

# The Impact of Information and Communication Technology on Bilateral Trade in Goods

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**Abstract**—This paper investigates the impact of Information and Communication Technology (ICT) on bilateral trade in goods. Empirical analysis is performed on the United States and 34 partnering countries from 2000 to 2013. Our econometric model fits the data well, explaining 52% of the variation in trade flows for goods trade, 53.2% of the variation in trade flows for goods export and 48% of the variation in trade flows for goods import. For every 10% increase in fixed broadband Internet subscribers per 100 people increases, goods trade by 7.9% and for every 5% increase in fixed broadband Internet subscribers per 100 people, goods export increases by 11%. For every 1% increase in fixed telephone line penetration per 100 people, goods trade increases by 26.3%, goods export increases by 24.4% and goods import increases by 24.8%. For every 1% increase in mobile-cellular telephone subscriptions, goods trade decreases by 29.6% and goods export decreases by 27.1%, whilst for every 0.01% increase in mobile-cellular telephone subscriptions, goods import decreases by 34.3%. For every 1% increase in the percentage of population who used the Internet from any location in the last 12 months Internet, goods trade increases by 32.5%, goods export increases by 38.9%, goods import increases by 33%. All our trade determinants as well as our ICT variables have significances on goods exports for the US. We can also draw from our study that the US relies more rather heavily on ICT for its goods export compared to goods import.

**Keywords**—Bilateral trade, goods trade, information and communication technologies, Internet.

## I. INTRODUCTION

ADVANCEMENTS in ICT over the years have brought basic telecommunications services within the reach of many. One of the most dramatic changes in the revolution of ICT took place in the mid-late 1990s and early 2000s. In 1993, only 0.3% of the world population had Internet access. This percentage has been steadily rising since then, and by 2016, 46.1% of the world population has Internet access. The first billion of the world's population was reached in 2005. The second billion of the world's population was reached in 2010. The third billion of the world's population was reached in 2014 [1]. Fig. 1 illustrates the world population that has Internet access from 1993 to 2016.

The US has the third largest share of world Internet users in 2016, with China holding the largest share. However, when we look at percentage of population that has penetration to the Internet; the US surpasses China by over 30%, with the US holding 88.5% and China holding 52.2%. According to Meltzer [2], the US has been, and remains, the focal point of the Internet and the burgeoning area of Internet policy.

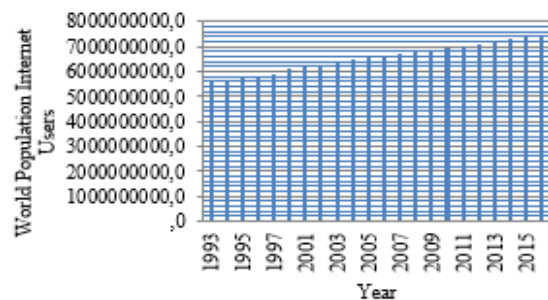


Fig. 1 Percentage of world population with Internet access 1993-2016 [1]

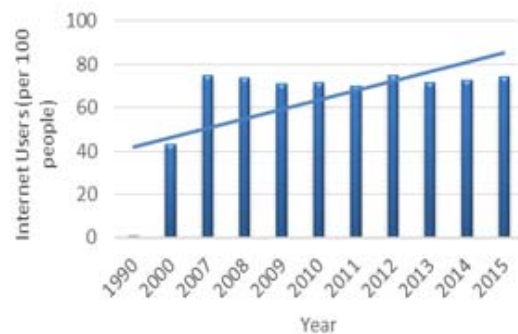


Fig. 2 US Internet Users, 1990-2015 [3], [4]

The US also captures the most value from the Internet, receiving more than 30% of global Internet revenues. Further insight into US Internet users (per 100 people) from 1990 to 2015 is illustrated in Fig. 2 [3], [4]. The highest growth of US Internet users (per 100 people) was experienced between 1990 and 2000 at a 5390% growth rate. When we compare 2015 and 2000, we also see high growth rates at a 2700% growth rate. Overall, we can see that number of Internet users has been on the rise from 1990 to 2015.

Fig. 3 shows US Internet users and goods trade from 1997 to 2013. When we compare data from 1997 to 2003, we find that Internet usage increased by 2146%, and goods trade increased by 222%. When we compare 2003 and 2013, we also see an increase of 243% for Internet users and, an increase of 122% for goods trade [1], [5]. Based on the aforementioned phenomenon, this study intends to investigate if growth in Internet over the years has indeed impacted goods trade, or just a matter of mere coincidence?

