A Study on the Effect of Information and Communication Technology (ICT) on Trade in Services in the United States

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Abstract

The pandemic of COVID-19 appears to boost trade in services and even the ICT service exports in the U.S. The U.S. has been recognized as the world's largest services market and became a leading exporter and importer of services over the last two decades. In this perspective, this study attempts to empirically identify the impact of ICT on trade in services and ICT service exports in the U.S. by employing the modified gravity model of trade from 1990 to 2021. The results indicate that overall ICT access and ICT use have significant positive effects on the trade in services and ICT service exports, but others brought about different results. The study also finds two important facts. First, FTS has a positive effect on the trade in services and ICT services exports, while, MCS has a completely negative effect on both the trade in services and ICT services exports. More interestingly, the dimension of ICT use of IUI and FBS have a different impact on both trade in services and ICT services exports. Another important finding is that the coefficients of IUI and FBS in relation to the trade in services have an unexpected negative sign, while both IUI and FBS have a positive influence on ICT service exports. Finally, these empirical results imply that ICT use has played a more productive role in enhancing ICT service exports than that of ICT access in the U.S. Consequently, these results might provide vital policy insights for the development of ICT and more rapid growth of services trade.

Keywords: Service Trade, ICT Service Exports, ICT Access, ICT Use, Unit Root Test, U.S.

1 Introduction

The development of internet, regarding Information and Communication Technology (ICT), has became one of the most crucial implements for communication and information in the globalized world. It is a clear fact that more than half of the world's population is connected to the internet today. Some countries have a rate of internet penetration near 100 percent, but other countries do not. It is also true that rapid development of ICT has brought a remarkable change to the service sectors in the world, especially for the international trade in services. This accomplishment was achieved through the reduction on cost from ICT, which finally leads to more opportunities for economic activity. In this light, the development of ICT has been a fundamental factor for enhancing economic growth and development and even international trade in services for a long period of time.

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According to the World Information Technology and Services Alliance (WITSA), it says that "facilitating access to information technology is an important way for countries to promote economic development and growth" (WITSA, 2016). In addition, (WITSA 2016) also maintains that "providing market access to IT and IT services can help attract Foreign Direct Investment (FDI)" as well. Consequently, it is certain that ICT has played a significant role in facilitating trade in services in the world.

Figure 1 shows the total ICT spending on traditional and new technologies worldwide from 2016 to 2023. Here, the spending on traditional technologies includes: hardware, software, services and telecommunications, while the spending on new technologies consists of: artificial intelligence (AI), robotics, augmented reality (AR), virtual reality (VR) and blockchain. The statistics in Figure 1 presents that the COVID-19 pandemic leads to a slight decline in overall ICT spending in 2020 compared to 2019, but overall ICT spending is expected to increase by 5 percent from 2021 to 2023 annually. According to United States International Data Corporation's (IDC) forecast, global ICT spending is 4.9 trillion in 2022 and is projected to reach almost 5.8 trillion U.S. dollars by 2023 (United States 2022). Here, total ICT spending of 4.45 trillion U.S. dollars is coming from traditional technologies (cloud, mobile, social and analytics) in 2023 and the rest is coming from new technologies, such as internet of things (IoT) and robots/drones. Significantly, ICT spending on new technologies is expected to increase more than 25 percent over the next 5 to 10 years. In this perspective, the overall influence of the new technologies on the global economy is expected to play a very positive role in accelerating the growth in trade in services through reduction on transaction costs. Consequently, more ICT spending on these technologies will lead to rapid return on this investment and completely modernize the way products are made and accelerate trade in services worldwidely.

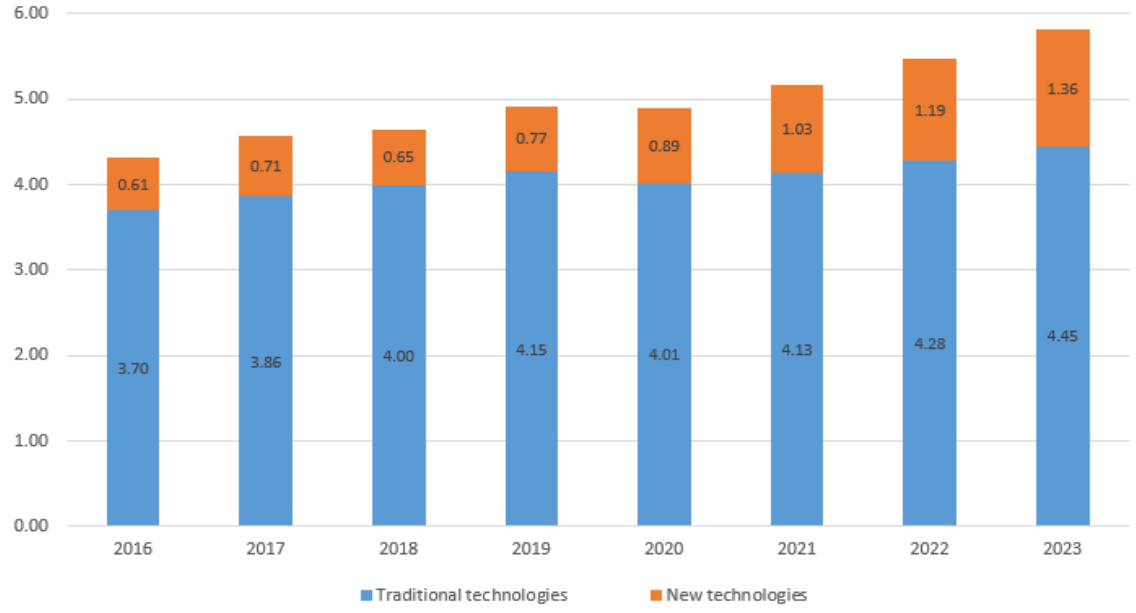

Figure 1: Total ICT spending worldwide 2016-2023, by technology generation (in trillion U.S. $)

Source: Statista 2023, International Data Corporation (IDC).

