has a strong and positive impact on service trade among them. However, they do not separate service categories to examine the effect of ICT on trade in services. In addition, Freund and Weinhold [8] apply the modified gravity model to examine the impact of internet usage on international trade for 56 countries over the period of 1995-1999 using both cross-sectional and panel data. The test results show that an increase of 10 percent point in Web hosts could increase a 0.2 percent points in exports growth. In addition, Clake and Wallsten [6] explore the impact of internet penetration, which is measured in per capita users, on service exports for 26 developed and 72 developing countries by applying OLS and 2SLS methods. They find that in the case of service exports, internet penetration has a positive impact from the developing countries to the developed countries, but it did not work the other way around. Choi [5] also examines the impact of internet usage on service trade for 151 countries using panel data from 1990 to 2006. The study results indicate that a doubling of internet usage would increase a country's exports services by 2-4 percent. Salmani et al. [21] also analyzes the impact of the internet on international trade in services for developing countries. They insist that the internet



plays an important role in increasing service trade among them and the empirical results show that GDP and population have a positive impact on service trade as well.

It is a well-known fact that ICT plays a pivotal role in increasing trade in many service categories due to the cost reduction effect that the diffusion of ICT development brings about. In this light, Liu and Nath [17] examine the effect of ICT on exports or imports of ten service categories for 49 countries by using panel data from 2000 to 2013. The empirical results show that the development of ICT has a positive impact on service trade. They also added that ICT use has a more important role in increasing service trade than ICT access and ICT skills in some categories. Yousefi [28] also tests the effect of the internet on services exports and imports for 63 developed and developing countries by applying GMM methods using data from 2000 to 2014. The empirical results indicate that most variables have the expected signs and statistically significant effects on trade in services. In addition, the study shows that in the case of service exports, the internet has a greater impact on developed countries than developing countries. Recently, Tee et al. [23] examines the impact of the development of ICT on the ASEAN-5's service exports by using data from 2000 to 2012. They find that ICT indicators have a significant and positive effect on the ASEAN's service exports. In this context, they suggest that policy need to strengthen trade facilitation in cooperation with the development of ICT in order to the ASENS-5's service exports.

On the sufficient theoretical basis from many previous researches, the study would like to establish an appropriate model and examine the effect of ICT access and ICT use on trade in eight service categories along with gravitational model variables. In this light, the study empirically makes an attempt to re-examine the role of ICT on trade in service categories by applying the gravity model. Accordingly, the study expects that ICT access and ICT use will enhance the volume or value of each service category for exports and imports in Korea. Given the importance of trade in services in Korea, an increase in service trade with regard to eight service categories will contribute greatly to both Korea's economic growth and the expansion and development of service trade in the future.

In this sense, the main purpose of this study is narrowed down to threefold. First of all, it is to identify the role of ICT access and ICT use separately on eight service categories in Korea. Secondly, it is to ascertain whether the variables of the gravitational model are elucidating the trade in eight service categories. Almost all countries have experienced a decline in service trade since the Covid-19 outbreak. Disruption and regulation on international mobility of all countries are the key factor in the collapse of service trade. Thirdly, therefore, it is to suggest a proper and useful policy regarding the outbreak of Covid-19 and recent decline in service trade.

## 4 Empirical Methodology and Data

The study estimates the impact of ICT access and ICT use on exports and imports of the selected eight service categories (commercial services) in Korea by incorporating time-series data over the period from 2005 to 2019. In addition, the study also includes gravitational model variables, such as; per capita GDP, population, trade openness and broad money. Ultimately, the study makes use of a gravity-like specification by omitting the distance variable from the original gravity equation. The gravity model suggests that relative economic size attracts countries to trade with each other, while greater distance weakens the attractiveness. Finally, in this light, the stability of the gravity equation and its ability to explain bilateral trade flows led to the decision to apply the model for this study.