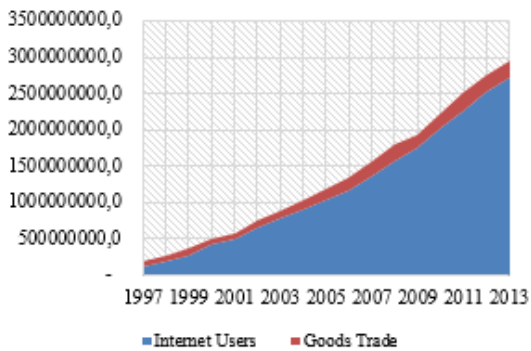


Fig. 3. US Internet Users & Goods Trade, 1995 to 2013 [1], [5]

The Internet has become one of the most important platforms for individuals, organizations as well as trade between nations, driving commerce, thereby international trade. ICT access and its reducing costs over the years have impacted how enterprises and consumers discover each other, how goods and services may be delivered, and how enterprises may go beyond traditional trade zones. Such advancements have empowered consumers with easier and greater access to information and created many varieties of innovative and user-driven business models. In addition, ICT has broken through and cut across countries, trade zones, and regulatory boundaries never possible before.

Since the inauguration of the Internet and the liberalization of the telecommunications industry beginning the first half of 1980s, there is unquestionable impact of ICT on trade. New communication possibilities made possible through the Internet are creating rapidly the conditions that could allow trade to flourish in the future [6]. To do this, we conduct a literature review based on several avenues on how the ICT and/or the Internet impacts goods trade. The first avenue is how ICT or the Internet reduces fixed costs of finding markets and buyers, and thus, increase exports – for example in a study by Daly & Miller [7]. The second avenue is how enterprises with Internet connections export more as a share of their total sales than enterprises without connections – for example in a study by Clarke [8]. The third avenue is how growth of Internet use is significantly correlated with the growth of trade – for example in [9]. The fourth avenue is how exports from poor countries to rich countries are positively related with the level of Internet usage – for example in [10]. The fifth avenue is how ICT infrastructure and the availability of the Internet for commercial transactions positively and significantly affect the volume of international trade – for example in [11].

In this study, we attempt to improve on existing studies in several ways. First, we use recent and more direct forms of measurements of ICT compared to existing studies [7]-[11]. Second, we investigate the impact of ICT on bilateral trade in goods using three variations: (a) sum of goods exports and goods imports, (b) export in goods, and (c) import in goods. Third, we compare the impact of the three variations of trade in goods: (a) sum of goods exports and goods imports, (b) goods export, and (c) goods import.

The rest of this paper is arranged as follows: Section I

reviews related literature. Section II discusses the model, data and measurement issues, Section III presents the empirical results, and the last section concludes.

## II. LITERATURE REVIEW

Upon review of literature, we find literature review based on several avenues on how the ICT and/or the Internet impacts goods trade. Literature on the impact of ICT and/or the Internet on trade in goods includes [7]-[11]. One of the earliest studies that investigate the impact of the Internet on trade in goods is by [7]. Daly & Miller uses a survey of enterprises from a combination of low as well as middle –income countries. The survey results show that half of the enterprises (26/58) use search engines to look for marketing the production information.

A later study by Clarke [8] investigates whether Internet use affects trade in goods using data from 20 low- and middle-income countries in Eastern Europe and Central Asia. They find that enterprises with Internet connections export more as a share of their total sales than enterprises without connections. Clarke [8] uses data from the World Business Environmental Survey. The period of their study is in mid-1999. Clarke [8] finds that Internet access affects industrial and service enterprises to similar degrees.

Freund & Weinhold [9] study the impact of the Internet on trade in goods between 1997 and 1999. Freund & Weinhold [9] uses the number of web hosts in each country and find that that trade growth is lower for more distant countries and lagged growth of Internet use is significantly correlated to growth of trade. They find evidence that the Internet stimulates trade, and that for every 10% increase in the growth of web hosts in a country, export grows by 0.2%.

Clarke & Wallsten [10] use data from 2001 to study the link between Internet penetration and exports from a country. They employ per capita Internet users as a measure of Internet penetration. In their formulation, exports from a country depend on the Internet penetration of that country alone, and not on that of its importing partners. To control for endogeneity, they use a country's regulation of data services as an instrument for Internet usage. They find that exports from poor countries to rich countries are positively related with the level of Internet usage.

Vemuri & Siddiqi [11] test the proposition that ICT and the Internet have world trade in merchandise. They use of balanced panel data for 64 countries for the years 1985 to 2005. An instrumental variable approach of Hausman & Taylor and other panel data methods are used. The international trade activity is compared before and after commercialization of the Internet. Vemuri & Siddiqi [11] conclude that ICT infrastructure and the availability of Internet for commercial transactions have a positive and significant impact on the volume of international trade.

