"Do more communication tools make us trade more? Reassessing the evidence"[1]

Preliminary version- Please do not cite without permission

Ana Lucía Abeliansky[2]

Martin Hilbert[3]

Theoretical reasoning and anecdotal evidence from global online retailers suggest that the digital network should affect global trade patterns. Previous research has used proxies for the installed digital capacity to test related hypothesis, such as the number of installed Information and Communication Technology (ICT) devices. We use a more accurate and informative independent variable and consider the installed telecommunication bandwidth in a country (in kbps per subscriber). The uniqueness of this new variable is that it is able to measure the total connectivity potential of countries, of all of their telecommunication devices. We study the relationship between telecommunication potential of countries with an augmented Gravity Model that properly controls for multilateral resistance, for a panel of more than 120 countries over the period 1995-2008. Regression results show a significant effect on export performance depending on the level of connectivity of the trading partner and the ICTs' technology gap between them. The size of the evidence differs according to the sample of countries, distinguished by the level of economic development. ICTs seem to have a higher impact on developed countries. Estimates also suggest a North-North polarization of World trade, given the deepening of the digital divide. Developing countries should catch up, if they want to increase their participation in the global trade network.

JEL Codes: F14, F63, D83

Keywords: International trade; ICTs; gravity model

---

[1] We would like to thank the participants of the XVI Goettingen International Economics Workshop, GLAD research seminar in Hannover and the internal research seminar of the International Economics Chair of the University of Goettingen. We are grateful to Astrid Krenz, Inmaculada Martinez-Zarzoso, Klaus Prettner, Johannes Schuenemann, Holger Strulik, Timo Trimborn and Katharina Werner for helpful advice and discussion. All errors remain ours.

[2] Corresponding author. University of Goettingen (ana-lucia.abeliansky@wiwi.uni-goettingen.de)

[3] UC Davis and United Nations' Commission for Latin America and the Caribbean

I. INTRODUCTION

International trade and digital networks have exploded during the past decades. Between 1995 and 2008, global trade of goods and services has grown with a compound annual growth rate of approximately 10 % per year, while global Gross National Income (GNI) has merely grown 5.7%. The number of worldwide installed telecom end-user devices (such as phones and internet subscriptions) has grown with annually 15.5 % during the same period, and the corresponding installed bandwidth with 44.7 %. Communication has been easier, faster and less expensive and it has changed the way we live, work and interact (Castells, 2009). In the economic sphere, it has been shown that the increasing digitizing of economic processes has led to a certain degree of reorganization and institutionalization of economic activities (Rosenblat et al (2004), Garicano and Rossi-Hansberg, 2006; Acemoglu, et al. 2007), labor skills upgrading (Autor, et al., 1998; Bresnahan, et al, 2002), increases in relative wages (Feenstra and Hanson, 1999), poverty reduction (Jensen, 2007), and positive network externalities (Shapiro and Varian, 1998). The enabled real-time communication through private or multiparty networks among economic actors (Brynjolfsson and Hitt, 1995) and the accompanying reduction of search costs through blatant transparency (Bakos, 2001; Borenstein and Saloner, 2001) has arguably helped to overcome geographical distance, resulting in the much-cited "death of distance" (Cairncross, 1997).

It can be expected that digital networks reduce search costs, management and control costs, shipping costs and time costs involved in trading. Buyers and sellers can find each other and connect quicker, trading partners and employees can be monitored more easily (management and control costs), and communication and coordination costs can be reduced (diminishing shipping costs) (Demirkan et al., 2009). From a theoretical perspective, Gravity models provide a tool to test the relationship of ICTs (Information and Communication Technologies) and the borderless digital networks with bilateral trade. These models have been used for over half a century to predict bilateral trade flows based on the distance between two economies and their economic masses (Tinbergen (1962), Anderson (2010) for example). Therefore, we follow the empirical trade literature and use the Gravity model as our theoretical underpinning.

Research that focuses on the impact of these technologies on trade volumes has been scarce so far, especially in comparison to other areas of studies of international trade. Just a decade ago, Freund and Weinhold (2002, 2004) provided the first evidence on the matter, while studying the effect of ICTs' growth on international trade growth using the internet penetration in the first paper while the number of websites on the second. Several studies include only cross-sectional data (Clarke et al (2006), Marquez-Ramos et al (2010), Demirkan et al (2009), among others), while others that are of a panel nature either are of a short time span (Portugal-Perez and Wilson (2012)) or include a small number of developing countries, if any (Vermuri et al (2009), Timmis (2011), Mattes et al (2009)). Another delicate issue in this strand of literature is that although Gravity models are alleged to be estimated, only few control for multilateral resistance as the theoretical model indicates, especially in panel data (Timmis (2011), Mattes et al (2012) and Portugal-Perez and Wilson (2012)).

Previous studies approximate the independent variable of digital capacity by using statistics on the number of ICT devices (such as the number of broadband subscriptions (e.g. Demirkan et al. (2009), personal computers, telephone lines and Internet users (Vermuri et al. (2009)), Internet and mobile phone subscribers, personal computers and Internet users (Ahmad et al (2011), among others) or some sort of ICT index (which combines the number of technological devices with variables on education and the diffusion of other innovations (Marquez-Ramos et al., 2010; Mattes, Meinen and Pavel, 2012, Portugal-Perez and Wilson, 2012)). These studies reveal several statistically significant and even non-linear effects that deserve closer attention, but face methodological challenges in the choice of their independent variables. The problem with using the number of ICT equipment as a proxy arises from the fact that the number of devices is not necessarily representative of the informational capacity, since bandwidth is highly diverse (Hilbert, 2011; 2013). The delicacy of the conclusions drawn from such indexes stems from the subjectivity of the highly sensitive index composition (Minges, 2005).

We therefore execute an analysis that improves the fidelity of the ICT infrastructure index, without the need to recur to subjective index compositions. We employ a unique dataset of the installed telecommunication capacity in kbps, which basically represents the sum of the product of the number of ICT devices and their installed end-user bandwidth (also called the "subscribed bandwidth potential" (see ITU, 2012; Ch. 5). We cover the period from 1995 till 2008 across 128 countries. Additionally to the better accuracy of the estimations granted by a better variable to proxy for ICTs technologies- kbps capacity per subscriber- we estimate a Gravity model, adjusting for multilateral resistance with the methodology of Baier and Bergstrand (2009) and Egger and Nelson (2011). Regression results show a significant effect on export performance depending on the level of connectivity of the trading partner. Evidence differs according to the sample of countries, divided by the level of economic development. ICTs' development- as well as how different your ICTs level is from your trading partners' seem to affect how much you trade.

The paper is structured as follows. Part II will provide an overview of the related literature and Part III will examine the development of ICTs across the globe. It will be followed by Part IV that provides the theoretical framework (Gravity Model) and by Part V that will describe the empirical strategy. Part VI explains the variables and data sources used to estimate the model. Part VII will show and analyze the results and finally Part VIII will conclude the study and will outline further lines of research.

II. Literature review

Economic Growth

The initial studies of the effects of the ICTs have focused on economic and productivity growth. They employed some proxies for a society's information processing capacity, like the amount of installed ICT devices (e.g. Hardy, 1980; Röller and Waverman, 2001; Datta and Agarwal, 2004; Duggal, et al., 2006), or the monetary value of the investments in the respective stock of technological infrastructure (e.g. Bresnahan, 1986; Siegel et al., 1992; Oliner and Sichel, 1994; Jorgenson and Stiroh, 1995; Vu, 2011). In general, positive effects of ICT on economic growth and productivity were detected. Most of the literature focuses on the United States (Jorgenson and Vu, 2007; Dimelis et al.; 2011), European countries (e.g. Crepon and Heckel, 2002; van Ark, et al., 2008), or the industrialized member countries of the OECD (Organization for Economic Co-operation Development) (Spiezia, 2012). Studies that include developing countries find differential effects among world regions, with a smaller effect in Latin America in comparison with OECD and Asia, and a bigger effect in others like Africa and Middle East (Campos, 2010).

International Trade

In comparison to the literature on ICTs and economic growth and productivity, the related trade literature is still in its early phase. The initial publications were from Freund and Weinhold (2002, 2004). In their first paper they assess the importance of ICTs on services' exports and imports Internet using penetration as a measure of ICTs. In their 2004 paper they study the effect of the growth of ICTs on merchandises' trade growth. In this case, the measure of ICTs is the amount of web hosts in a country. They do not find evidence that ICTs dampens "the law of gravity".

Among the empirical applications that later on continued to fill in the research agenda among these lines, augmented gravity models were estimated. Many papers alleged to have been estimating these models (since they include distance and GDPs as the explanatory variables), although proper care of the multilateral resistance terms was not considered. Among the surveyed literature on the impact of ICTs on international trade, with the use of gravity models to assess it, we have observed that they were simply ignored -especially in a panel setting- except for Timmis (2011), Mattes (2012), Portugal-Perez and Wilson (2012) and Francois and Manchin (2013).