Figure 2 indicates the business and government spending on information and business technology in the U.S. from 2012 to 2022. The U.S. total spending on technology products, services and staff was

estimated to reach around 2,075 billion U.S. dollars in 2022, which shows that it quickly recovered from the COVID-19 pandemic (Bakhtina and Matulevicius 2022).

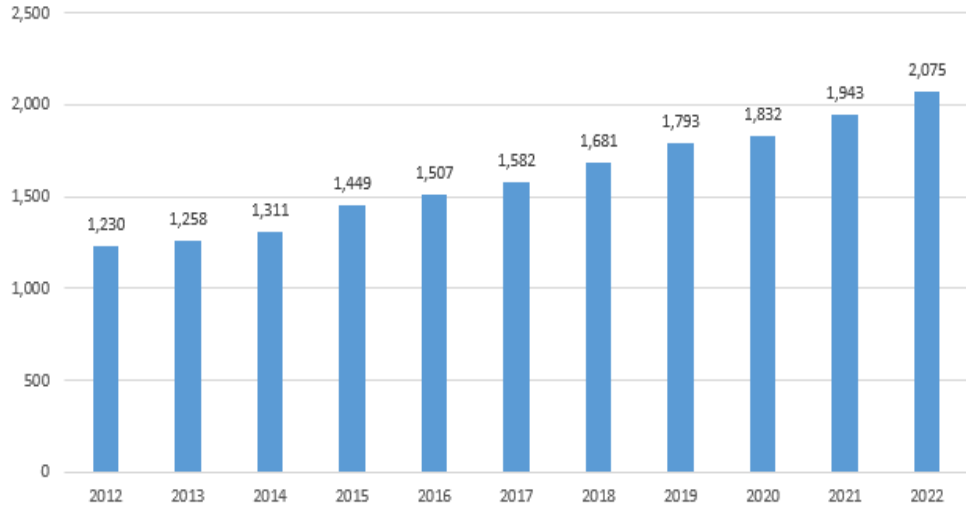

Figure 2: Total Expenditure on IT and Business Technology 2012-2022 in US (in billion U.S. $)

Source: Statista 2023, International Data Corporation (IDC).

As the digital transformation is currently underway, accelerating information technology is gradually becoming an crucial factor of trade in services throughout the world. Therefore, it is expected that the large number of internet users in any country will have a positive impact on the expansion of service trade. Figure 3 shows countries with the largest digital population in the world. In Figure 3, China is ranked first with 1.02 billion internet users followed by India and the U.S which are ranked second and third place respectively in 2022. This result might have to do with China's ongoing and rapid economic development and cultural inclination towards technology. The statistics also indicate that the internet user population of China is continuously growing and is more than three times than that of the U.S. in 2022. In addition, Figure 4 presents and forecasts the number of internet users in the U.S. from 2018 to 2027 and shows that the number of internet users in the U.S. has continued to increase every year. Finally, it also indicates that the number of internet users is over 307 million in 2022. Given this trend, this figure is predicted to increase to 328 millions by 2027.

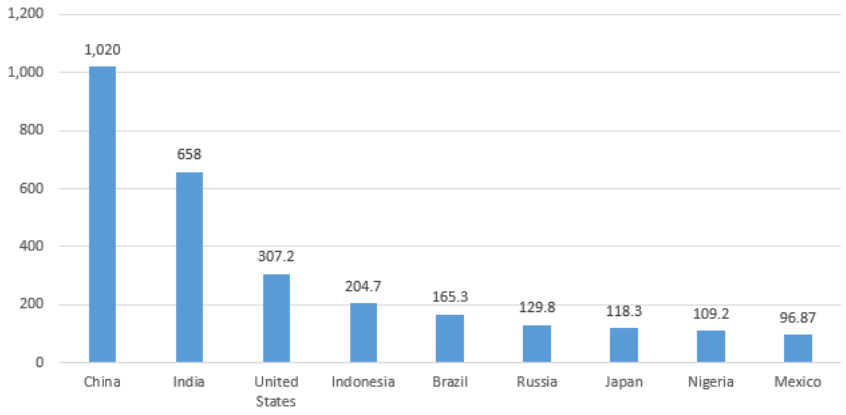

Figure 3: Countries with the largest digital population in the world (in millions U.S. dollars)

Source: Statista 2022.