Upon review of existing literature, we note that the measurements used in existing studies are either not recent or a direct form of measurement that reflects ICT in today's context [7]-[11]. For example, Daly & Miller [7] uses a 1998 survey of enterprises of 15 low- and middle- income countries, using

enterprises using search engines to research market opportunities. The year 1998 was a time when the Internet was still in its inaugural stages, and is not as widely used as today. A study by Clarke [8] investigates whether Internet use affects trade in goods using data from 20 low- and middle- income countries in Eastern Europe and Central Asia, using the World Business Environment Survey (WBES), a cross-sectional survey of industrial and service enterprises conducted in mid-1999 by the World Bank and several other agencies, as their main source of study. At the time of their study, Clarke [8] claimed that there were no other data on investment in information technology (IT) available in the WBES.

Freund & Weinhold [9] uses the number of web hosts in each country. The problem they find at the time of their study is that they did not necessarily find any correlation between a host's domain name and country location, and hosts under the domains they used could be located anywhere. For example, the hosts they used, including edu/org/net/com/int, could have been located anywhere in the world. One of the reasons attributing to this is that their study was conducted at a time when Internet data was still in its inaugural stages, between 1997 and 1999, a time when data was not complete.

Clarke & Wallsten [10] use data from 2001 to study the link between Internet penetration and exports from a country. They employ per capita Internet users as a measure of Internet penetration. Vemuri & Siddiqi [11] uses an estimation model uses data for the years 1985 to 2005. Although the data they use is considered one of the latest, compared to the aforementioned studies, the period of their study covers a period of which the Internet had not existed, that is 1985 to 1995, possibly creating biasness in their results. However, in this study, we attempt to use recent data that covers the surge of Internet usage from 2000 to 2013, a period of time which does is not covered by the study by Vemuri & Siddiqi [11].

### III. DATA, MEASUREMENTS AND MODEL SPECIFICATION

#### A. Data Sources

The data for this study is obtained for the period 2000 to 2013 from several archival sources. Data on ICT is obtained from International Telecommunication Union (ITU, hereinafter). ITU [3] is one of the United Nation's groups with the most reliable source of data for the ICT sector. The ITU develops a composite index to monitor and compare development of ICT across countries called the ICT Development Index (IDI), reflecting the level of ICT readiness, ICT intensity and ICT skills in a respective country. Indicators of ICT readiness include fixed-telephone line penetration, mobile-cellular telephone subscriptions, international Internet bandwidth (bit/s) per Internet user, the percentage of households with a computer and percentage of households with Internet access. ICT intensity indicators include percentage of individuals using the Internet and fixed (wired)-broadband subscribers per 100 inhabitants. For purposes of this study, data provided by ITU [3] from 2000 to 2013 are used to measure the indices for the Internet.

We use, as the dependent variable, the bilateral trade in

goods drawn from the recently published US Bureau on Economic Analysis statistics on international trade in services and goods [12]. The US Bureau on Economic Analysis data comprises of goods trade, goods export, and goods import between the US. A list of the 34 partnering countries is illustrated in Appendix A.

The four measurements for ICT include: (a) fixed broadband Internet subscribers (per 100 people); (b) individuals using the internet access; (c) mobile-cellular telephone subscriptions; and (d) fixed-telephone line penetration (per 100 people). These data are obtained compositely from variable sources including the ITU [3], World Bank [4], US Census Bureau [5], Internet World Stats [13] and US Central Intelligence Agency. Data on the gross domestic product (GDP per capita, in US dollars) and population are obtained from the International Monetary Fund [15]. Information on common language is obtained from the US Central Intelligence Agency [14]. Geographical distance between partnering countries are calculated using the Mapcrow Travel Distance Calculator [16].

#### B. The Model

This article investigates the impact of ICT on bilateral trade in goods. We posit that there is an association between international trade and ICT arguing that ICT can provide new communication channels, and through time, these communication costs decreases, leading to new and improved trading stimuli for trade.

##### 1. More on the Dependent Variable

We investigate the impact of ICT on bilateral trade in goods using three variations: (a) sum of goods exports and goods imports, (b) goods export, and (c) goods import.

Thus, our dependent variable, consists of three variations of trade from/to country,  $u$  to/from country,  $j$ , where,  $t = 2000 \dots 2013$ .