ICTs have been proxied as ICTs use, ICTs infrastructure, both (included as independent variables) or a hybrid of the aforementioned, in the shape of an index. Marquez-Ramos et al (2010) use a technological achievement index (TAI) constructed on the basis of four indicators: level of technological innovation in a country, diffusion of old innovations (potential absorptive capacities), diffusions of recent innovations and the human skills index[4] (realized absorptive capacities). They include this index in the cross-sectional gravity specification (for both partner countries) and also include a quadratic term to allow for non-linearity. They also instrument this index with the average research and development expenditure. Specifications including sub indexes from the TAI are also included. They find in several cases a positive relationship between technological innovations and export performance (plus a non linear effect that was also found for the other sub-indexes and across subsamples). Moreover, a u-shape effect was found for diffusion of old innovations and human skills and an inverted u-shape effect for realized absorptive capacity. Mattes et al (2012) also use an index to proxy for ICTs (ICTs development index), constructed by the International Telecommunication Union (ITU). Studying EU trade between 1995 and 2007, they find a positive impact if both countries have a high level of ICTs development. They properly account for multilateral resistance terms using time-varying fixed effects for the exporter and the importer country. In a similar nature, Francois and Manchin (2013) construct an infrastructure index based on principal component analysis and find a positive effect of this index on the exporting and importing activity.

Demirkan et al (2009) consider internet use (number of internet users) as a proxy for ICTs. They estimate a cross-section for the year 2005 for 175 countries. They find a positive effect, and conduct an interesting analysis with subsamples, that group economies according to their economic size. There they discover that the effect is higher between large economies than for smaller ones. The same larger effect also applies between more distant economic exchange partners and geographically closer ones.

Vermuri et al (2009) also find a positive and statistically significant effect of “ICT Infrastructure”, which includes personal computers, telephone lines and Internet users. They use a Hausman-Taylor estimator for 82 countries between 1985-2005. They do not provide any information on how they use this estimator in an unbalanced panel. An interesting point in their analysis is the use of “fixed proportions”, which means they employ a minimum level of ICTs for each country pair. The rationale behind the use of this

[4] For a more detailed description of the index please refer to Marquez-Ramos et al (2010). For simplicity, an overview of the index is presented.

is that the minimum level within a country would have an effect via the restraint it will place on the extent of the bilateral communication. Ahmad et al (2011), with a time series analysis, estimate the effect of Malaysian ICTs infrastructure (measured by Internet and mobile phone subscribers, personal computers and Internet users) between 1980 and 2008. They find a statistically significant effect of all of the ICTs infrastructure measures, in a pooled, fixed effects as well as a random effects model.

Clarke et al (2006) find a positive effect of higher internet penetration (number of internet users) in the trade between developing countries to developed ones, in a cross sectional analysis with an extensive and representative sample of countries of the developed and developing world. They also allege endogeneity due to reverse causality, although they imply that openness is just exports, unlike the international trade literature that considers exports plus imports. They consider an instrument for Internet penetration, which is related to the regulation of the market that they view as exogenous to the trade growth variable they employ.

Portugal-Perez and Wilson (2012) study the effects of hard (physical infrastructure and ICTs) and soft infrastructures (border and transport efficiency and the business regulatory envioronment) on the export performance of developing countries. With a panel of 101 countries for the period 2004-2007 they find that export performance is indeed improved by infrastructure. An interesting approach was to assess their impact also, considering the potential marginal effects in terms of per capita income. When they include ICTs (proxied by an indicator that includes information on availability of latest ICT technology, extent of business internet use, level of technical absorption and government prioritization of ICT), they find a positive effect on exports but when including an interaction with GDP per capita they find that the effect is increasing with the latter (though the estimated impact of ICTs is negative while the interaction of ICTs and GDP per capita is positive, both statistically significant).

Finally, Timmis (2011) estimates a panel model for OECD countries between 1990 and 2010. His proxy for ICTs is Internet users, broadband connections, fixed lines connections and percentage of broadband connections. He includes each variable as a proxy for ICTS in different regressions and considers mobile phones, computers and telephone lines as a robustness check. He finds that country pairs with high adoption rates trade more with each other and that a rise in adoption within a pair of countries has a small effect on trade. He also controls for multilateral resistance terms with time varying country fixed effects for exporter and importer country.

The impact of ICTs on international trade still needs some further study, specially controlling for multilateral resistance terms in a panel setting that includes a wider selection of developing countries. This paper therefore aims to fill in this gap, besides using a novel proxy for ICTs infrastructure.

III. WORLD TRADE AND ICTS: A QUICK LOOK AT THE DATA

Most of the existent studies that investigate the effects of ICTs on international trade are of a cross-sectional nature, and that type of analysis was the original idea of this paper. The approach changed when Graph 1 was constructed, depicting the rise in international trade in the last few decades, especially in the 90's, while the ICTs revolution took off later, mainly in the 2000's. Therefore, it is difficult to stipulate at first sight that the increase in world trade is irrevocably due to ICTs (understood in this graph as internet capacity per subscriber).

Upon a closer look at our variable of interest, we can observe in Graph 2 that the amount of total subscribers (subscribers and equipment will be used as synonyms) has increased more steeply since the second half of the 90's and the capacity of the countries since the beginning of the 2000's.

Hilbert, López and Vásquez (2010) note that while in 2008 the penetration of the service in European countries (broadband internet subscribers per inhabitant) was 2.3 times bigger than in Latin America (26.7% versus 11.6%), the difference in the communication capacity was almost 5 times as big: while each inhabitant of the EU had 625 Kbps for his own use, the average Latin American inhabitant had only 128 Kbps. This difference has increased considerably since 5 years before, when the difference was only 27 Kbps. The growing difference can be explained mostly due to the low velocity offered by providers in the Latin

American region. In 2008, downloading speeds ranged from 512Kbps to 1Mbps in Latin America while the average was of 17Mbps in OECD countries. These differences are just an example of the evolution and disparities of ICTs between countries. These disparities can also be seen in Graph 3 and Graph 4. We observe that the average installed bandwidth capacity per ICT equipment of OECD countries has been increasing exponentially, especially during the 2000's. There has been an increasing capacity gap with non-OECD countries that can be observed in Graph 3. On the contrary, we do not see such strong increasing gap in Graph 4, when observing the average amount of equipments per OECD versus non-OECD countries.

Given the evolution of ICTs, they could have an effect on the exporting performance as well as on the importing behavior. Moreover, they could have different impact depending on the country type. In a nutshell, this is what we aim to study.

IV. Theoretical framework: the Gravity Model

The Gravity Model has been the workhorse of the international trade literature since the seminal paper of Tinbergen (1962). An extensive literature has emerged since and it has been used to model the impact of different variables such as migration, culture, governance, trade agreements, among others, on trade flows. The core of these models is the inclusion of GDP and distance as explanatory variables (Rose (2004), Subramanian and Wei (2007), Javorcik et al (2011), Stein and Daude (2007), Rauch (1999), Guiso, Sapienza and Zingales (2009), among many others) that resemble the Newton's gravitational equation, where masses are replaced by GDP and distance. Given the theoretical foundation of Anderson and Van Wincoop (2003), these models have started to increase in importance and popularity. Applications besides trade have extended to the study of Foreign Direct Investment as well (Javorcik et al (2011), for example). These models are popular given their simple and straightforward essence, plus their high explanatory power in empirical applications.

There are several complexities in estimating the model, as outlined by Anderson and Van Wincoop (2003), since it requires solving a system of non linear equations. Feenstra (2002) shows that the use of fixed effects would suffice to control for the multilateral resistance terms[5]. In a later paper, Baier and Bergstrand (2009) have derived from a theoretical model, an equation to consistently estimate the gravity equation with OLS, acknowledging the multilateral resistance terms. Applications of this method (hereupon called BB) on panel data are growing but also have differed across authors. We follow the approach of Egger and Nelson (2011) who apply the BB methodology also including time dummies and in a fixed effects framework- controlling for country-pair unobserved heterogeneity. Time dummies are justified from a theoretical perspective- replacing world GDP- and the Hausman tests indicates that the models favor the fixed effects estimator instead of the random effects specification (nevertheless, it will be reported as a robustness check).