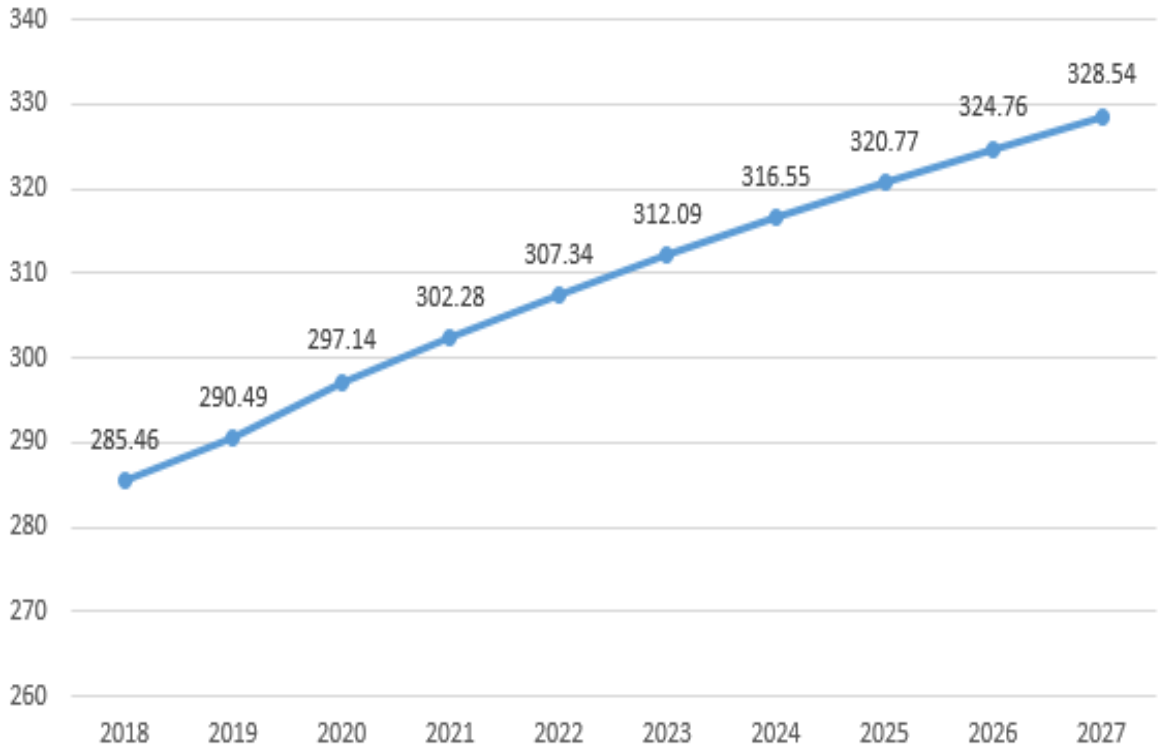

Figure 4: Number of internet users in the united states from 2018 to 2027 (in millions U.S. $)

Source: Statista, 2022.

In this regard, the development of ICT technologies and an increase in the population of internet users in the U.S. seem to play a major role in promoting trade in services between the U.S. and its trading partners. Unquestionably, the development of ICT services will facilitate information processing and communication, which can predominantly be delivered over the ICT network. Therefore, the development of ICT technologies and reduction on costs in return are expected to contribute to an increase in trade in services in the U.S. According to the U.S. International Trade Commission (USITC), the U.S. is the world's largest services market and became a leading exporter and importer of services (USITC 2020). As mentioned earlier, the U.S. is ranked third among the largest online markets in the world. In addition, the digital population of the U.S. has increased over the past 20 years and currently more than 90 percent of Americans have access to the internet in 2022. Therefore, it is true that an increase in trade in services, which consistently generates surpluses has played a crucial role in increasing overall trade in the U.S. Figure 5 shows that the U.S. service trade surplus has continued to increase until the COVID-19 outbreak since 2012. It also presents that U.S. exports of services were 795.3 billion dollars and imports of services were 550.0 billion dollars, which creates a surplus of 245.2 billion dollars in 2021. Moreover, U.S. imports of services increased at a faster rate of 18 percent than that of U.S. exports of services, which recorded a 9 percent growth rate in 2021. As a result of this, there is a decrease in the service trade surplus of 14.6 billion dollars in 2021.

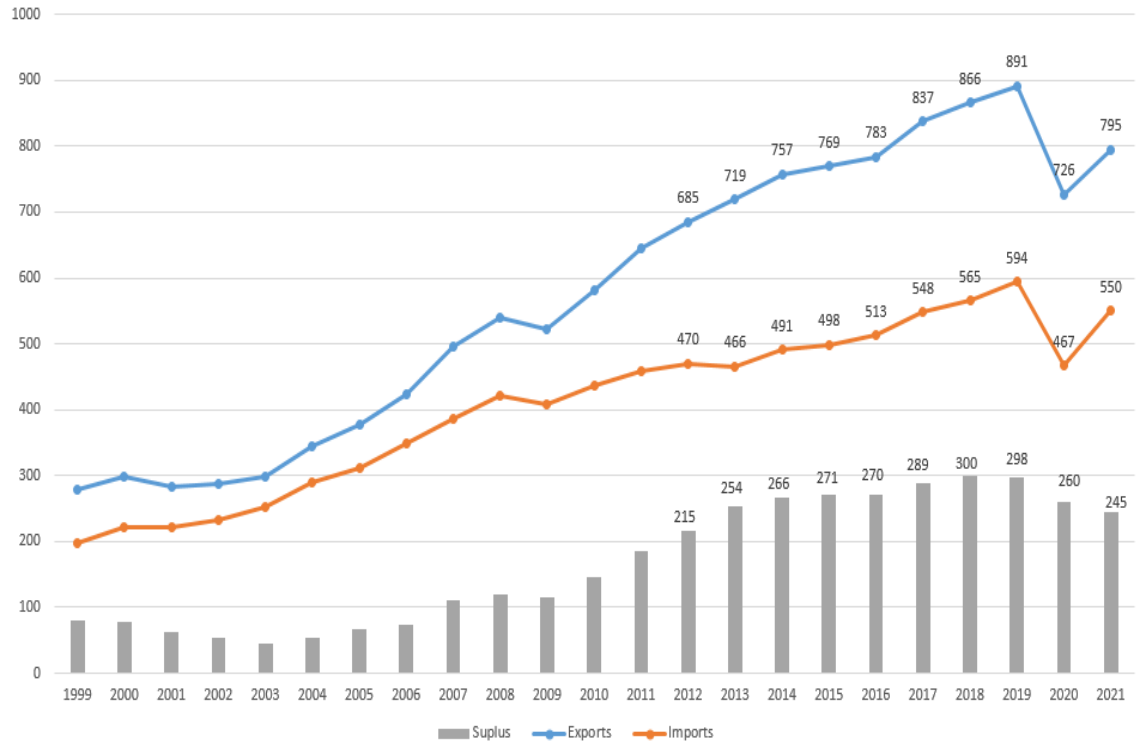

Figure 5: U.S. International trade in services from 1999 to 2021 (in billions U.S. $)

Source: U.S. Bureau of Economic Analysis (BEA), July 2022.

Given the current circumstances in trade in services in the U.S., this study focused on two dependent variables, such as total trade in services and ICT service exports, which denotes the percentage of service exports by including computer and communication services. First, total trade in services refers to the sum of U.S. exports and imports of services, which implies the trade in services between U.S. and its trading partners. Secondly, ICT services exports refers to the trade in services that are delivered over ICT networks. Based on what was mentioned earlier on trade in services, this study focused on investigating the impact of ICT on trade in services in the U.S. Given these essential purposes, the rest of this paper is as follows. In Section 2, the study reviews many previous studies that make an attempt to identify the influence of ICTs on international trade, trade in services and other areas. Section 3 constructs and specifies the empirical model based on a simple theoretical framework and explains the data used in this study. Section 4 reports and discusses the estimation results of this study. Finally, in Section 5, the study concludes by referring to the key findings that this study found.