As a matter of fact, Tinbergen first introduced the original gravity equation in 1962 [24]. Tinbergen's main equation can be written as follows:

$$T_{ij} = G \frac{GDP_i^\alpha GDP_j^\beta}{Dis_{ij}^\theta} \quad (1)$$

In this equation,  $T_{ij}$  stands for the bilateral trade flow between country  $i$  and  $j$ ,  $G$  is a constant.  $GDP_i$  and  $GDP_j$  represent the gross domestic production for both countries  $i$  and  $j$ , and  $D_{ij}$  represents the geographical distance between the two countries. Instead of assuming that trade is directly proportional to the GDP of both countries and inversely proportional to the distance between trading partners, the alpha, beta and theta variables show that the weight (or size) of the GDPs and distance must be considered in the final equation. In the end, the higher the distance, the higher the cost of trade. In order to estimate the standard gravity model of equation (1), it can be converted in the following linear form of specification for the purpose of econometric analyses by employing logarithms.

$$\log(T_{ij}) = \delta + a_1 \log GDP_i + \beta_2 \log GDP_j - \theta_3 \log DIS_{ij} + \mu_{ij} \quad (2)$$

The model has been an empirical success in that it accurately predicts trade flows between countries for many goods and services. Regarding this model, “the trade flows between countries  $i$  and  $j$  is assumed to depend positively on income and country size of the exporting and importing countries and negatively on the distance between these countries” [11].

In this regard, a modified version of this study includes the following variables: per capita GDP, population, trade openness, broad money. In addition, ICT access and ICT use are regarded as more interesting and important variables. In the end, the model can be specified as follows. First of all, the dependent variables are exports and imports of the selected eight service categories. On the other hand, the independent variables are per capita GDP, population, trade openness, and broad money. Trade openness and broad money are defined as the ratio of Korea’s total trade in goods and services to its GDP and the ratio of GDP respectively. Further, the study includes the development of ICT in terms of ICT access and ICT use. First, ICT access includes FTS and MCS, which are fixed-telephone subscriptions per 100 inhabitants and mobile-cellular subscriptions per 100 inhabitants respectively. In addition, ICT use includes internet users (ITN) and FBS, which are the percentage of individuals using the internet and the fixed-broadband subscriptions per 100 inhabitants individually. Lately, it is widely noted that “ICT-enabled trade in services is regarded as an important ingredient of the information economy and society more than ever”. [11]. Therefore, as ICT advances, it is likely to promote trade in the selected service categories in Korea. By assuming that ICT access and ICT use along with gravitational model variables play an important role on increasing trade in the selected service categories, the study fundamentally considers the following basic equation form (3):

$$\text{Trade in Service Categories} = f(\text{ICT Access}, \text{ICT Use}, \text{PCGDP}, \text{POP}, \text{TO}, \text{BM}, ) \quad (3)$$

In order to examine the effect of ICT access and ICT use on exports and imports of the selected service categories, the study establishes the following form:

$$TSC_{it}^j = \beta' ICT_{it} + \gamma' Z_{it} + \varepsilon_{it} \quad (4)$$

Where  $TSC_{it}^j$  is the logarithm of exports (or) imports of service  $j$  for country  $i$ , that is, Korea in year  $t$ ;  $ICT_{it}$  is the vector of ICT access and ICT use variables;  $Z_{it}$  is the vector of control variables;  $\varepsilon_{it}$  is the error terms. By taking the logarithms of the dependent and independent variables, the study obtains the following form of a log-log linear function for export and import models:

$$\begin{aligned} \log(TSC_{it}^j) = & \beta_0 + \beta_1 \log FTS_{it} + \beta_2 \log MCT_{it} + \beta_3 \log ITN_{it} + \beta_4 \log FBS_{it} \\ & + \beta_5 \log PCGDP_{it} + \beta_6 \log TO_{it} + \beta_7 \log POP_{it} + \beta_8 \log BM_{it} + \varepsilon_{it} \end{aligned} \quad (5)$$