The augmented gravity equation that will be estimated is in line with the international trade empirical literature and includes the *traditional gravity models'* variables. The main difference with using this methodology is that we take care of multilateral resistance in each of the terms of the bilateral costs (as can be seen in upcoming Equation (II)). Since we cannot use time varying fixed effects (which could be an appropriate option for panel data) given our interest on exporter/importer ICTs', we will follow this line of research. For simplicity and since our interest lies in the estimation, we will follow the methodology of Márquez-Ramos et al (2011) and Egger et al (2011) for the definition of the estimating equation, who use a simplified version of the Baier and Bergstrand (2009) methodology[6]. The baseline gravity equation that applies to this case is the following:

(I) $X_{itj}= (GDP_{jt}*GDP_{it}/ GDP_{wt})*(t_{ijt}/(P_{it}P_{jt}))^{1-\sigma}$ where $t_{ijt} = dist_{ij}{}^{\alpha} * c_{it}{}^{\mu}c_{jt}{}^{\mu}q_{ijt}{}^{\rho}$

t_{ijt} denotes the trade costs that comprise of transport costs (proxied by distance) and by other costs (c_{jt} , c_{it} and q_{sjt}). Other costs would normally include the information costs

[5] Anderson and Van Wincoop already acknowledge the possibility of using fixed effects although they do not elaborate fully on this. For a panel setting, time varying fixed effects would be appropriate. For a detailed explanation refer to Feenstra (2002).

[6] Egger et al (2011) also use simple averages instead of shares.

(related to cultural variables (like common language)- though here they will be absorbed by the fixed effects) and other general trade costs that can relate to regional trade agreements, for example. Furthermore, our main variable of interest included in other costs is ICTs, that could be understood as transport cost, costs, but also as general costs, as aforementioned (and the reason for this can be seen in Chart 1 as a reminder).

We apply logs to (I) and obtain the following equation:

$$\text{(II)}\ \ln x_{ijt}=\alpha+\ln GDPpc_{it}+\ln GDPpc_{jt}-\ln Y_{wt}+\rho\ln dist_{ij}+\beta\ln c_{it}+\delta\ln c_{jt}+\gamma\ln q_{ijt}^{*}-\ln P_{it}-\ln P_{jt}+u_{ijt}$$

where the subscript i refers to the exporter country and j is the partner country. The dependent variable is the export trade flow between i and j. *GDP* per capita is included for the exporter and importer country. *Dist* refers to the distance between the capital cities between the trading partners. $C_{1,2}$ stands for variables of the partner countries that remain constant for each country, irrespective of the partner (ICTs). Variables included in q^* are specific to the bilateral relationship of the trading countries (they are included in the trade cost equation of the gravity model (Equation (I)). [7] The World GDP (Y_{wt}) will be included into the regression analysis with year dummies.

In order to account for multilateral resistance, namely considering $\ln P_{it}$ and $\ln P_{jt}$, the BB correction that includes a log linear first order Taylor series approximation of the price indexes[8] has been made to the bilateral independent variables. We follow Márquez-Ramos

[7] Equation II, as derived from Equation I, made some coefficient assumptions for simplicity in exposition. All of the coefficients should be multiplied by (1- σ), in order to properly interpret the estimated coefficients. When q is a dummy variable it enters the cost equation as e^{dij} and therefore we end up with the dummy variable when applying the logarithm. Distance is treated the same as q*.

[8] Previously one has to express the price indexes in terms of the trade costs and with some formula manipulation we are able to correct each bilateral trade cost friction with (III). Egger et al (2011) provide a clear derivation.

et al (2011)[9] and Egger et al. (2011) and define the independent variables that are specific to the bilateral relationship (also applies for distance) between the partner countries using the BB transformation. We then obtain the following:

$$\text{(III)} \quad -\ln P_{it} = \left(-1/N \sum_{j=1}^{Nj} \ln q_{ijt} + 1/2 * 1/N_i * N_j \sum_{i=1}^{Ni} \sum_{j=1}^{Nj} \ln q_{ijt}\right)$$

$$-\ln P_{jt} = \left(-1/N \sum_{i=1}^{Ni} \ln q_{ijt} + 1/2 * 1/N_i * N_j \sum_{i=1}^{Ni} \sum_{j=1}^{Nj} \ln q_{ijt}\right)$$

So we get the next equation for the bilateral trade costs adjusted for multilateral resistance:

$$\text{(IV)} \quad q_{ijt}{}^* = q_{ijt} - 1/N_i \sum_{i=1}^{Ni} \ln q_{ijt} + 1/N_i * N_j \sum_{i=1}^{Ni} \sum_{j=1}^{Nj} \ln q_{ijt} - 1/N_j \sum_{j=1}^{Nj} \ln q_{ijt}$$

where the subscripts refer to the partner countries as before. The second term is basically the simple average of the trading cost of the exporter across all partners j, while the third one is the average of the trading cost of the partner with all of its potential partners. Finally, the last term is the simple average of all the trade costs between all of the potential partners (for a more detailed explanation refer to Egger et al. (2011) or Márquez-Ramos et al. (2011)). Although we consider symmetric costs in this case, this methodology also allows for asymmetric trade costs (Baier et al., 2009).

V. Empirical Strategy

Given Equation (II) we estimate the augmented gravity model. We first estimate the Gravity Model as stipulated in equation (II), though not controlling for multilateral resistance. Then we estimate a simple pooled OLS. Then we go back to the fixed effects specification and add the ICTs variables. Later, we augment the model with the interactions with the level of ICTs of the partner country and with GDP per capita. As a last step we add a "technology gap" variable calculated as the log of the absolute value of the ICTs

[9] Other such as Portugal-Perez et al (2012), Carrere et al. (2010) and Jong et al (2011) also only correct bilateral variables for multilateral resistance, while also including other country specific variables of interest. Carrere et al (2010) specifically derive and show that the BB method for non bilateral variables creates fixed values per year that can be absorbed by the time dummies.

difference between exporting and importing country (standardized by the level of ICTs of the importer- results do not vary whether we do it with the exporter or importer). We finally control later for multilateral resistance for the bilateral variables with the BB methodology and we therefore consider this specification the full model. As robustness checks, we add a measure of infrastructure- road density per capita, we estimate a random effects model (with and without the BB methodology) and a Mundlak specification (see de Sousa et al, 2012) .

Another way to analyze the effects of ICTs on the export performance is to just focus on the exporter and partially control for multilateral resistance with the use of importer-country time fixed effects (as estimated in Martinez-Zarzoso et al (2008) though for a cross sectional analysis). We can also combine the BB methodology with the time varying fixed effects specification (we include P_{it} with the BB method and then we include importer-time dummies to control for P_{jt}). We do then an analysis quite similar to the previous case- we also then estimate a random effects and a Mundlak model, besides also using 5year fixed effects that vary by exporter country (it should be noted that since we have 14 years, the periods have been divided by the following amount of years: 5 - 5 - 4).

We then proceed to analyze to analyze what we referred as the full model (controlling for multilateral resistance and including interactions) in further subsamples, by differentiating between OECD or non OECD countries as exporters and importers. With the interactions from the "full model" we want to see if there is a “network” effect between countries- the impact on trade of my level of ICTs depends on the level of the partner country and then if the level of ICTs affects trade, depending on the level of economic development (measure by GDP per capita). [10]

Therefore, to summarize, the estimating equations will be variations of (II):

(1) Panel without ICTs

[10] An issue we will not deal with in this paper since we consider that it is not of great concern is the *zero problem* (De Benedictis and Taglioni, 2011). Our reasoning relies on the fact that this only affects 15% of the full sample.

(2) Pooled OLS with ICTs

(3) Panel with ICTs

(4) Panel with ICTs and interaction of importer and exporter country ICTs, plus interaction of GDP per capita for importer and exporter country

(5) Same as before but including the "technology gap"

(6) Same as before but controlling for multilateral resistance of the bilateral variables

(7) Same as (6) but adding an infrastructure measure- (log of) road density per capita.

(8) Random effects estimation of (5)

(9) Random effects estimation but controlling with BB methodology for bilateral variables

(10) Mundlak estimation of (5)

Furthermore, we include another analysis which only studies the effect of ICTs on the export performance. We then estimate the following:

(1) Gravity model with only exporter variables and bilateral variables (not including ICTs difference) with importer-year fixed effects

(2) Same as before but including ICTs difference and correcting for multilateral resistance of the exporter with BB method

(3) Same as (1) but with importer-5yr fixed effects instead

(4) Same as (2) but with importer-5yr fixed effects instead

(5) Regression controlling for multilateral resistance by Exporter and Importer country-time fixed effects.

(6) Random effects estimation but controlling with BB methodology for bilateral variables

(7) Mundlak model

Finally, focusing on the exporter and importer type (they can be classified as “South” (non-OECD) or “North” (OECD)) we will also try to see if there is any particular effect for each. Therefore, we will estimate for each potential trading partner pair (all-all, Non OECD-all, OECD-all, OECD-OECD, Non OECD-Non OECD, Non OECD-OECD and OECD-Non OECD):

(1) Panel fixed effects with ICTs of importer and exporter.