2 Literature Review

Recently, for more than 20 years, many previous studies have attempted to analyze with interest how advances in ICT affects international trade, or services trade. Most previous research papers have shown that ICT has had a very positive and significant effect on international trade. From this point of view, the main purpose of this study is to examine how ICT influences trade in services in a developed country such as the U.S. To achieve this goal, this section of the study evaluates previous studies with respect to research methodologies and test results of empirical work. These procedures are a very necessary process to verify the reliability of this study. Therefore, this study looks through and deals with previous studies, which examines the effect of ICT on macroeconomic variables, trade in services and other economic

spheres. Just as well known, most previous papers mostly focused on examining the effect of ICT on macroeconomic variables, such as international trade, economic growth and employment. However, recent studies are more interested in trade in services and even further in dis-aggregated trade in services. It is true that there are relatively few studies are conducted to identify the relationship between ICT and trade in services with an interest in the U.S. Reflecting recent trends, this study performs to identify the influence of ICT on trade in services in the U.S. To do this, the study pays close attention to a well known gravity model of trade, which is widely used in the previous empirical works. Substantially, Tinbergen was first person, who introduced the gravity model into international trade in 1962 (Tinbergen 1962). This model has been used very extensively to cover all areas of international trade. Therefore, this study fulfills to examine the impact of ICT on total trade in services and ICT service exports by applying the gravity model. In connection with recent research trends, the review on the impact of ICT on economic activities was classified into three categories which are: international trade, trade in services and other areas of studies.

First of all, the study reviews the previous studies, which are generally focused on examining the impact of ICT on the macroeconomic variables. First, (Vemuri and Siddiqi 2009) evaluate the influence of commercialization of the internet on international trade by utilizing the gravity model for 64 countries over 1985~2005. The study argues that ICT infrastructure and internet penetration have a positive and significant impact on bilateral trade and economic development for trading partners. (Ahmad et al., 2011) also make an attempt to examine the impact of ICT infrastructure on trade for Malaysia with 36 trading partners. The empirical results indicate that the infrastructure of ICT plays a pivotal role in promoting Malaysian exports. (Liu and Nath 2013) also test the impacts of ICT on international trade for 40 emerging countries from 1995 to 2010 with respect to panel data. The results show that ICT has a strong positive impact on exports and imports in emerging countries. In addition, (Yushkova 2014) investigates the relationship between the internet and exports of goods for 40 countries. The study reports that the internet has a strong and positive influence on exports among them. (Wang and Li 2017) analyze the impact of ICT development index on trade. The study insists that the development of the internet has a positive and significant impact on improving countrys' exports. Furthermore, (Alderete 2017) pays attention to the role of ICT on socioeconomic development with respect to ICT access, ICT use and ICT skills for 163 countries. The results asserts that both ICT use and ICT skills enhance the effect of ICT access on socioeconomic development. (Ozcan 2018) also applies the gravity model of trade to examine the impacts of ICT on international trade between Turkey and its trading partners, regarding 34 countries for export goods and 35 countries for import goods from 2000 to 2014. The empirical result claims that ICT has a positive and significant effect on Turkey's export and import respectively. Recently, (Solomon and Van Klyton 2020) test the effect of digital technology usage on economic growth by applying Generalized Methods of Moments (GMM) methods for 39 African countries. The study results insist that the individual usage category has a strong and positive impact on economic growth. More recently, (Ramasubramnian et al 2021) discuss the impact of the development of ICT on sustainable economic growth, energy consumption and productivity by applying data for 39 countries. As a result, the study yields conflicting results between high-income countries and low-income countries. It turns out that the development of ICT has a positive relationship with GDP per capita in high-income countries.

The following review will be related to the previous papers, which examines the impact of ICT on trade in services. First, (Freund and Weinhold 2002) test the impact of the internet on trade in 14 service industries from 1995 to 1999. The results indicate that the internet has a positive and significant effect on the growth of trade in services. (Clarke and Wallsten 2006) examine the impact of internet penetration on service exports for developed and developing countries by using OLS and 2SLS methods respectively. The result argues that the penetration of internet has a strong positive impact on service exports from

the developing countries to the developed countries, but it did not work in the opposite direction. (Salmani et al., 2013) examines the impact of the internet on international services trade in the organization of the Isamic Cooperation (OIC) from 1990 to 2011 by using unbalanced panel data. They find that the internet has a positive and significant effect on the trade in services among the OIC. The empirical results also show that both GDP and population have a positive impact on trade in services. (Choi 2010) also evaluates the impact of internet access and internet usage on total trade in services, services export and import respectively for 151 countries over 1990~2006. The test result indicates that the internet has a positive and statistically significant impact on trade in services. However, the estimation results indicate that the impact of internet on service exports and imports turns out to be bigger than that of total trade in services. (Nath and Liu 2017) investigate the effect of the development of ICT on total trade, exports and imports of ten dis-aggregated service items for 49 countries over 2000~2013. The empirical results indicate that ICT development has a positive and statistically significant effect on services trade, exports and imports as well. The study also suggests that ICT use plays a more crucial role in enhancing trade in services than that of ICT access and ICT skills do in some service items. (Yousefi 2018) considers the relationship between the internet and services exports and imports for 63 developed and developing countries from 2000 to 2014. The study suggests that the result of this study is consistent with the previous studies in that internet users have a positive and statistically significant effect on service exports and imports. (Tay 2018) examines the impact of ICT on bilateral trade in services between the US and 34 trading countries from 2000 to 2013. He shows that ICT of fixed broadband and fixed telephone have a significant effect on three variation of services trade, service exports and imports, while mobile-cellular phone does not.