The first variation is the sum of goods export and goods import:

$$\log TG_{u \leftrightarrow j, t} = \sum_{j=1}^{34} (\alpha_{u \leftrightarrow j, t} + \theta_{u \leftrightarrow j, t}) \quad (1)$$

The second variation is goods export:

$$\log GE_{u \leftrightarrow j, t} = \sum_{j=1}^{34} \alpha_{u \leftrightarrow j, t} \quad (2)$$

The third variation is goods import:

$$\log GI_{u \leftrightarrow j, t} = \sum_{j=1}^{34} \theta_{u \leftrightarrow j, t} \quad (3)$$

##### 2. More on the Trade Determinants

It is obvious that ICT, by itself cannot stimulate trade. It is a combination of trade determinants, along with ICT determinants that act as stimuli. In (4), we formulate a model taking into consideration the aforementioned three variations of trade in goods.  $\log X_{u \leftrightarrow j, t}$  is the logarithm used to represent the three variations of trade in goods from/to country,  $u$  to/from country,  $j$  in time,  $t$ .

$$\log X_{u \leftrightarrow j, t} = \beta_0 + \beta_1 \log GDP_{u \leftrightarrow j, t} + \beta_2 \log POP_{u \leftrightarrow j, t} + \beta_3 \log CL_{u \leftrightarrow j} + \beta_4 \log DIST_{u \leftrightarrow j} + \gamma_u + \gamma_j + \gamma_t + v_{u \leftrightarrow j, t} \quad (4)$$

where, the right-hand side of the equation includes four trade determinants: (1) Gross Domestic Product ( $GDP_{ji}$ ), (2) population ( $POP_{ji}$ ), (3) common language ( $CL_{uj}$ ), and (4) distance ( $DIST_{uj}$ ). This three-dimension panel structure of the data represents errors for country,  $u$ , ( $\gamma_u$ ), partnering country,  $j$  ( $\gamma_j$ ), and time-specific effects ( $\gamma_t$ ).  $v_{u \leftrightarrow j, t}$  is a random disturbance variable.

The first trade determinant,  $\log GDP_{ji}$  refers to the GDP per capita of the partnering country,  $j$ , in time,  $t$ . We expect that when the market size of a foreign economy is large that there to be greater potential to trade with that country. Economies with greater income levels are expected to attract more exports. Moreover, the higher level of income in a country, the higher the tendency to adopt different ICT technologies, which in turn, increases the bilateral trade in goods. The coefficient of  $\beta_1$  is expected to be positive.

As for the second trade determinant,  $\log POP_{ji}$  refers to the population of the partnering country,  $j$ , in time,  $t$ . We expect that the higher the population of a country in relation to other countries, the greater the percentage of its population to adopt different ICT and Internet technologies. This in turn, increases trade in goods. The coefficient of  $\beta_2$  is expected to be positive.

The third trade determinant is a dummy variable: common language ( $CL_{uj}$ ). If a partnering country has a common language, either English or Spanish with the US, then a value of 1 is assigned, which otherwise, would assume a value of 0. It is hypothesized that existence of a common language enhances trade. The existence of a common language between the US and a partnering country ( $CL_{uj}$ ) is much likely to lower search and communication costs and hence, boost trade. In order to incorporate such a linguistic tie, we include a dummy variable for the countries which use the same language. Thus, the coefficient of  $\beta_3$  is expected to be positive.

Traditionally, trade models not only use distance to model trade costs in terms of transport costs [17], but also, public infrastructure [18]. Our fourth trade determinant,  $\log DIST_{uj}$ , refers to the log of physical distance of country  $u$  from  $j$ . We expect distance to be a trade barrier. Thus, the coefficient of  $\beta_4$  is expected to be negative since it is a proxy for all possible trade costs.

### 3. More on the ICT Explanatory Variables

Our ICT measurements include fixed telephone ( $FT_{ji}$ ) and fixed broadband subscriptions ( $FB_{ji}$ ), mobile phones subscriptions ( $MB_{ji}$ ) and Internet subscriptions ( $INT_{ji}$ ). We use the definitions for these ICT variables given by ITU [3] as follows. Fixed-telephone line penetration (per 100 people) refers to fixed telephone lines that connect a subscriber's terminal equipment to the public switched telephone network and that have a port on a telephone exchange ( $\log FT_{ji}$ ), whilst fixed broadband Internet subscribers (per 100 people) refers to the number of broadband subscribers with a digital subscriber line, cable modem, or other high-speed technology ( $\log FB_{ji}$ ).

We expect the cost of connecting additional users to the

communication to differ across these variables due to the age of use of each type of ICT technology. For  $FT_{ji}$  and  $FB_{ji}$ , we expect that when long-run marginal costs are above long-run average costs, average costs rise as well. This would consequently decrease this form of ICT adoption in a country. Thus, we expect there to be a positive correlation between both  $FT_{ji}$  and  $FB_{ji}$  and bilateral trade in goods.