Where, subscript  $j$  indicates service categories with  $j=1, 2, \dots, J$  and subscript  $t$  denotes the time period with  $t= 1, 2, \dots, T$ . The dependent variable  $TSC$ , stands for each of the service categories of exports and

imports for Korea in year  $t$ . As it were, it stands for eight commercial services, such as transportation, travel, construction, insurance, finance, telecommunications, other business and personal services respectively. Therefore, the main object of this study is to examine the influence of ICT access and ICT use on exports and imports of the eight different service categories. First,  $\beta_0$  is the intercept of the regression. In here,  $\beta_i$  is the coefficient for the right hand side variables of ICT access and ICT use and it can have a positive or negative effect on eight service categories. ICT access and ICT use variables include four variables, such as FTS and MCS variables for ICT access and ITN and FBS variables for ICT use. These variables are expected to stimulate trade in the selected service categories in Korea.

On the other hand, in cases of gravitational variables,  $PCGDP$  stands for the economy size and it is likely to increase trade in service categories. Thus,  $\beta_5$ , the coefficient of  $PCGDP$ , is expected to have a positive sign.  $TO$ , stands for trade openness, is also anticipated to increase trade in service categories. It implies that “the more the degree of trade openness increases, the more the trade in service expands” [11].  $POP$  stands for the population of Korea and it is also likely to increase trade in service categories and have a positive impact on trade. Lastly,  $BM$  stands for broad money, which is measured in as a percentage of GDP. Broad money is a category for measuring the amount of money circulating in an economy. This can be a proxy for financial depth. Thus, the higher financial depth, the higher in service trade for this case. Therefore,  $\beta_8$ , the coefficient of  $BM$ , is assumed to have a positive impact on trade in the selected service categories. Finally,  $\varepsilon_{it}$  indicates the error term. In conclusion, most variables are likely to have a positive effect on trade in the selected service categories.

The study obtains data of the selected eight service categories, ICT access and ICT use and gravitational model variables from many different international organizations, such as the WTO, World Bank (WB) and International Telecommunication Union (ITU). First, the study uses annual data of Korea export and import of the selected eight service categories. Those data are all obtained from the WTO statistics on trade in commercial services. On the other hand, the data of ICT access and ICT use are collected from ITU’s World Telecommunication/Information and Communication Technology (ICT) indicators database. In addition, the data of per capita GDP, trade openness, population and broad money are all obtained from World Bank’s World Development Indicators (WDI). Finally, this study admits that the impact of ICT access and ICT use on trade in service categories are not fully analyzed due to data limitation. Therefore, to overcome this matter and achieve a more accurate analysis of ICT access and ICT use on trade in service categories, a more sufficient data set is needed in the future.

## 5 Empirical Results and Discussion

The empirical model applies the gravity model by establishing a log-log linear equation form to identify the impact of ICT access and ICT use on exports and imports of the selected service categories in Korea. In this section, the paper reports the summary of descriptive statistics in Table 4 and presents the estimation results of the proposed model for exports and imports on the selected service categories in Table 5 and Table 6 respectively.

First of all, Table 4 provides the summary statistics of the major variables regarding the dependent variables, ICT access and ICT use variables, and the control variables for the baseline specification. It indicates that there are wide variations in mean value of exports and imports of the selected service categories. In addition, there are substantial differences in variability of export and import across service categories as reflected in the standard deviations. Based on the modified gravity model, Table 5 and Table 6 present the estimation results for exports and imports of service categories respectively. More importantly, \*\* and \* denote statistical significance at the 5% and 10% significance level. In addition, t-statistics are reported in parentheses. Table 5 presents the impact of ICT access and ICT use on exports of the service categories including the control variables. First of all, the values of  $R^2$  for all service

Table 4: Summary Statistics of the Major Variables.