(2) Same as (1) but including ICTs interaction with GDP per capita and with the ICTs level of the trading partner.

(3) Same as (1) but including ICTs interaction with GDP per capita and ICTs technology gap.

(4) Same as (3) but including interaction with the ICTs level of the trading partner.

VI. Variables and Data Sources

Bilateral trade data was obtained from the BACI dataset from the Centre d'Etudes Prospectives et d'Informations Internationales (CEPII). It is a mirrored dataset, which is of special use in this case given the amount of developing countries of the sample and the reporting errors that could potentially arise. Values are in millions of US dollars. We do not deflate the trade flow since the multilateral price indexes actually take care of this issue- in this case they are controlled with the BB adjustment. Results remain fairly the same when we just include the log of trade minus the log of GDPs as the dependent variable.

The measure of Gross Domestic Product per capita in current values (**GDPpc**) used in this study was obtained from the World Development Indicators (WDI) from the World Bank. The theoretical model of Anderson and Van Wincoop (2003) does not specify if it is GDP or GDP per capita, therefore we assume it is GDP per capita, because we are also interested in the interaction of GDP per capita and ICTs. Given the importance that regional trade agreements (**RTA**) have been having in shaping the world interactions (economic, social, political, etc), we see the need of including them in the model. Moreover, an extensive literature in international trade has emerged trying to quantify the impact of these on trade flows (Baier and Bergstrand, 2007). Therefore, the variable was included in the model. It takes the value 1 if the country is engaged in a regional trade agreement with the partner country, otherwise it is 0. This variable was obtained from De Sousa's website[11] and includes the dataset from Baier and Bergstrand (2007), the most recent regional trade agreements in force obtained from the WTO website and information from Frankel (1997).

[11] http://jdesousa.univ.free.fr/data.htm

The variable common currency (***Comcur***) was also included from the same source and was firstly used in de Sousa (2012). A dummy equal to 1 indicates the existence of a common currency between trading countries.

Unfortunately, given the nature of our fixed effects estimator traditional variables in the literature could not be included- namely **common language, colonial ties, common border/contiguity** and **distance (**since they are absorbed by the fixed effects, that also controls for all of the potential country-pair variables, though does not allow us to obtain the estimated coefficients for each of these)**.** Nevertheless, these variables were included when using the Mundlak estimator and the Random Effects. The source is CEPII as well. Moreover, we also include another infrastructure measure to verify that our ICTs variables are not picking up the effects of other infrastructure measures such as physical infrastructure. Therefore, we check the robustness of our results using the road density per capita calculated with data from the World Development Indicators.

Finally, our main variable of interest **ICTs** (our proxy for information and communication technologies) is constructed with the total Internet capacity of kbps by each country divided by the amount of internet subscribers in each country. The novelty of this variable is that it measures ICTs infrastructure by a combination of (a) devices and (b) the capacity per device, divided by the amount of subscribers. This allows us to test for differential effects of "more" and "better" ICTs. This variable was constructed by Hilbert and Lopez (2011), using data from ITU (International Telecommunication Unit) for (a) and they own estimations for (b)[12]. Moreover, with this variable we construct the "technology gap" in the following manner:

$Diff_{ijt}$=log(absolute value (kbps per susbcriber$_{it}$- kbps per susbcriber$_{jt}$)/ kbps per susbcriber$_{jt}$)

Given data availability, an unbalanced panel from 1995 to 2008 was estimated for 122 countries (refer to Chart 2 for a detailed list of countries). Descriptive statistics can be found in Chart 3.

[12] For a detailed description of the variable please refer to http://www.martinhilbert.net/LopezHilbertSupportAppendix2012.pdf

We expect Regional Trade Agreements to have a positive value since neighbors should be expected to trade more and countries engaged in RTAs are expected to trade more as well since they have special agreements that should boost trade given preferential tariffs, simpler customs controls, etc. A common currency should facilitate commercial transactions- therefore we would expect a positive coefficient. Finally, regarding ICTs we expect a positive coefficient for the exporter and the importer. This is because we expect that the use/access to these types of technologies eases trade given the cost reduction and access to other markets it potentially entails.

Regarding interactions, we would expect a positive coefficient for the "network effect" given that the positive effect of my ICTs would be higher if the other country increases their ICTs as well. Furthermore, as aforementioned, following Portugal-Perez and Wilson (2012) we include an interaction term of GDP per capita to our measure of ICTs for the exporter and the importer. These interaction terms were constructed as the result of the multiplication of the log of one variably by the log of the other one. A priori we would expect to find a negative coefficient, since ICTs should affect more developing economies in all the ways outlined in Chart 1. Finally, we would expect a negative effect of the technology gap given that countries that are far apart in their communication technologies should make them trade less given the more troublesome communications since the lack of advanced information and communication technologies.

VII. RESULTS

The estimated regressions were outlined in Section V. As Chart 4 depicts, all of the estimated coefficients of GDPs per capita have a positive sign and are statistically significant. Although the values vary somehow between specifications, that should not be a concern since they also lie between the magnitudes found in the literature (the theoretical model from Anderson et al (2003) implies that the coefficients of GDP should be around 1 - though this is usually never fulfilled by the data, especially when including developing countries in the sample). Regional trade agreements have a positive and statistically significant effect in all of the specifications (only a negative but not statistically significant effect of the non-OECD exports to OECD countries and positive but also not statistically significant within OECD). Regarding sharing the same unit of account for transactions has had a positive effect on most of the specifications where multilateral resistance is properly accounted for with the BB methodology. Only within OECD and with OECD and the whole world trade partners it has been found to have a negative effect, though rather small. This is a puzzling result but it could be related to the introduction of the Euro of some OECD countries over the period considered and that could have had a detrimental effect on trade flows, given the adjustments of the economy to this new currency.

Our first variable of interest, ICTs of exporter, has had a positive and statistically significant effect in all of the specifications from Chart 4 (though in specification (3) the interaction terms were not included, and the estimated coefficients were negative - similar results as Portugal-Perez and Wilson (2012)). This interaction term with GDP per capita has mostly a negative sign and statistically significant effect. This means that the positive effect of ICTs on trade diminishes, as countries "get richer". This could be correlated to the fact that small countries can benefit from ICTs by accessing far away markets, but that when they are developed they are probably already integrated into the markets and therefore ICTs do not have a significant impact on the matter. The “network effect” is also mostly positive within the specifications, depicting that the positive impact of my extra ICTs also depends on the level of the ICTs of my trading partner.

In terms of the ICTs of the importer, the impact is not as clear as before. The estimates are mainly positive but not statistically significant throughout specifications. Interactions with GDP depict a similar picture as before (negative coefficient), but with a smaller size. Since most of the coefficients related to importer activity are smaller in size, we could think that the effect on the importer activity is less important and we will continue focusing on the exporter since it is our main interest.

Finally, we see that our robustness checks (specifications (7) to (10))- the Random Effects, Mundlak and the addition of another infrastructure variable corroborate the results.

Overall, from Chart 6 we can see that ICTs enhance an especially positive effect on exporters, related to trade within developed economies or the one originated from developed countries. Given the "digital divide" (Hilbert (2011, 2013)) in terms of communication capacity that we find between developed and developing economies, we can think that these results support the argument that this divide is also deepening commercial relations within the countries with high level of ICTs infrastructure. This is supported by the fact that no effect was found on the level of ICTs between developing countries- probably their actual amount of ICTs is too small to have an impact. Nevertheless, in this case the network effect was still positive highlighting the importance of the level of ICTs of the other country when assessing the contribution of ICTs on trade. Also, developed countries are affected by the ICTs' gap between them. In terms of the "North"-"South" and "South"-"North" trade from Chart 6, it seems that ICTs matter more for OECD countries. In the case of exports of Non-OECD countries to OECD, the interaction is negative though the ICTs effect on exporter and importer is positive and statistically significant. The negative interaction could mean that in the case of exporters, when the OECD countries are increasing their level of ICTs they would be able to trade more with other OECD countries that have a higher ICTs level, therefore diverting trade. In this specification the interaction effect with GDP is also positive and for exporter this could make less negative the effect coming for the interaction of ICTs since a bigger GDP of the exporter would close the gap between the development levels of the countries.