Mobile-cellular telephone subscriptions are subscriptions ( $MB_{ji}$ ) to a public mobile telephone service using cellular technology, which provide access to the public switched telephone network. Internet access ( $INT_{ji}$ ) refers to the percentage of population who used the Internet (from any location) in the last 12 months and can be used via a computer, mobile phone, personal digital assistant, games machine, digital TV [3]. For ICT technologies such as the mobile phone ( $MB_{ji}$ ) and the Internet ( $INT_{ji}$ ), we expect that when long-run marginal costs are below long-run average costs, long-run average costs fall as well. Thus, we expect there to be a negative correlation between both mobile phones ( $MB_{ji}$ ) and the Internet ( $INT_{ji}$ ) and bilateral trade in goods.

We formulate (5) to converge trade determinants and ICT variables as:

$$\log X_{u \leftrightarrow j, t} = \beta_0 + \beta_1 \log GDP_{u \leftrightarrow j, t} + \beta_2 \log POP_{u \leftrightarrow j, t} + \beta_3 \log CL_{u \leftrightarrow j} + \beta_4 \log DIST_{u \leftrightarrow j} + \beta_5 \log FB_{u \leftrightarrow j, t} + \beta_6 \log FT_{u \leftrightarrow j, t} + \beta_7 \log MB_{u \leftrightarrow j, t} + \beta_8 \log INT_{u \leftrightarrow j, t} + \gamma_u + \gamma_j + \gamma_t + v_{u \leftrightarrow j, t} \quad (5)$$

Here, the subscript  $u$  represents trade in goods from/to country,  $u$  to/from country,  $j$  in time,  $t$ , where  $t = 2000 \dots 2013$ . This three-dimension panel structure of the data represents errors for country,  $u$ , ( $\gamma_u$ ), partnering country,  $j$  ( $\gamma_j$ ), and time-specific effects ( $\gamma_t$ ).  $v_{u \leftrightarrow j, t}$  is a random disturbance variable.

## IV. EMPIRICAL RESULTS

### A. Ordinary Least Squares for Bilateral Trade in Goods

Coefficients of determination ( $R^2$ ) are 0.52, 0.532 and 0.48 for goods trade, goods export and goods import, respectively. Models (a), (b) and (c) in Table I show Ordinary Least Squares estimation results for goods trade, goods export and goods and goods import, respectively. GDP is positive import in the dataset, respectively.

There are four traditional trade determinants in our econometric model. The coefficients of the first traditional trade determinant: GDP, are 0.382, 0.466 and 0.363 for goods trade, and highly significant at the 0.01% levels for service trade, service export and service import.

The coefficients for our second traditional trade determinant: population, are 0.631, 0.562 and 0.770 for goods trade, goods export and goods import, respectively. It is negative and highly significant at 0.01% for goods trade, goods export and goods import.

The coefficients for our third traditional trade determinant: common language, are 0.363, 0.637 and 0.181 for goods trade, goods export and goods import, respectively. They are both

positive and highly significant at the 0.01%, 0.01%.

TABLE I  
ORDINARY LEAST SQUARES RESULTS FOR BILATERAL TRADE IN GOODS

Pooled Ordinary Least Squares			
Models	(a)	(b)	(c)
Dependent variables	Goods Trade	Goods Export	Goods Import
(a) Log (GDP)	0.382**** (4.304)		0.363**** (3.689)
(b) Log (POP)	0.631**** (4.401)	0.562**** (3.830)	0.770**** (4.843)
(c) Log (CL)	0.363**** (4.299)	0.637**** (7.370)	0.181** (1.930)
(d) Log (DIST)	-0.068**** (-5.324)	-0.065**** (-4.944)	-0.076**** (-5.323)
(e) Log (FB)	0.071* (1.695)	0.092* (2.138)	0.044 (0.958)
(f) Log (FT)	0.303**** (3.431)	0.311**** (3.434)	0.271*** (2.762)
(g) Log (MB)	-0.362**** (-3.983)	-0.335**** (-3.601)	-0.415**** (-4.117)
(h) Log (INT)	0.318**** (2.860)	0.356**** (3.130)	0.342**** (2.770)
Constant	4.154*** (2.721)	1.612 (1.031)	5.172*** (3.054)
Adjusted R <sup>2</sup>	0.520	0.532	0.480
No. of countries	34	34	34
No. of observations	431	431	431
Durbin Watson	2.072	1.932	2.059
F-test	59.276	62.161	50.656
VIF values	(a) 9.696	(a) 9.696	(a) 9.696
	(b) 34.484	(b) 34.383	(b) 34.484
	(c) 1.431	(c) 1.431	(c) 1.431
	(d) 1.133	(d) 1.133	(d) 1.133
	(e) 5.780	(e) 5.780	(e) 5.780
	(f) 9.384	(f) 9.384	(f) 9.384
	(g) 10.635	(g) 10.635	(g) 10.635
	(h) 10.061	(h) 10.061	(h) 10.061

**Notes:** t-statistics are in parentheses. \*significant at 10%, \*\*significant at 5%, \*\*\*significant at 1%, \*\*\*\*significant at 0.01%. The explanatory variables are as follows: (a) GDP = gross domestic product, (b) POP = population, (c) CL = common language, (d) DIST = distance, (e) FB = fixed broadband Internet subscribers (per 100 people), (f) FT = fixed-telephone line penetration (per 100 people), (g) MB = mobile-cellular telephone subscriptions, (h) INT = percentage of population who used the Internet (from any location) in the last 12 months. VIF values are reported for each of the explanatory variables (a) ~ (h)

The coefficients for our fourth traditional trade determinant: distance, are -0.068, -0.065 and -0.076 for goods trade, goods export and goods import, respectively. They are all negative and highly significant at the 0.01% levels.