Variables	Mean	Max.	Min.	St. Devi.
<b>Export (millions of US \$)</b>				
Construction services	13100	20375	4707.0	4419.9
Financial services	1825.3	2936.0	773.0	569.60
Insurance and pension services	595.87	1114.0	169.0	258.75
Personal, cultural, and recreational services	663.20	1320.0	105.0	374.76
Other business services	16111	23418	9393.0	4866.3
Telecommunication, computer, and information services	2348.3	5528.0	295.0	1753.0
Transport services	32685	44695	24082	6694.3
Travel services	12206	17844	5717.0	4149.9
<b>Import (millions of US \$)</b>				
Construction services	2786.7	4852.0	879.0	1036.2
Financial services	1736.9	2446.0	235.0	588.9
Insurance and pension services	893.8	1351.0	686.0	187.2
Personal, cultural, and recreational services	641.3	966.0	141.0	216.4
Other business services	25305.7	34743.0	13199.0	6873.6
Telecommunication, computer, and information services	1957.3	3454.0	410.0	902.8
Transport services	29317.9	37187.0	20854.0	3946.4
Travel services	22667.2	31973.0	15035.0	5402.5
<b>Independent Variables</b>				
FTS	53.63	60.30	45.90	4.992
MCT	107.1	134.5	78.73	16.35
ITN	85.81	96.20	73.50	6.964
FBS	34.53	41.59	24.58	5.571
PCGDP	26047	33422	19143	4586
POP	50096372	51709098	48184561	1181869
TO	84.27	105.6	68.32	12.77
BM	129.1	151.8	106.7	11.45

Source: author's calculation.

categories are shown in Table 5. R-square ( $R^2$ ) is a statistical measure that represents the proportion of the variance for a dependent variable that is explained by independent variables in a regression model. Consequently, most  $R^2$  values turn out to be over 0.9 except transport services. However, contrary to

Table 5: The ICT and Exports in Commercial Services.

Variables	Construction services	Financial services	Insurance services	Personal services	Other business services	Telecom services	Transport services	Travel services
Log FTS	-0.099 (-0.052)	2.671 (-1.429)	1.828 (0.939)	1.542 (1.064)	-0.049 (-0.068)	0.240 (0.285)	2.287 (1.151)	2.679* (2.317)
Log MCT	-7.632* (-1.920)	0.600 (0.154)	-6.299* (-1.554)	-6.875* (-2.278)	-5.029** (-3.298)	-8.764** (-4.998)	-6.056 (-1.464)	-3.428 (-1.423)
Log ITN	5.708 (0.962)	5.696 (0.981)	6.989 (1.156)	6.657 (1.478)	-2.310 (-1.015)	10.89** (4.164)	-0.928 (-0.150)	-5.852 (-1.628)
Log FBS	4.763* (2.133)	5.10** (2.333)	2.985 (1.311)	0.483 (0.285)	1.904* (2.222)	0.292 (0.297)	3.207 (1.379)	0.121 (0.089)
Log PCGDP	2.619* (2.166)	0.567 (0.487)	3.363** (2.728)	3.263** (3.552)	1.938** (4.177)	3.896*** (7.301)	2.689* (2.135)	1.144 (1.561)
Log TO	2.319* (1.992)	0.724 (0.635)	-0.198 (-0.167)	0.920 (1.041)	-0.254 (-0.568)	1.055* (2.054)	-0.366 (-0.302)	-1.037 (-1.470)
Log POP	-40.40** (-2.874)	-53.83** (-3.912)	-32.61* (-2.276)	-9.731 (-0.912)	13.35** (2.475)	-1.387 (-0.224)	-28.93* (-1.977)	20.37 (2.392)
Log BM	6.418 (1.455)	0.397 (0.092)	6.395 (1.422)	8.745** (2.611)	3.74*5 (2.213)	7.215** (3.708)	7.490 (1.631)	7.437** (2.782)
Constant	651.5** (2.797)	915.4** (4.014)	500.6* (2.108)	93.73 (0.530)	-236.6** (-2.648)	-56.83 (-0.553)	473.2* (1.952)	-364.1** (-2.579)
R <sup>2</sup>	0.941	0.923	0.963	0.990	0.987	0.997	0.772	0.977

Source: author's calculation.