Also, in Chart 6, we can see that most of the coefficients regarding free trade agreements and common currency are quite similar to the previous charts. We find a negative coefficient for the technological gap for all of the samples included, though not always statistically significant (when OECD are exporter to the whole world or when OECD are exporters to non-OECD countries). The gap seems to matter within OECD countries, who lead the "digital divide" and therefore are increasing their ICTs frequently (and probably not all at the same time - keeping in mind that the development level of OECD countries is not exactly the same) and therefore reducing their trade costs. Related to their trade with developing countries, it could be that the products that these buy from them do not vary with the level of ICTs given that OECD countries have already established their trade relations in the past, sending elaborated products that developing countries do not usually produce. Trade within developing economies is also affected by the gap, though the ICTs' endowment does not seem to have an effect per se, it does seem to affect in terms of the relative endowment of the other partner (and potential partners). Finally, it seems that ICTs' difference matter for developing economies since their possibilities to sell their products to developed countries is restricted by their ICTs installed capacity per subscriber. They cannot compete with other developed economies.

Overall, from Chart 6 we can conclude that the overall impact of ICTs - on average- is higher for developed countries rather than developing ones- reinforcing the "digital divide". Although the interaction with GDP is negative, the overall effect is higher (looking at the coefficients or calculating the marginal effects at the means).

VIII. CONCLUSION AND FURTHER RESEARCH

The developing world requires this kind of analysis, as Governments Agencies and Ministries have considered the development of ICTs as an important element that could potentially help to increase productivity and achieve the catching-up with the developed world. In this analysis we see a positive correlation between ICTs and exports. This is an interesting result (in terms of international trade) for International Organizations and Development Agencies, since they promote the development of ICTs in developing countries. This analysis shows that the ICTs' quality matters, rather than focusing in the amount of equipments as it has been done in the past. ICTs seem to have benefited more OECD countries, who actually lead the digital divide. Increasing a high already level of communicational capacity fosters more trade – policy should focus on making developing countries more competitive in this regard and diminishing the gap (found to affect trade in most of the samples). Also, we should recall the positive interaction of ICTs between trading partners, signaling a "network effect". Moreover, if more and better ICTs were to be developed, it could also increase "South"-"South" trade - which still lags behind in terms of participation of world trade. Finally, this paper also provides evidence on the importance of the ICTs' technology gap as a trade barrier between countries. To the best of our knowledge, this is the first paper in the literature to assess the importance of this gap in the context of international trade, besides providing an extensive panel that includes a significant amount of countries (122) for 14 years.

Further work still could be done to investigate the link between trade and ICTs. Firstly, regarding trade flows, they could be disaggregated applying Rauch's classification (1999) of differentiated, reference priced or commodities, where we would expect a greater effect on differentiated goods. We have omitted the discussion regarding the missing values present in the dataset and have opted to eliminate them from the sample, given their low participation. Portugal-Perez and Wilson (2012) employ the two-stage sample selection model used in Helpman, Melitz and Rubinstein (2008) to take into account the zero flows. It could be relevant also to consider this methodology in order to deal with the zero/missing trade flows, especially in the subsamples.

REFERENCES

Acemoglu, D., Aghion, P., Lelarge, C., Van Reenen, J., and F. Zilibotti (2007), "Technology, Information, and the Decentralization of the Firm". *Quarterly Journal of Economics,* Vol. 122, No. 4, 1759- 1799.

Ahmad, N. A., N. W. Ismail and L. S. Hook (2011), "The Role of ICT Infrastructure on Malaysian Trade," *Journal of Economics and Management*, Vol. 5, No. 1, 140-148.

Anderson, J. E and E. van Wincoop (2003), "Gravity with Gravitas: A Solution to the Border Puzzle," *American Economic Review*, vol. 93, No. 1, 170-192.

Autor, D. H., Katz, L. F. and A. B. Krueger.(1998). Computing Inequality: Have Computers Changed the Labor Market?. *Quarterly Journal of Economics*, 113(4), 1169-1213.

Baier, S. L. and J. H. Bergstrand (2009), "Bonus vetus OLS: A simple method for approximating international trade-cost effects using the gravity equation," *Journal of International Economics*, vol. 77, No. 1.

--- (2007), "Do free trade agreements actually increase members' international trade?," *Journal of International Economics,* vol. 71, No. 1.

Bakos, Y (2001). The Emerging Landscape for Retail E-Commerce. *The Journal of Economic Perspectives*, 15(1), 69-80.

De Benedictis, L., and D. Taglioni (2011). “The Gravity Model in International Trade” in L. De Benedictis and L. Salvatici (eds.) *The Trade Impact of European Union Preferential Policies: An Analysis through Gravity Models.* Berlin: Springer.

Borenstein, S., and G. Saloner (2001), Economics and Electronic Commerce. *The Journal of Economic Perspectives*, 15(1), 3-12.

Bresnahan, T F. (1986), “Measuring the Spillovers from Technical Advance: Mainframe Computers in Financial Services,” *American Economic Review*, vol. 76, No. 4.

Bresnahan, T. F., Brynjolfsson, E. and L.M. Hitt (2002), Information Technology, Workplace Organization, and the Demand for Skilled Labor: Firm-Level Evidence. *Quarterly Journal of Economics*, 117(1), 339-376.

Cairncross, F. (1997), *The Death of Distance: How the Communications Revolution Will Change Our Lives* (Other Printing Edition.). Harvard Business Press.

Carrere, C., Melo, J. and J. Wilson. (2010), "Distance and Regionalization of Trade for Low-Income Countries", *World Bank Policy Research Working Paper*, 5214, 1-48.

Castells, M. (2009), *The Rise of the Network Society: The Information Age: Economy, Society, and Culture* Volume I (2nd ed.). Wiley-Blackwell.

Cimoli, M., A. A. Hofman and N. Mulder (2010), *Innovation and Economic Development: The Impact of Information and Communication Technologies in Latin America*, Edward Elgar, January.

Clarke, G. R. G. and S. J. Wallsten (2004), “Has the internet increased trade? Evidence from industrial and developing countries,” *World Bank Policy Research Working Paper*, 3215,1-28.

Crepon, B. and T. Heckel (2002), “Computerization in France: An Evaluation Based on Individual Company Data,” *Review of Income and Wealth*, vol. 48, No. 1, March .

Datta, A., and S. Agarwal (2004), Telecommunications and economic growth: a panel data approach. Applied Economics, 36(15), 1649.

Daude, C. and E. Stein (2007), “The Quality of Institutions and Foreign Direct Investment,” *Economics & Politics*, vol. 19, No. 3.

de Sousa, J. (2012), "The currency union effect on trade is decreasing over time", *Economics Letters*,117 (3), 917-920.

de Sousa, J. and J. Lochard (2012). "Trade and Colonial status", *Journal of African Economies*, 21(3), 409-439.

Demirkan, H., Goul, M., Kauffman, R. and D. M. Weber (2009), “Does Distance Matter? The Influence of ICT on Bilateral Trade Flows,” *GlobDev 2009,* Paper 17, 1-24.

Dimelis, S. P. and S. K. Papaioannou (2011), “ICT growth effects at the industry level: A comparison between the US and the EU,” *Information Economics and Policy*, vol. 23, No.

1.

Duggal, V. G., Saltzman, C., and L. R. Klein (2007). "Infrastructure and productivity: An extension to private infrastructure and it productivity" *Journal of Econometrics*, 140(2), 485-502.

Egger, P. and R. Nelson.(2011) "How bad is antidumping? Evidence from Panel Data". *Review of Economics and Statistics*, 93 (4), 1374-1390.

Feenstra, R. C., and G.H. Hanson (1999). "The Impact of Outsourcing and High-Technology Capital on Wages: Estimates For The United States, 1979–1990". *Quarterly Journal of Economics*, 114(3), 907-940.

Feenstra, R. C. (2002), "Border Effects and the Gravity Equation: Consistent Methods for Estimation," *Scottish Journal of Political Economy*, vol. 49, No. 5.

Frankel, J. (1997). *Regional Trading Blocs in the World Economic System*, Peterson Institute, 1-364.

Freund, C. L. and D. Weinhold (2004), "The effect of the Internet on international trade," *Journal of International Economics*, vol. 62, No. 1, January .

Freund, C. and D. Weinhold (2002), "The Internet and international trade in services," *The American Economic Review*, vol. 92, No. 2.

Garicano, L., and E. Rossi-Hansberg (2006). Organization and Inequality in a Knowledge Economy. *The Quarterly Journal of Economics*, Vol. 121, No. 4, 1383-1435.

Guiso, L., Sapienza, P. and L. Zingales (2009), "Cultural biases in economic exchange?," *The Quarterly Journal of Economics*, vol. 124, No. 3.

Hardy, A. P. (1980). The role of the telephone in economic development. *Telecommunications Policy*, 4(4), 278-286.

Helpman, E., Melitz, M. and Y. Rubinstein (2008), "Estimating Trade Flows: Trading Partners and Trading Volumes," *The Quarterly Journal of Economics*, vol. 123, No. 2.