The final review on previous studies covers more a broad area, excluding trade. First, (Bankole et al. 2011) test the impact of ICT investment on human development for 51 countries from 1993 to 2003. The empirical work indicates that ICT investment in hardware, software, internal spending and telecommunication draw different results on the components of human development and on high-income, middle-income and low-income countries as well. In addition, (Balouza 2019) investigates the effect of ICT on human development for 6 countries of the Gulf Cooperation Council (GCC). The results reports that the impact of the implementation of ICT on human development is not consistent because there are discrepancies among them in terms of in technology and qualified human capital. Additionally, (Rajesh 2020) examines the impact of ICT service exports in revealed comparative advantage of India from 2005 to 2018. The study results suggest that there is a very strong comparative advantage of ICT services in terms of production and exports in India. In addition, (Haini 2021) analyzes the impact of ICT and human capital on carbon emissions (CO_2) in the ASEAN countries from 1995 to 2019 by applying panel data. He finds that the development of ICT reduces carbon emission, whereas human capital increases carbon emissions. Therefore, he insists that ASEAN policymakers should develop ICT infrastructure to reduce the amount of carbon emissions in ASEAN countries. Further, (Karaman Aksentijević et al., 2021) study the impact of ICT on human development for 130 countries from 2007 to 2019 based on dynamic panel data framework by applying Generalized Method of Moments (GMM). They find that ICT plays a positive role in enhancing human development in lower-income countries but it does not work in high and middle-income countries. Lastly, (Abeliansky, et al 2021) identify the impact of ICT's quality on the extensive and intensive margin of trade for 150 countries from 1995 to 2014. The study results indicate that ICTs quality is a very crucial extensive margin of trade and provides much more stronger evidence for developing countries with respect to quality.

Based on the theoretical foundation through many previous studies as noted above, the study attempt to establish a proper model and determine the impact of ICT on trade in services and ICT service exports respectively by employing the gravity model of trade. Therefore, the purpose of this study is to identify

the main determinants of services trade in the U.S. On this basis, the study anticipates that the development of ICT will eventually promote trade in services and ICT service exports in the U.S.

3 The Empirical Model and Data

The study estimated the impact of ICT access and ICT use on the trade in services and ICT service exports in the U.S. from 1990 to 2021. Further, the study includes frequently used variables in a gravity model, such as; GDP per capita, population, trade openness and broad money. The gravity model of trade indicates that relative economic size increases trade between countries, while greater distance decreases trade among them. Up to this day, the gravity model has been one of the most widely used model in analyzing international trade flows. In this light, a modified version of gravity model for this study includes the following variables: GDP per capita, population, trade openness and broad money. This study also regarded ICT access and ICT use as important variables in evaluating the impact of ICT on total trade in services and ICT services exports in the U.S.

From this perspective, a modified gravity model of the trade in services in the U.S. is as follows. First, the dependent variables are classified into two categories, such as total trade in services and ICT service exports in the United States. Meanwhile, the independent variables include ICT access and ICT use, GDP per capita, population, trade openness and broad money. Above all, the study tries to reflect the impact of the development of ICT on total trade in services regarding ICT access and ICT use. Here, ICT access consists of FTS and MCS. FTS indicates fixed-telephone subscriptions and MCS denotes mobile-cellular subscriptions per 100 people each. On the other hand, ICT use contains IUI and FBS. IUI, which stands for an individual using the internet, is connoted the percentage of population and FBS is the fixed-broadband subscriptions per 100 people. Therefore, the study anticipates that the development of ICT will play a very positive role in increasing trade in services in U.S. The model also includes the following four variables as explanatory variables. First, GDP per capita is a measure of US's economic output, where GDP divided by its total population. POP implies total population of the U.S. In addition, both trade openness and broad money can be calculated from the percentage of GDP individually. By incorporating explanatory variables of ICT access and ICT use with gravity variables together in the model, the study anticipates that all those variables will play a significant role in promoting the trade in services and ICT service exports in the U.S. Therefore, the study essentially establishes the following basic model of trade in services in the U.S..

$$\text{Trade in Services} = f(\text{ICT access, ICT use, PCGDP, POP, TO, BM,}) \quad (1)$$

In order to clearly identify the effect of the development of ICT and gravity model variables on trade in services and ICT service exports in the U.S., the study constructs the following equation form:

$$TS_{it} = \beta' ICT_{it} + \theta' Z_{it} + \varepsilon_{it} \quad (2)$$

Here, TS_{it} indicates the independent variables, which stand for the logarithm of trade in services and ICT service exports individually for the U.S. in year t. ICT_{it} are the vector of ICT access and ICT use variables. In addition, Z_{it} is the vector of control variables, such as: GDP per capita, POP, TO and BM. Finally, ε_{it} indicates the error terms. This is also known as the residual term or disturbance term. An error term appears in a statistical model to indicate the uncertainty in the model. In order to obtain a log-log linear function for the proposed models, the study converts a raw data into logarithms for both the dependent and explanatory variables:

$$\log(TS_{it}) = \beta_0 + \beta_1 \log FTS_{it} + \beta_2 \log MCS_{it} + \beta_3 \log IUI_{it} + \beta_4 \log FBS_{it} + \beta_5 \log PCGDP_{it} + \beta_6 \log POP_{it} + \beta_7 \log TO_{it} + \beta_8 \log BM_{it} + \varepsilon_{it} \quad (3)$$

Where, subscript *i* indicates the U.S. and subscript *t* denotes the time period with t = 1, 2,..., T. The dependent variable *TS*, refers to the trade in services and ICT service exports for the US in year t. Based on this proposed model, the main purpose of this study is to obviously determine the impact of ICT access and ICT use on the trade in services and ICT service exports in the United States.

First of all, β_0 denotes the intercept of the regression in the model. In addition, β_i is the coefficient for the explanatory variables of ICT access and ICT use, which will have a positive or negative effect on trade in services and ICT service exports. As mentioned earlier, ICT access and ICT use contain four variables, such as *FTS* and *MCS* variables for ICT access and ICT use includes *IUI* and *FBS* variables. In this study, those variables are all expected to stimulate the trade in services in the U.S. Aside from this, variables of the gravity model are also considered to be beneficial to trade in service. Therefore, most coefficients of those ICT variables are likely to have a positive signs. For the variables of the gravity model, *PCGDP* presents the economy mass or size and it is expected to enhance trade in service and ICT service exports. Thus, β_5, the coefficient of PCGDP, is expected to have a positive sign. *TO* stands for trade openness, is also supposed to improve trade in services and ICT service exports. It means that as the degree of trade openness expands further, trade in services and ICT service exports will be enlarged in the U.S. *POP* denotes the population of the US and is also likely to increase trade in services and ICT service exports. Therefore, the coefficient of POP will have a positive sign. Moreover, *BM* indicates broad money, which is a percentage of GDP, that is (M_2/GDP). Broad money is the most flexible method for measuring an country's money supply, which is accounts for cash and other assets. Therefore, broad money can be easily converted into cash to buy goods and services. Hence, the more broad money, the more trade in services is likely to be in the US. Consequently, β_8 is expected to have a positive sign in this case. Finally, ε_{it} denotes the error term. In conclusion, most variables are expected to have a positive effect on trade in services in this study.