Table 6: The ICT and Imports in Commercial Services.

Variables	Construction services	Financial services	Insurance services	Personal services	Other business services	Telecom services	Transport services	Travel services
Log FTS	-0.368 (-0.123)	-0.687 (-0.409)	-1.973 (-0.953)	0.944 (0.674)	0.046 (0.043)	1.162 (0.647)	0.859 (0.591)	-0.733* (-2.144)
Log MCT	-3.904 (-0.625)	-7.156 * (-2.044)	4.434 (1.029)	-3.468 (-1.189)	-0.482 (-0.214)	-7.545 (-2.019)	-4.766 (-1.574)	-1.516* (-2.128)
Log ITN	2.825 (0.303)	19.67 ** (3.764)	-0.169 (-0.026)	10.85** (2.494)	0.589 (0.176)	17.64* (3.164)	1.317 (0.291)	3.104 ** (2.919)
Log FBS	4.255 (1.213)	8.263** (4.200)	0.227 (0.094)	1.161 (0.709)	1.899 (1.504)	-0.181 (-0.086)	3.269* (1.922)	1.180** (2.948)
Log PCGDP	2.304 (1.213)	2.291* (2.151)	-0.514 (-0.392)	4.298** (4.844)	0.059 (0.087)	3.286* (2.889)	1.807* (1.961)	1.046** (4.826)
Log TO	2.073 (1.134)	3.127* (3.049)	0.266 (0.211)	2.113** (2.474)	0.165 (0.250)	1.265 (1.155)	-0.362 (-0.408)	0.061 (0.294)
Log POP	-38.79 (-1.757)	-106.4*** (-8.593)	-7.352 (-0.482)	-67.8*** (-6.578)	-2.101 (-0.264)	-39.25* (-2.969)	-21.93* (-2.048)	-3.734 (-1.482)
Log BM	4.823 (0.696)	6.593* (1.697)	-3.457 (-0.723)	7.369 * (2.278)	0.400 (0.161)	6.811* (1.642)	4.265 (1.269)	-0.832 (-1.052)
Constant	631.7 (1.726)	1743*** (8.499)	145.1 (0.574)	1080.*** (6.322)	36.81 (0.279)	583.9* (2.666)	363.0 (2.046)	61.36 (1.469)
R <sup>2</sup>	0.887	0.981	0.722	0.978	0.970	0.974	0.748	0.994

Source: author's calculation.

expectations, the result does not fully support the inquiry of this study. The empirical results show that the coefficients of some variables turn out to be negative contrary to its expectation. These empirical results are the least expected and are not the consistent with previous study results perfectly.

In Table 5, some of the coefficient values of ICT access for FTS and MCT have a negative effect on service exports. Looking at the significance test results, in case of FTS, it is not strongly significant on service exports, except for the travel services. On the other hand, in case of MCT, other business and telecommunications services have a statistically significant effect on service exports. Meanwhile, most of the coefficient values of ICT use for INT and FBS have a positive effect on service exports as expected and turn out to be statistically significant at the 5 percent significant level for telecommunications and financial services respectively. The reason behind the results could be partly related to using disaggregated data of commercial services instead of using aggregated data for service trade. On the other hand, in case of the gravitational variables, most of the variables have a positive effect on service export except for the population variable. The coefficient values of per capita GDP, trade openness and broad money all have the expected signs and are robustly significant at the 1 percent and 5 percent significant level respectively.

More importantly, the coefficient value of the ICT use (ITN) and per capita GDP and broad money proves to increase exports of telecommunications service and FBS for financial service compared to other services. These empirical results imply that the association between the internet user and service exports is very robust. Finally, the results indicate that a 1 percent increase in internet user per hundred people increases 10.9 percent of telecommunication service exports. Also, per capita GDP and broad money increase telecommunication service exports by 3.9 percent and 7.5 percent respectively.