Four coefficients are used to represent ICT and its derivative technologies. They are fixed broadband Internet subscribers per 100 people (FB), fixed telephone line penetration per 100 people (FT), mobile-cellular telephone subscriptions (MB), and the percentage of population who used the Internet from any location in the last 12 months (INT).

The coefficients for fixed broadband are 0.071, 0.092 and 0.044 for goods trade, goods export and goods import, respectively. They are all positive. Goods trade and goods export are significant at the 10% levels, whereas goods import is insignificant.

The coefficients for fixed telephone line penetration per 100 people are 0.303, 0.311 and 0.271 for goods trade, goods export and goods import, respectively. They are all positive. goods trade and goods export are significant at the 0.01% levels, whereas goods import is significant at the 1% level.

The coefficients for mobile-cellular telephone subscriptions are -0.362, -0.335 and -0.415 for goods trade, goods export and goods import, respectively. They are all insignificant and negative at the 0.01% levels. These results bear similar results to service trade in Sections A and B for our ols as well as fixed effects estimations. Mobile-cellular telephone subscriptions do not have any impact on goods trade in our study.

The coefficients for the internet are 0.318, 0.356 and 0.342 for goods trade, goods export and goods import, respectively. they are all positive and significant at the 1% levels for goods trade, goods export and goods import, unlike our findings for services trade, where we find that the internet has a highly significant impact on service trade and service export, except for service import.

Results of the multicollinearity test may be measured by the value of the variance inflation factor (VIF). According to Kutner, Nachtsheim, Neter, and Li [19], a VIF value higher than 10 indicates multicollinearity. Table I indicates no multicollinearity within the independent variables. A second check for robustness is conducted. Durbin Watson values less than 2.50, showing no signs of multicollinearity for all our models. The use of ols as an estimation methodology may suffer from heterogeneity bias in the gravity model context [20].

Trade between any pair of countries is likely to be influenced by certain unobserved individual effects. if these effects are correlated with the explanatory variables, which an examination of the ols residuals supports, this will lead to pooled ols estimates being biased. Therefore, two more models of estimation are employed in this study: The fixed effects model and the random effects model, as presented in the following sections.

#### A. Fixed Effects Models for Bilateral Trade in Goods

Coefficients of determination ( $r^2$ ) are 0.478, 0.46 and 0.447 for goods trade, goods export and goods import, respectively. Our econometric model fits the data well, explaining 47.8% of the variation in trade flows for goods trade, 46% of the variation in trade flows for goods export and 44.7% of the variation in trade flows for goods import. Models (d), (e) and (f) in Table II present the estimation results for our fixed-effects model for goods trade, goods export and goods import, respectively.

The coefficient values for gdp, are 0.213, 0.189 and 0.248 for goods trade, goods export and goods import, respectively. gdp is positive and significant at the 1% levels for goods trade and goods import, and significant at the 5% level for goods export.

The coefficient values for population are 0.529, 0.422 and 0.675 for goods trade, goods export and goods import, respectively. It is positive and highly significant at 0.01% for goods trade and goods import, and significant at the 1% for goods export.

TABLE II  
FIXED EFFECTS MODEL FOR BILATERAL TRADE IN GOODS

Fixed Effects Estimation Models			
Models	(d)	(e)	(f)
Dependent variables	Goods Trade	Goods Export	Goods Import
(a) Log (GDP)	0.213*** (2.450)	0.189** (2.066)	0.248*** (2.602)
(b) Log (POP)	0.529*** (3.561)	0.422*** (2.820)	0.675*** (4.142)
(c) Log (FB)	0.079* (1.824)	0.110** (2.394)	0.046 (0.966)
(d) Log (FT)	0.263*** (2.868)	0.244*** (2.521)	0.248*** (2.467)
(e) Log (MB)	-0.296*** (-3.151)	-0.271*** (-2.736)	-0.343*** (-3.328)
(f) Log (INT)	0.325*** (2.810)	0.389*** (3.186)	0.330*** (0.295)
Constant	5.213*** (3.389)	4.006*** (2.470)	5.293*** (3.138)
Adjusted R <sup>2</sup>	0.478	0.460	0.447
No. of countries	34	34	34
No. of observations	431	431	431
Durbin Watson	1.991	1.871	2.028
F-test	66.592	62.152	58.906
VIF values	(a) 8.524	(a) 8.524	(a) 8.524
	(b) 34.033	(b) 34.033	(b) 34.033
	(c) 5.752	(c) 5.752	(c) 5.752
	(d) 9.297	(d) 9.297	(d) 9.297
	(e) 10.446	(e) 10.446	(e) 10.446
	(f) 10.010	(f) 10.010	(f) 10.010