The study collects data to support the proposed model of the trade in services and ICT service exports in the U.S. Most data of trade in services and ICT service exports, ICT access and ICT use are collected from the World Bank (WB)'s World Development Indicators (WDI), which was updated on December 22, 2022. Based on this procedure, the study applies annual data of services trade and ICT service exports. In addition, the data of GDP per capita, trade openness, population and broad money are all obtained from World Bank as well. The unfortunate part of this study is that the impact of ICT access and ICT use on trade in services and ICT service exports are not fully analyzed due to data limitation in ICT use. This is because the data for ICT use of IUI and FBS are not available before 1990. Therefore, it is regrettable that more abundant data could not be used in this study. With all this in mind, to get over this problem and accomplish the given study objective, the study needs more sufficient data in the future. Lastly, Table 1 shows the expected signs and data sources of the important variables used in this study.

Table 1: Expected Signs and Data Sources

Explanatory Variables	Expected Signs	Data Sources
FTS	+	World Bank, WDI (World Development Indicators), 2022
MCS	+	World Bank, WDI (World Development Indicators), 2022
IUI	+	World Bank, WDI (World Development Indicators), 2022
FBS	+	World Bank, WDI (World Development Indicators), 2022
PCGDP	+	World Bank, WDI (World Development Indicators), 2022
POP	+	World Bank, WDI (World Development Indicators), 2022
TO	+	World Bank, WDI (World Development Indicators), 2022
BM	+	World Bank, WDI (World Development Indicators), 2022

Source: author’s calculation.

4 Empirical Results and Discussion

This study incorporates the gravity model of trade to evaluate the impact of ICT on trade in services and ICT services exports in the U.S. by using an annual time-series data from 1990 to 2021. In order to analyze this model, the study regards ICT access and ICT use as significant variables reflecting the recent surge in the number of internet user in the U.S. Therefore, the empirical model utilizes the modified gravity model to do this by taking a log-log linear equation form. First of all, in this section, the paper reports the summary of descriptive statistics of the variables used in this study in Table 2. Furthermore, the study presents the results of the unit root test for variables in Table 3 and Table 4 respectively. This is to judge the stability of the variables. In addition, the results of the empirical model of this study is presented in Table 5. First, Table 2 provides the summary statistics of the major variables regarding the two dependent variables and eight explanatory variables. Table 2 indicates that there are wide variations in the mean value among variables. In addition, there are substantial differences in variability between dependent variables and independent variables as reflected in the standard deviations as well.

Table 2: Summary Statistics of the Variables

Variables	Indicator Name	Unit	Mean.	St. Dev.
Log TS	Trade in Services	(% of GDP)	1.7284	0.1764
Log EXP	ICT Service Export	(% of Service Export)	1.4361	0.3158
Log FTS	Fixed Telephone Subscriptions	(per 100 people)	3.9119	0.2594
Log MCS	Mobile Celluar Subscriptions	(per 100 people)	3.7237	1.1617
Log IUI	Individual Using the Internet	(% of population)	3.4974	1.4028
Log FBS	Fixed Broadband Subscriptions	(per 100 people)	1.6140	2.2036
Log PCGDP	GDP per capita	(Constant 2015 US $)	10.8229	0.1391
Log POP	Population	(Total)	5.5685	0.0866
Log TO	Trade Openness	Trade (% of GDP)	3.2131	0.1350
Log BM	Broad Money	(% of GDP)	4.3537	0.1733

Source: author's calculation.

First of all, in order to build an appropriate model, regarding the stability problem of time-series data, the study needs to conduct further analysis. The popular option for this procedure is to run an Augmented Dickey-Fuller (ADF) test. Therefore, the study executes ADF unit root test to check whether time-series data of this study has that problem or not. The first step in transforming a time-series is to see if the data has a unit root problem. An ideal situation for time-series data is that it should be stationary. That implies that a shift in time does not cause a change in the shape of the distribution. On the other hand, the existence of a unit root process creates an instability problem for the data. Regarding the stability problem of time-series data, (Kang et al., 2014) explains that "the underlying assumption in econometric models is that the present time-series is stationary. If this assumption is not correct, then the whole analysis will be incredible and the regression results will be spurious". Because of this problem, the study performs unit root test first.

Table 3 and Table 4 show the results of the unit root test with respect to constant and constant & linear trend at level and first difference respectively by using automatic lag length selection method in terms of Schwarz Information Criterion (SIC). SIC is a criterion for model selection among a finite set

of models. In general, models with lower SIC are more preferred. Table 3 shows that the critical values of all variables are smaller than that of ADF values at 1 percent and 5 percent significant level individually. Consequently, the results of ADF unit root test indicates that most variables used in the study have the unit root problem and are not stable variables in this case.