Table 6 shows the empirical results of the impact of ICT access and ICT use and the gravitational variables on imports of service categories. The result show that the coefficients of ICT access for FTS and MCT have a negative sign and are statistically insignificant on service imports as in the case of service exports. On the other hand, in case of ICT use for ITN and FBS both have positive signs and the coefficient of financial service, personal service and travel services turn out to be statistically significant at the 5 percent significance level respectively. In addition, most of the coefficient values of per capita GDP, trade openness, and broad money have a positive impact on service import variables and some of them turn out to be statistically significant at the 5 percent significance level. Meanwhile, the coefficient value of population has a negative sign and is statistically significant for financial and personal services at the 5 percent significance level respectively. These results are very similar to the results of the service exports as shown in Table 5.

## 6 Conclusions and Implications

Information and communications technology (ICT) is an important feature of learning more information and a vital source for the economic welling of the country. Basically, ICT stresses the role of unified communications and the integration of telecommunications & computers and it also enables users to access and manipulate information. Until recently, many previous studies were more focused on examining the effect of ICT on international trade. However, there is an increasing tendency to study the impact of ICT on service trade. Reflecting this trend, this study investigates the effect of ICT access and ICT use on export and imports of the selected service categories (commercial services) in Korea from 2005 to 2019. The reason why Korea is selected as the research country is because Korea has been the leading country in ICT development index for a long time. Finally, the study includes disaggregated data of service export and import by using the modified gravity model to identify the impact of ICT variables on trade in selected service categories in Korea.

To sum up the regression results, the study notes three important points. First, from Table 5 and

Table 6, these tables show the same results of ICT access (FTS and MCT) and ICT use (ITN and FBS) for service exports and imports respectively with only a few exceptions. Many coefficient values of ICT access for service exports and imports have negative signs contrary to its expectations. On the other hand, ICT use is found to be more important than ICT access for exports and imports in increasing many service categories. The results denote that most coefficients of ICT use for service exports and imports have positive signs and has a statistically significant effect on telecommunications services for ITN and financial services for FBS in case of service exports. Secondly, in case of service imports, ITN has a strong positive effect on financial services, personal service and travel service respectively and FBS has a significant positive effect on financial services and travel service as well. Finally, the study shows robust results with respect to per capita GDP, trade openness and broad money variables for all dependent variables except population variables. The regression results indicate that the coefficients of per capita GDP, trade openness and broad money are statistically significant and have consistently robust results for exports and imports of the selected service categories. This consequence comes from the fact that those components have been regarded as some of the key factors in international trade for a long time. Per capita GDP is a global measure for gauging the prosperity of nations and developed countries tend to have a higher per capita GDP. As its most basic interpretations, it shows how much economic production value can be attributed to each individual citizens. Therefore, the study could confirm that the impact of gravitational variables on exports and imports of the selected service categories turns out to be firmly remaining in this case.

Finally, this study concludes that the eight selected service categories have the potential to contribute in Korea's trade promotion and economic growth through continuous development of ICT in the future. However, although the diffusion of ICT development is the driving force of the expansion of service trade, there are some restrictions in Korea. In this regard, it is necessary to review the Services Trade Restrictiveness Index (STRI). STRI is "a unique tool that provides up-to data information on regulatory changes that affect trade in services in 46 countries across 22 sectors. The STRI indicators take values between zero and one, where one indicates the most restrictive trade environment". According to the OECD's STRI in 2021 [18], Korea is relatively high compared to other countries and higher than the OECD average. Changes in the regulatory environment have been moderated between 2014 and 2018 and there is no significant change in between 2019 and 2020 in Korea as well. This result implies that an open regulatory environment is necessary for Korea to enhance more trade in services. Innovation and adoption of technology relies on access to knowledge and the networks, people, goods and services that carry the knowledge around the world. In this light, Korea can benefit from more open markets for service trade. For sophisticated future research in examining the impact of ICTs on service trade, it is desirable to use panel data. This is because it usually has more degree of freedom and sample variability than time-series data. In addition, it will allow us for more accurate inference about the parameters of the model.

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