Notes: t-statistics are in parentheses, \*significant at 10%, \*\*significant at 5%, \*\*\*significant at 1%, \*\*\*\*significant at 0.01%. The explanatory variables are as follows:

- (a) GDP = gross domestic product
- (b) POP = population
- (c) FB = fixed broadband Internet subscribers (per 100 people)
- (d) FT = fixed-telephone line penetration (per 100 people)
- (e) MB = mobile-cellular telephone subscriptions
- (f) INT = percentage of population who used the Internet (from any location) in the last 12 months.

VIF values are reported for each of the explanatory variables (a) ~ (f)

The coefficient values for fixed broadband are 0.079, 0.110 and 0.046 for goods trade, goods export and goods import, respectively. They are all positive. Goods trade is significant at the 10% level, and goods export is significant at the 5% level, whereas, goods import is insignificant.

The coefficient values for fixed telephone line penetration per 100 people are 0.263, 0.244 and 0.248 for goods trade, goods export and goods import, respectively. They are all significant and positive at the 1% levels.

The coefficient values for mobile-cellular telephone subscriptions are -0.296, -0.271 and -0.343 for goods trade, goods export and goods import, respectively. They are all hold negative coefficients. Goods trade and goods export are significant at the 1% levels, and goods import is significant at the 0.01% level.

The coefficient values for Internet are 0.325, 0.389 and 0.330 for goods trade, goods export and goods import, respectively. They are all positive and significant at 1% for goods trade, goods export and goods import.

Using multicollinearity tests as mentioned in Section A, we find no signs of multicollinearity for all our models.

### B. Comparison of the Results of Three Variations

Table III presents the summary of the estimated coefficients for (1) goods trade, (2) goods export, and (3) goods import.

We find that GDP for goods export has greater impact than both goods trade and goods import. As for population, we find that goods trade has a greater impact than goods import, whilst goods import has a greater impact than goods export. Common language has a greater impact for goods export than both goods trade and goods import. As for distance, we find that goods export has a greater impact than both goods trade and goods import.

As for our ICT variable, fixed broadband, we find that goods export has a greater impact on both goods trade and goods import. Our second ICT variable, fixed telephone lines, goods export has a greater impact for both goods trade and goods import. Our third ICT variable, mobile cellular phones, goods export has a greater impact on both goods trade and goods import. Finally, our fourth ICT variable, the Internet, goods export has a greater impact on both goods trade and goods import.

TABLE III  
COMPARISON OF THE RESULTS OF THREE VARIATIONS OF GOODS TRADE

Dependent Variables	Goods Trade		Goods Export		Goods Import
(a) Log (GDP)	0.382*** (4.304)	<	0.466*** (4.900)	>	0.363*** (3.689)
(b) Log (POP)	0.631*** (4.401)	>	0.562*** (3.830)	<	0.770*** (4.843)
(c) Log (CL)	0.363*** (4.299)	<	0.637*** (7.370)	>	0.181** (1.930)
(d) Log (DIST)	-0.068*** (-5.324)	<	-0.065*** (-4.944)	>	-0.076*** (-5.323)
(e) Log (FB)	0.071* (1.695)	<	0.092* (2.138)	>	0.044 (0.958)
(f) Log (FT)	0.303*** (3.431)	<	0.311*** (3.434)	>	0.271*** (2.762)
(g) Log (MB)	-0.362*** (-3.983)	<	-0.335*** (-3.601)	>	-0.415*** (-4.117)
(h) Log (INT)	0.318*** (2.860)	<	0.356*** (3.130)	>	0.342*** (2.770)
Range of adjusted R <sup>2</sup>	0.520	<	0.532	>	0.480

Notes: t-statistics are in parentheses. \*significant at 10%, \*\*significant at 5%, \*\*\*significant at 1%, \*\*\*\*significant at 0.01%. The explanatory variables are as follows: (a) GDP = gross domestic product, (b) POP = population, (c) CL = common language, (d) DIST = distance, (e) FB = fixed broadband Internet subscribers (per 100 people), (f) FT = fixed-telephone line penetration (per 100 people), (g) MB = mobile-cellular telephone subscriptions, (h) INT = percentage of population who used the Internet (from any location) in the last 12 months.