Table 3: Unit Root Test Results in the Level

Variables	Level							
	With Constant				With Constant and Linear Trend			
	ADF	1%	5%	P-value	ADF	1%	5%	P-value
Log TS	-1.3564	-3.6616	-2.9604	0.5904	-0.2691	-4.2846	-3.5629	0.9881
Log EXP	-0.4943	-3.6616	-2.9604	0.8793	-2.3844	-4.2846	-3.5629	0.3799
Log FTS	-0.1219	-3.6793	-2.9677	0.9378	-2.2515	-4.2967	-3.5684	0.4459
Log MCS	-20.247	3.6616	-2.9604	0.0001	-7.3936	-4.2846	-3.5629	0.0000
Log IUI	-7.8690	-3.6616	-2.9604	0.0000	-3.3889	-4.2846	-3.5629	0.0723
Log FBS	-1.2796	-3.6702	-2.9639	0.6257	-1.1081	-4.2967	-3.5684	0.9109
Log PCGDP	-0.9469	-3.6616	-2.9604	0.7593	-1.5427	-4.2846	-3.5629	0.7922
Log POP	-3.8535	-3.6892	-2.9718	0.0067	-0.8324	-4.3239	-3.5806	0.9466
Log TO	-1.9306	-3.6616	-2.9604	0.3146	-1.8304	-4.2846	-3.5629	0.6655
Log BM	-1.4559	-3.6616	-2.9604	0.9988	-3.2949	-4.2967	-3.5684	0.0864

Source: author's calculation.

Due to this result, the study needs to conduct another unit root test by using the first order differential model, which is related to the series of changes from the first period to the next one. Therefore, a difference stationary time-series can be integrated and the order of integration is denoted I(d). In here, d stands for the order of integration. If we have in our time-series data, a series of successive differences, d, can transform the time-series data into one with stationary. Finally, I(d) indicates the minimum number of differences required to get a stationary time-series data. In general, the order of integration is either I(0) or I(1). For instance, a time-series can be integrated of order *d,* if,

$$(1 - L)^{d} X_t$$

is a stationary process, where L is the lag operator and 1-L indicates the first difference, that is

$$(1 - L)X_t = X_t - X_{t-1} = \Delta X$$

In other words, a process is integrated to order d if taking repeated differences d times to achieve a stationary process. In particular, if a series is integrated of order zero, then

$$(1 - L)^{0} X_t = X_t \text{ is stationary}$$

Therefore, an I(0) process is a non-integrated process, which means it is a stationary process.

Table 4 shows the results of the unit root test in the first difference method. As a result of the unit root test of all variables, the statistics indicates that most variables turn out to be integrated order one at 1 percent significant level with constant and with constant & trend except MCS and IUI variables. By comparing the ADF values for critical value at 1 percent and 5 percent level of significant, the results denote that most of variables are integrated order one, that is I(1) and finally most variables can be transformed into stationary process in the end.

Table 4: Unit Root Test Results in the First Differences

Variables	1st Difference								Lag
	Constant				Trend and Constant				
	ADF	1%	5%	P-value	ADF	1%	5%	P-value	
Log TS	-4.7337	-3.6702	-2.9639	0.0007	-4.8847	-4.2967	-3.5683	0.0024	I(1)
Log EXP	-6.0223	-3.6702	-2.9639	0.0000	-6.1305	-4.2967	-3.5683	0.0001	I(1)
Log FTS	-0.9918	-3.6892	-2.9718	0.7421	-4.3512	-4.2967	-3.5683	0.0088	I(1)
Log MCS	-5.5235	-3.7241	-2.9862	0.0001	-1.4312	-4.3743	-3.6032	0.8258	I(0)
Log IUI	-1.3877	-3.6793	-2.9677	0.5746	-1.7997	-4.3098	-3.5742	0.6787	I(0)
Log FBS	-3.0197	-3.6702	-2.9639	0.0444	4.5007	-4.3943	-3.6122	0.0080	I(1)
Log PCGDP	5.1915	-3.6702	-2.9639	0.0002	-5.3713	-4.2967	-3.5683	0.0007	I(1)
Log POP	-0.7859	-3.6793	-2.9677	0.8082	-4.5120	-4.3239	-3.5806	0.0065	I(1)
Log TO	5.9722	-3.6702	-2.9639	0.0000	-6.1806	-4.2967	-3.5683	0.0001	I(1)
Log BM	-7.7694	-3.6793	-2.9678	0.0000	-7.5624	-4.3098	-3.5742	0.0000	I(1)

Source: author's calculation.

Finally, Table 5 presents the estimation results for trade in services and ICT service exports respectively. One important fact in regression analysis is that there are three marks of ***, ** and *, which denote statistical significance at the 1 percent, 5 percent and 10 percent significance level individually. In addition, t-statistics are reported in parentheses. First of all, the values of R squared, (R^2), are shown in Table 5. In here, R^2 is a statistical calculation that measure the degree of interrelation and dependence between two variables. Therefore it determines the relationship of independent variables with a dependent variable to predict its behavior. To put it more simply, the R^2 formula measures the degree in which the independent variables explain the dependent variable. Consequently, most of R^2 values in this study turn out to be in the range of 0.923 to 0.955. This implies that the behavior of the dependent variable is highly explained by the behavior of the independent variables. On the other hand, one remarkably disappointing outcome is that the empirical results are not perfectly consistent with what the study expected. The empirical results indicate that the coefficients of some variables have a negative effect on trade in services and ICT service exports individually contrary to its expectation.

In Table 5, the study finds that not only some coefficient values of ICT access and ICT use, but also some variables of the gravity model have an unexpected negative influence on trade in services and ICT service exports. First of all, the study identifies the role of ICT access and ICT use in terms of FTS, MCS, IUI and FBS variables. The empirical result shows that FTS has a positive effect on trade in services and is statistically significant at 10 percent significant level. This implies that an increase in fixed telephone subscriptions enhance the trade in services in the U.S. However, the coefficients of MCS has a negative effect on service trade, but they are not statistically significant at any significant level except when the variables of ICT use is excluded from the model. This implies that an increase in mobile cellular subscription does not promote trade in services in the U.S.