Hilbert, M. (2011), Mapping the dimensions and characteristics of the world's technological communication capacity during the period of digitization. In Working Paper. Presented at the 9th World Telecommunication/ICT Indicators Meeting, Mauritius: International Telecommunication Union (ITU). Retrieved from http://www.itu.int/ITU-D/ict/wtim11/documents/inf/015INF-E.pdf

Hilbert, M. (2013), Technological Information Inequality as an Incessantly Moving Target: The Redistribution of Information and Communication Capacities Between 1986 and 2010. *Journal of the American Society for Information Science and Technology*. Retrieved from www.martinhilbert.net/TechInfoInequality.pdf

Hilbert, M. and P. López (2011), "The World's Technological Capacity to Store, Communicate, and Compute Information," *Science*, vol. 332, No. 6025 (PMID: 21310967), April 1. United Nations publication, sales No. 332.

Hilbert, M., López, P. and C. Vásquez (2010), "Information Societies or 'ICT Equipment Societies?' Measuring the Digital Information-Processing Capacity of a Society in Bits and Bytes," *The Information Society*, vol. 26, No. 3.

ITU (International Telecommunication Union), (2012). Measuring the Information Society 2012. Geneva: International Telecommunication Union, ITU-D. Retrieved from http://www.itu.int/ITU-D/ict/publications/idi/

Javorcik, B. S. (2011), "Migrant networks and foreign direct investment," *Journal of Development Economics*, vol. 94, No. 2.

Jensen, R. (2007), "The Digital Provide: Information (Technology), Market Performance, and Welfare in the South Indian Fisheries Sector". *Quarterly Journal of Economics*, 122(3), 879-924.

Jong, E. and C. Bogmans. (2011),"Does corruption discourage international trade?", *European Journal of Political Economy*, 27, 385-398.

Jordan, V., Galperin, H. and W. Peres (eds) (2013), *Banda ancha en América Latina: más allá de la conectividad*, Santiago, Chile, ECLAC.

Jorgenson, D. W. and K. Stiroh (1995), "Computers And Growth," *Economics of Innovation and New Technology*, vol. 3, No. 3-4.

Jorgenson, D. W. and K. Vu (2007), "Information technology and the world growth resurgence," *German Economic Review*, vol. 8, No. 2.

Marquez-Ramos, L. and I. Martinez-Zarzoso (2010), "The Effect of Technological Innovation on International Trade," No. ID 1726880, Rochester, NY, Social Science Research Network.

Márquez-Ramos, L., I. Martínez-Zarzoso and C. Suárez-Burguet (2012), "Trade policy versus trade facilitation: An application using good old OLS," *Economics - The Open-Access, Open-Assessment E-Journal*, vol. 6, No. 11.

Martinez-Zarzoso, I. and L. Marquez-Ramos (2008). "The Effect of Trade Facilitation on Sectoral Trade", *The B.E. Journal of Economic Analysis & Policy*, 8(1), 1935-1682.

Mattes, A., Meinen, P., and F. Pavel (2012), "Goods Follow Bytes: The Impact of ICT on EU Trade". SSRN Scholarly Paper No. ID 2006481, 1-25.

Minges, M. (2005), *"Evaluation of e-Readiness Indices in Latin America and the Caribbean"*. Santiago: United Nations ECLAC. Retrieved from http://www.cepal.org/SocInfo/publicaciones

Oliner, S. D. (1994), "Computers and output growth revisited: how big is the puzzle?," *Brookings Papers on Economic Activity*, vol. 1994, No. 2.

Portugal-Perez, A. and J. S. Wilson (2012), "Export Performance and Trade Facilitation Reform: Hard and Soft Infrastructure," *World Development*, vol. 40, No. 7, July .

Röller, L., and L. Waverman (2001), Telecommunications Infrastructure and Economic Development: A Simultaneous Approach. The American Economic Review, 91(4), 909-923.

Rose, Andrew K. (2004), "Do WTO members have more liberal trade policy?," *Journal of International Economics*, vol. 63, No. 2, July .

Rosenblat, T. S. and M. M. Mobius (2004), "Getting Closer or Drifting Apart?" *Quarterly Journal of Economics,* 119(3), 971-1009.

Shapiro, C., and H. R. Varian (1998), *"Information Rules: A Strategic Guide to the Network Economy".* 1st ed. Harvard Business Press.

Siegel, D. and Z. Griliches (1992), "Purchased Services, Outsourcing, Computers, and Productivity in Manufacturing," *National Bureau of Economic Research*, pg. 429–460.

Solow, R. M. (1987), 'We'd better watch out,' *New York Times* (July 12), Book Review, 36.

Subramanian, Arvind and Shang-Jin Wei (2007), "The WTO promotes trade, strongly but unevenly," *Journal of International Economics*, vol. 72, No. 1.

Timmis, J. (2012), "The Internet and International Trade in Goods", *Discussion Paper-University of Nottingham*, 12/03, 1-43.

Tinbergen, J. (1962), *"Shaping the World Economy; Suggestions for an International Economic Policy."* New York: Twentieth Century Fund.

Van Ark, B., O'Mahony, M. and M. P. Timmer (2008). The Productivity Gap between Europe and the United States: Trends and Causes. *Journal of Economic Perspectives*, 22(1), 25-44.

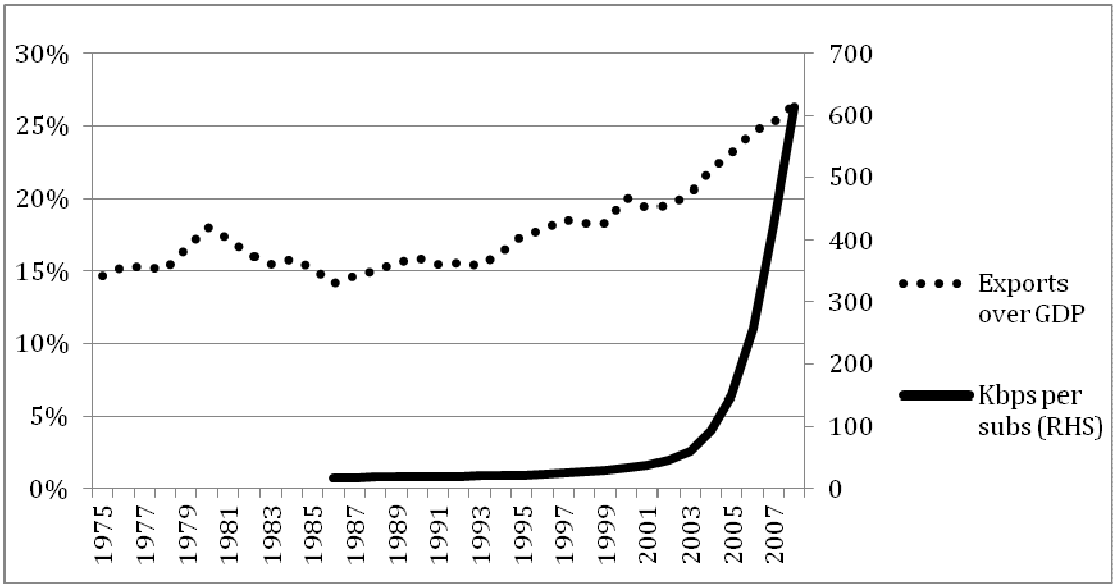
Vemuri, V. K. and S. Siddiqi (2009), "Impact of Commercialization of the Internet on International Trade: A Panel Study Using the Extended Gravity Model," *The International Trade Journal*, vol. 23, No. 4, October 14.

Vu, K. M. (2011), "ICT as a source of economic growth in the information age: Empirical evidence from the 1996–2005 period," *Telecommunications Policy*, vol. 35, No. 4, May .