VIF values are reported for each of the explanatory variables (a) ~ (h)

Range of adjusted R<sup>2</sup> is the minimum and maximum values of adjusted R<sup>2</sup> obtained for the regression equations for each type of transaction.

### APPENDIX

Argentina, Australia, Belgium-Luxembourg, Bermuda, Brazil, Canada, Chile, China, France, Germany, Hong Kong, India, Indonesia, Ireland, Israel, Italy, Japan, Republic of Korea, Malaysia, Mexico, Netherlands, New Zealand, Norway, Philippines, Saudi Arabia, Singapore, South Africa, Spain, Sweden, Switzerland, Taiwan, Thailand, United Kingdom, and Venezuela.

## REFERENCES

- [1] Internet Live Stats, 1993-2014. *Internet Users in the World* (online), (cited 29 October 2015). Available from Internet: <http://www.internetlivestats.com/internet-users/#byregion>.
- [2] J. Meltzer, "The Internet, cross-border data flows and international trade," *Issues in Technology and Innovation*, no. 22, February 2013.
- [3] ITU, Information and communicative technology data, (online), International Telecommunication Union (cited 23 October 2015). Available from Internet: <http://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx>, 2000-2015.
- [4] World Bank, International Telecommunication Union, World Telecommunication/ ICT Development Report and database, and World Bank estimates, (online), (cited Dec. 21, 2016). Available from Internet: <http://databank.worldbank.org/data/reports.aspx?source=2&series=IT.N ET.USER.P2&country=#>, 1990-2015.
- [5] US Census Bureau, *U.S. International Trade in Goods and Services Report* (online), (cited 29 October 2015). Available from Internet: <http://www.census.gov/foreign-trade/data/index.html>, 1995-2014.
- [6] K. Larsen, R. Morris, "Trade in educational services: trends and emerging issues," *World Economy*, vol.25, no.6, pp. 849-68, 2002.
- [7] J. Daly, R. R. Miller, "Corporations' use of the Internet in developing countries," Discussion Paper No. 35. The World Bank and International Finance Corporation, *Library of Congress*, Washington, D.C., 1998.
- [8] G. R. G. Clarke, "Does Internet connectivity affect export performance? Evidence from the transition economies," *WIDER Discussion Papers // World Institute for Development Economics (UNU-WIDER)*, no. 2002/74, ISBN 929190273, 2002.
- [9] C. Freund, D. Weinhold, "The effect of the Internet on international trade," *Journal of International Economics*, no. 62, pp.171-189, 2004.
- [10] G. R. G. Clarke, W.J. Wallsten, "Has the Internet increased trade? Developed and developing country evidence," *Economic Inquiry*, vol. 44, no. 3, pp. 465-484, 2006.
- [11] V. K. Vemuri, S. Siddiqi, "Impact of commercialization of the Internet on international trade: a panel study using the extended gravity model," *The International Trade Journal*, vol. 23, no.4, pp. 458-484, 2009.
- [12] US BEA, US Bureau of Economic Analysis, Department of Commerce. (online), (cited 23 October 2015), Available from Internet: <http://bea.gov>, 1999-2013.
- [13] Internet World Stats, Internet usage and population in North America, (online), (cited 23 October 2015). Available from Internet: <http://www.internetworldstats.com/stats14.htm#north>, 2000-2013.
- [14] US Central Intelligence Agency, (online), (cited 26 December 2016), Available at <https://www.cia.gov/>, 2000-2013.
- [15] IMF, International Monetary Fund, (online), (cited 26 December 2016), Available at (<http://www.imf.org/>), 2000-2013.
- [16] Mapcrow Travel Distance Calculator, (online), (cited 23 November 2016). Available from Internet: [www.mapcrow.com](http://www.mapcrow.com), 2000-2013.
- [17] S. Bouheas, P. O. Demetriades, T. P. Mamuneas, "Infrastructure, transport costs and trade," *Journal of International Economics*, vol. 47, pp.169-189, 1999.
- [18] I. M. Zarzoz, F. N. Lehmann "Augmented gravity model: an empirical application of Mercosur-European Union trade flows, *Journal of Applied Economics*, vol. 4, no. 2, pp.291-316, 2003.
- [19] M. H. Kutner, C. J. Nachtsheim, J. Neter, and W. Li *Applied linear statistical models*. 5th ed. Boston: McGraw-Hill/Irwin, Vienna Institute for International Economic Studies, 2005.
- [20] I. H. Cheng, H. J. Wall, "Controlling for heterogeneity in gravity models of trade and integration," *Federal Reserve Bank of St. Louis Review*, vol. 87, no. 1, pp.49-63, 2005.