Table 5: Estimation Results for Total Service Trade and ICT Export

Explanatory Variables	Dependent Variables						
	LogTS(1)	LogTS(2)	LogTS(3)	Log TS(4)	LogICTEXP(5)	LogICTEXP(6)	LogICTEXP(7)
Log FTS	0.559* (2.053)	0.534* (1.828)	0.346* (1.698)	-	1.519 *** (2.941)	1.578** (2.712)	1.213 * (1.962)
Log MCS	-0.221 (-1.608)	-0.091 (-0.685)	-0.221** (-2.510)	-	-0.828 *** (-3.177)	-1.139*** (-4.310)	-1.438*** (-5.564)
Log IUI	-0.069 (-0.851)	-0.111 (-1.300)	-	-0.068 *** (-3.954)	0.199 * (1.588)	0.298* (1.761)	0.527*** (3.392)
Log FBS	-0.006 (-0.250)	-0.025 (-1.038)	-	0.006 (0.470)	0.002 (0.041)	0.046 (0.989)	0.089* (1.841)
Log PCGDP	-0.921 * (-2.185)	-0.733 (-1.653)	-1.099*** (-3.321)	-0.883** (-2.480)	0.902 (1.128)	0.449 (0.509)	-0.046 (-0.049)
Log POP	7.952*** (3.891)	6.433*** (3.119)	5.839*** (3.395)	3.365 *** (5.568)	12.44*** (3.210)	16.08 *** (3.917)	14.72*** (3.294)
Log TO	0.835 *** (7.249)	0.845*** (6.833)	0.933*** (9.228)	0.833*** (7.988)	-0.586 ** (-2.684)	-0.609** (-2.478)	-
Log BM	-0.311* (-2.168)	-	-	-0.226 (-1.643)	0.745** (2.742)	-	-
Constant	-35.95** (-2.866)	-30.95** (-2.337)	-23.13** (-2.464)	-9.308 *** (-3.569)	-83.99*** (-3.531)	-95.969*** (-3.639)	-83.131** (-2.928)
Adj. R^2	0.955	0.948	0.948	0.948	0.949	0.936	0.923

Source: author's calculation.

On the other hand, in the case of ICT use, the results show that they have negative signs. In case of IUI and FBS, the coefficients of these variables have a negative effect on trade in services and are not statistically significant. In addition, the coefficients of PCGDP, POP, TO and BM for trade in services are not fully supportive of the inquiry of this study. The coefficients of POP and TO have a strong level of association with trade in services as expected and are statistically significant at 1 percent significant level. However, both coefficients of PCGDP and BM have a negative effect on service trade and are statistically significant at 1 percent and 10 percent significant level respectively.

Secondly, the study also attempts to examine the role ICT access and ICT use mainly focused on ICT service exports. Basically, it was found that coefficients of ICT access, ICT use and some variables of gravity model have a positive effect on ICT service exports as the study expected except MCS and TO variables. First, in case of ICT access for ICT service exports, it turns out that the coefficient of FTS has a positive effect and is statistically significant at 1 percent significant level. This implies that an increase in fixed telephone subscription promotes ICT service exports. In addition, the coefficient of MCS still has a negative effect on ICT service exports and is statistically significant at 1 percent significant level. This indicates that an increase of mobile cellular subscriptions does not increase ICT service exports in

the U.S. In case of ICT use, the results are totally different compared to the case of trade in services. First of all, the coefficient of IUI has a positive effect and is statistically significant at 1 and 10 percent significant level. It means that an increase in individual using the internet boosts ICT service exports. The coefficient of FBS also has a positive effect on ICT service exports, but it is only statistically significant at 1 percent significant level in the model (7). The coefficient of PCGDP has a positive effect contrary to the case of trade in services, but it turns out that it is not statistically significant. The coefficient of POP has a positive effect and is statistically significant at 1 percent significant level. It draws the same results as the previous case of the trade in services. However, the coefficient of TO has a negative effect on ICT service exports, which is completely different from the previous result. This implies that an increase in trade openness does not encourage ICT service exports in the U.S.

Summarizing the effect of ICT access and ICT use both in trade in services and ICT service exports, the result of this study does not fully support its expectation. In this study, preferentially the paper pays attention to two important findings. First of all, an interesting result is that only FTS has a positive effect on service trade and ICT service exports, while only MCS has a negative effect on both trade in services and ICT service exports. Second, more interestingly, ICT use of IUI and FBS turn out to have a very opposite effect on both total trade in services and ICT service exports. In this connection, the coefficients of IUI and FBS for trade in services has a negative effect, but it turns out that the coefficients of IUI and FBS have a positive effect for ICT service exports. Therefore, these results imply that ICT use has been more useful and helpful than that of ICT access for promoting ICT service exports in U.S.

5 Concluding Remarks

Many previous research papers have attempted to identify the impact of ICT on international trade. Recently, more and more studies have been interested in trade in services regarding the development of ICT. The COVID-19 pandemic has greatly affected the services sectors in international trade since its outbreak. Therefore, it is precisely true that the increased use of online services during the COVID-19 period has accentuated technology related to ICT. By promoting digitalization, it seems that the outbreak of COVID-19 has stimulated significant trade in services and even ICT services trade globally. The U.S. is one of the countries, where ICT has been developed rapidly compared to any other country in the world. This reflects the development of ICT stimulate trade in services between the U.S. and its trading partners. To determine the influence of ICT on trade in services in the U.S., the study measures ICT by four dimensions, including FTS and MCS for ICT access and IUI and FBS for ICT use individually. Finally, this study individually examines the impacts of ICT access and ICT use on trade in services and ICT service exports in the U.S.

To meet this objective, the study employs the modified gravity model of trade and finds that the four dimensions of ICT access and ICT use have slightly different impacts on the trade in services and ICT service exports in the U.S. There are two interesting results of this study. First of all, FTS has a positive effect on trade in services and ICT services exports, whereas MCS does not have the same effect on trade in services and ICT service exports. More interestingly, the coefficients of IUI and FBS have a opposite effect on trade in services and ICT services exports. First, the coefficients of IUI and FBS have negative signs for trade in services, while they have a strong positive influences on ICT service exports. In addition, the study presents that there are no robust results regarding the variables of GDP per capita, trade openness and broad money for trade in services and ICT service exports respectively except for POP. Finally, this empirical results imply that ICT use has been more productive in enhancing ICT services exports than that of ICT access. With new technologies and more digital work environment than ever, urgent adaptation to the changes that the COVID-19 pandemic has made is necessitated in the

future. Therefore, adopting trade facilitation measures to smooth the export process in the U.S. will be the most important thing in order to enhance the role of ICT access in the digital economy.

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