APPENDIX

Graph 1

Evolution of World Trade and Internet capacity per subscriber, 1975-2007



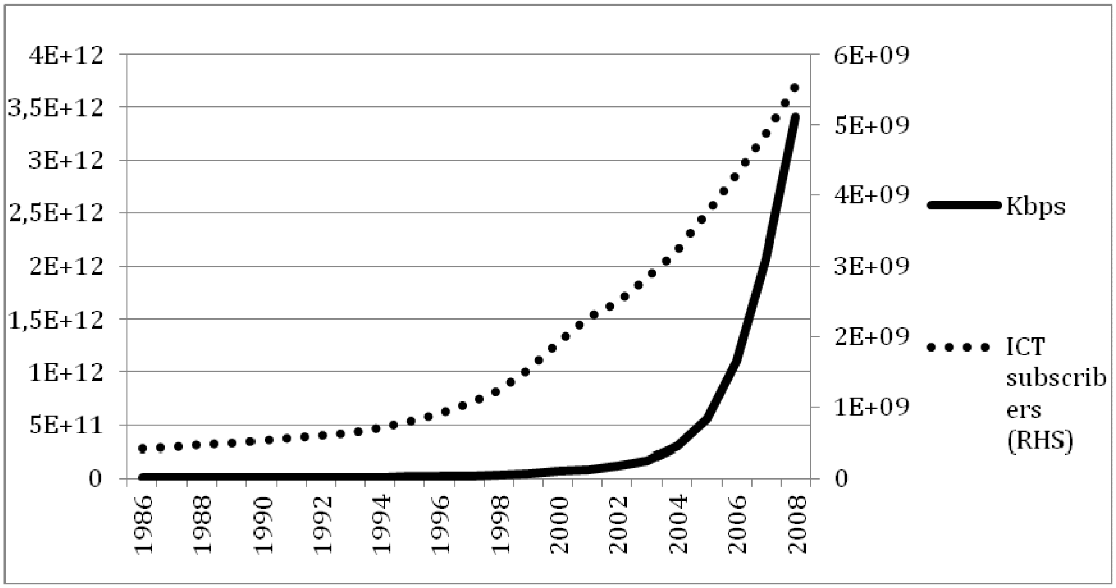
Source: own elaboration based on data from World Development Indicators, ITU and Hilbert and Lopez (2011).

World: all of the countries included in the WDI database for exports

Countries included in the ICT measure in this section: Albania, Algeria, Andorra, Angola, Antigua and Barbuda, Argentina, Armenia, Australia, Austria, Azerbaijan, Bahamas, Bahrain, Bangladesh, Barbados, Belarus, Belgium, Belize, Benin, Bermuda, Bhutan, Bolivia, Botswana, Brazil, Brunei Darussalam, Bulgaria, Burkina Faso, Burundi, Cameroon, Canada, Cape Verde, Central African Rep., Chad, Chile, China, Colombia, Comoros, Congo, Congo (Democratic Republic of the), Costa Rica, Cote d'Ivoire, Croatia, Cyprus, Czech Republic, Denmark, Djibouti, Dominica, Dominican Rep., Ecuador, Egypt, El Salvador , Equatorial Guinea, Eritrea, Estonia, Ethiopia, Fiji, Finland, France, Gabon, Gambia, Georgia, Germany, Ghana, Greece, Greenland, Grenada, Guatemala, Guinea, Guyana, Honduras, Hong Kong, China, Hungary, Iceland, India, Indonesia, Iran (Islamic Rep. of), Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kazakhstan, Kenya, Kiribati, Korea (Rep. of), Kuwait, Kyrgyzstan, Lao P.D.R., Latvia, Lebanon, Lesotho, Liberia, Liechtenstein, Lithuania, Luxembourg, Macao, China, Madagascar, Malawi, Malaysia, Mali, Malta, Mauritania, Mauritius, Mexico, Moldova, Mongolia, Morocco, Mozambique, Namibia, Nepal, Netherlands, New Zealand, Nicaragua, Niger, Nigeria, Norway, Oman, Pakistan, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Poland, Portugal, Puerto Rico, Romania, Russia, Rwanda, Saint Kitts and Nevis, Saint Lucia, Samoa, Saudi Arabia, Senegal, Seychelles, Sierra Leone, Singapore, Slovak Republic, Slovenia, South Africa, Spain, Sri Lanka, St. Vincent and the Grenadines, Sudan, Suriname, Swaziland, Sweden, Switzerland, Syria, Taiwan, Tajikistan, Tanzania, Thailand, Togo, Tonga, Trinidad and Tobago, Tunisia, Turkey, Turkmenistan, Uganda, Ukraine, United Arab Emirates, United Kingdom, United States, Uruguay, Uzbekistan, Vanuatu, Venezuela, Vietnam, Yemen, Zambia and Zimbabwe

Graph 2

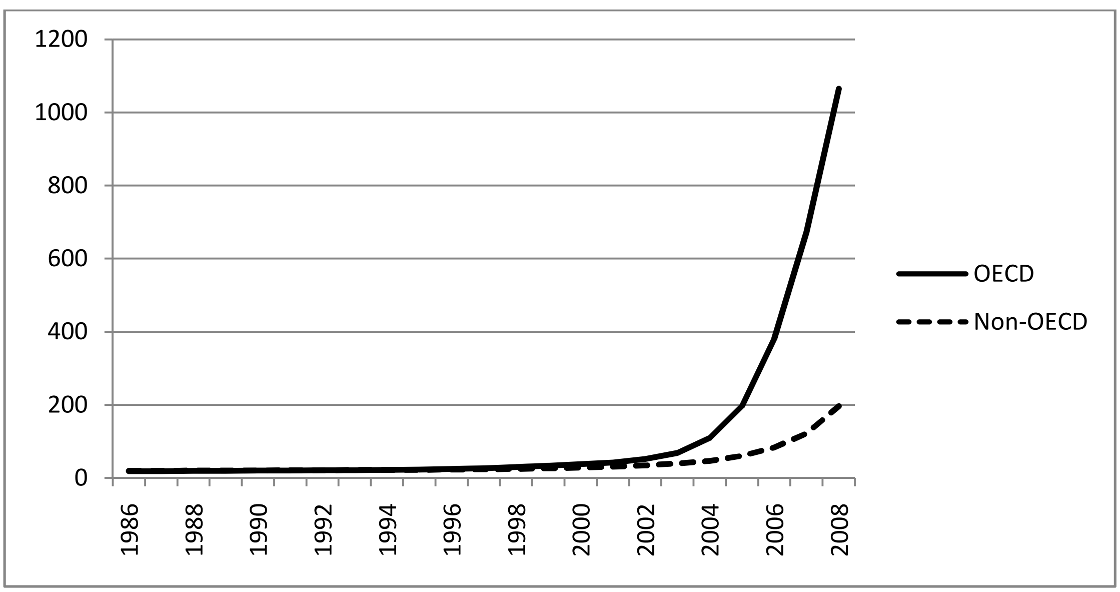
Total World's capacity versus ICT subscribers, 1986-2008



Source: own elaboration based on data from ITU and Hilbert and Lopez (2011).

Graph 3

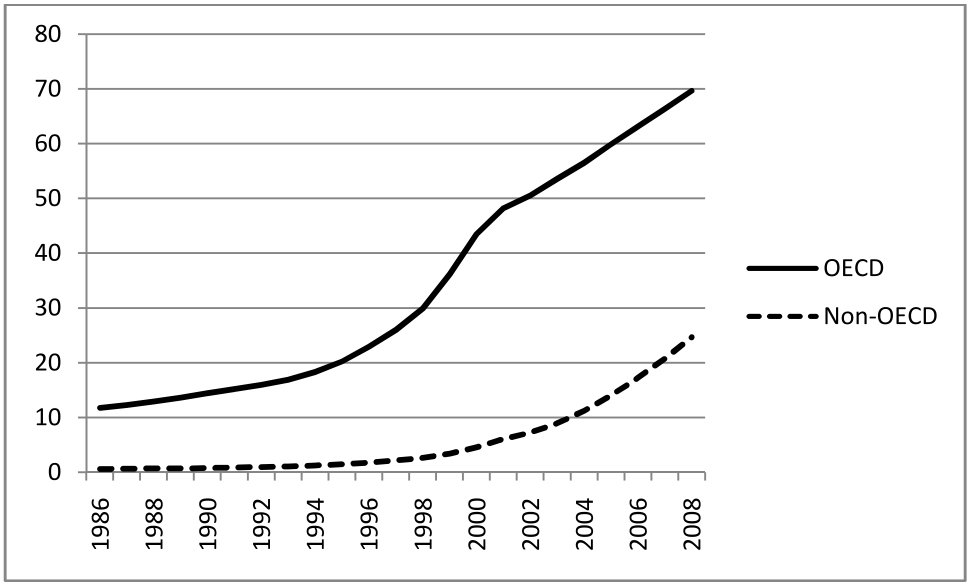
Average installed capacity per equipment (in kbps): OECD versus Non-OECD countries, 1986-2008



Source: own elaboration based on data from ITU and Hilbert and Lopez (2011).

Graph 4

Total ICTs' equipment: OECD versus Non-OECD countries, 1986-2008



Source: own elaboration based on data from ITU and Hilbert and Lopez (2011).

Chart 1

Potential effect of ICTs on International Trade

Type	**Effect of TICs**
Search Cost	ICT- supported intermediation between buyers and sellers creates an e-maketplace that lowers buyer costs to acquire information about seller prices and produce offerings. This reduces buyer search cost inefficiency (Bakos, 1997)
Management and control Cost	Monitoring employees and trading partners ensures transactions can be performed electronically by the principal, reducing cost (Gurbaxani and Whang, 1991)
Shipping Cost	ICTs reduce coordination cost, which reduces shipping cost (Gurbaxani and Whang, 1991). This reflects ICT-led reduces in supply chain management overall.
Time Cost	ICTs support communication at a lower cost; the marginal cost of communicating at any greater distance is essentially zero (Cairncross, 1997).

Source: Demirkan et al (2009)

Chart 2

Countries included in the Analysis

Albania	Burkina Faso	Ecuador	***Hungary***	Lebanon	Nicaragua	***Slovakia***	Uganda
Algeria	Cameroon	Egypt	***Iceland***	Lithuania	Niger	Slovenia	Ukraine
Argentina	***Canada***	El Salvador	India	Madagascar	Nigeria	South Africa	United Arab Emirates
Australia	Chile	Estonia	Indonesia	Malawi	***Norway***	***Spain***	***United Kingdom***
Austria	China	Ethiopia	Iran	Malaysia	Oman	Sri Lanka	***United States of America***
Azerbaijan	Colombia	***Finland***	***Ireland***	Mali	Pakistan	Sudan	Uruguay
Bahrain	Congo	***France***	Israel	Malta	Panama	Suriname	Venezuela
Bangladesh	Costa Rica	Gabon	***Italy***	Mauritania	Paraguay	***Sweden***	Vietnam
Barbados	Croatia	Georgia	Jamaica	Mauritius	Peru	***Switzerland***	Yemen
Belarus	Cyprus	***Germany***	***Japan***	***Mexico***	Philippines	Syrian Arab Republic	Zambia
Belgium	***Czech Republic***	Ghana	Jordan	Moldova, Rep.of	***Poland***	Tanzania	
Belize	Côte d'Ivoire	***Greece***	Kazakhstan	Morocco	***Portugal***	Thailand	
Benin	Dem. Rep. Congo	Guatemala	Kenya	Mozambique	Russian Fed.	Togo	
Bolivia	***Denmark***	Guinea	***Korea, Rep.***	Nepal	Saudi Arabia	Trinidad and Tobago	
Brazil	Dominica	Guyana	Kuwait	***Netherlands***	Senegal	Tunisia	
Bulgaria	Dominican Rep.	Honduras	Latvia	***New Zealand***	Singapore	***Turkey***	

Countries in red, bold and italics where the countries considered as OECD- some other countries that entered OECD later than 2007 where not considered

Chart 3

Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
ICTs	175612	96.11	237.39	17.45	3940.63
Trade	175612	568622	4606605	1	328000000
RTA	175612	0.12	0.33	0.00	1.00
Common currency	175612	0.01	0.12	0.00	1.00
Road density per capita	75618	0.009	0.001	0.0001	0.06
GDP per capita	175612	10399.02	13666.39	91.70	95200.00
ICTs difference (log)	175612	-1.50	1.54	-12.30	4.44
Distance	175612	7126.61	4369.16	10.48	19772.34
Colony	175612	0.02	0.13	0.00	1.00
Contiguity	175612	0.03	0.16	0.00	1.00
Common language	175612	0.14	0.34	0.00	1.00

Chart 4

Effects of ICTs (kbps per subscriber) on trade, including interaction with GDP per capita and technology gap.

1995-2008

	FE	Pooled OLS	FE					RE	RE BB	Mundlak
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Logtrade	Logtrade	Logtrade	Logtrade	Logtrade	Logtrade	Logtrade	Logtrade	Logtrade	Logtrade
logICTi		0.867***	-0.0402***	0.367***	0.403***	0.386***	0.338***	0.377***	0.349***	0.449***
logICTj		0.564***	-0.114***	0.058	0.070	0.0768	0.0761**	0.167**	0.156**	0.098
logICTi*logICTj				0.037***	0.028***	0.0321**	0.0303***	0.022***	0.024***	0.028***
logGDPpci	0.361***	0.654***	0.367***	0.502***	0.491***	0.503***	0.499***	0.820***	0.832***	0.502***
logGDPpcj	0.654***	0.523***	0.667***	0.752***	0.740***	0.753***	0.550***	0.816***	0.835***	0.742***
rta	0.0327***	2.070***	0.0696***	0.081***	0.0797***			0.116***		0.087***
comcur	-0.219***	0.979***	-0.134***	-0.080***	-0.087***			-0.018		-0.057**
logGDPpci*logICTi				-0.053***	-0.051***	-0.0520***	-0.0505***	-0.043***	-0.043***	-0.054***
logGDPpcj*logICTj				-0.032***	-0.030***	-0.0314***	-0.0268***	-0.034***	-0.033***	-0.032***
MRrta						0.0631***	0.0464*		0.236***	
MRcomcur						0.192***	0.111***		0.385***	
MRdiffICTs						-0.012**	-0.011**		-0.015***	
diffICTs					-0.022**			-0.017***		-0.022***
logroaddenspci							-0.019			
logroaddenspcj							0.268**			
logroaddenspci*logGDPpci							-0.008			
logroaddenspcj*logGDPpcj							-0.046***			
Yr. Dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Country pair FE	YES	NO	YES	YES	YES	YES	YES	NO	NO	NO
Observations	175,612	175,612	175,612	175,612	175,612	175,612	75,618	175,612	175,612	175,612
Number of groups	14,548	-	14,548	14,548	14,548	14,548	13,136	14,548	14,548	14,548

Driscoll-Kraay robust standard errors in parentheses, adjusted for autocorrelation of a maximum of third order and cross-sectional dependence. (8), (9) and (10) are robust standard errors clustered at the country pair level. Constant (in all specifications); logdistance, colony, common language and border (in specifications (8) to (10)) and means of the time changing variables of specification (10) were included, not reported.*** p<0.01, ** p<0.05, * p<0.1

Chart 5

Effects of ICTs' only export performance.

1995-2008

	Fixed effects					Random Effects	Mundlak
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Logtrade	Logtrade	Logtrade	Logtrade	Logtrade	Logtrade	Logtrade
logICTi	0.534***	0.531***	0.528***	0.526***		0.395***	0.555***
logGDPpci	0.490***	0.480***	0.486***	0.477***		0.746***	0.478***
rta	0.142***		0.133***		0.074***		0.089***
comcur	0.071**		0.041		0.244***		-0.176***
logGDPpci*logICTi	-0.051***	-0.049***	-0.050***	-0.049***		-0.034***	-0.050***
MRrta						0.085***	
MRcomcur						0.220***	
MRdiffICTs						-0.015***	
diffICTs					-0.020***		-0.024***
MRrtaExp		0.138***		0.139***			
MRrtaComcurExp		-0.015		-0.021			
MRdiffICTsExp		-0.029***		-0.027***			
MRlogdistance						-1.486***	
MRcommonlanguage						0.603***	
MRContiguity						0.861***	
MRcolony						1.631***	
Logdistance							-0.470***
Commonlanguage							0.147**
Contiguity							1.738***
Colony							3.236***
Yr. Dummies	YES	YES	YES	YES	YES	YES	YES
Country pair FE	YES	YES	YES	YES	YES	YES	YES
Other FE	Importer-Year	Importer-Year	Importer-5 Year	Importer-5 Year	Importer and Exporter Year	NO	NO
Observations	175,612	175,612	175,612	175,612	175,612	175,612	175,612
Number of groups	14,548	14,548	14,548	14,548	14,548	14,548	14,548

Robust standard errors clustered at the country pair level. Constant (in all specifications) and means of the time changing variables of specification (7) were included, not reported. *** p<0.01, ** p<0.05, * p<0.1

Chart 6

Effects of ICTs' according to exporter type.

1995-2008

	(1) Logtrade	(2) Logtrade	(3) Logtrade	(4) Logtrade	(5) Logtrade	(6) Logtrade	(7) Logtrade	(8) Logtrade	(9) Logtrade	(10) Logtrade	(11) Logtrade	(12) Logtrade
logICTi	-0.039***	0.371***	0.517***	0.386***	0.144***	0.007	0.082	0.026	-0.045	0.873***	0.861***	0.874***
logICTj	-0.113***	0.062	0.208**	0.077	-0.140***	0.191*	0.257**	0.208**	-0.047***	0.096	0.080	0.097
logICTi*logICTj		0.036***		0.032**		0.018*		0.013		-0.003		-0.004
logGDPpci	0.371***	0.505***	0.489***	0.503***	0.281***	0.271***	0.265***	0.270***	0.555***	0.719***	0.720***	0.719***
logGDPpcj	0.670***	0.754***	0.739***	0.753***	0.613***	0.703***	0.696***	0.701***	0.807***	0.832***	0.835***	0.832***
MRrta	0.068***	0.066***	0.065***	0.063***	0.099***	0.094***	0.093***	0.090***	0.068***	0.069***	0.070***	0.070***
MRcomcur	0.217***	0.198***	0.213***	0.192***	0.459*	0.453*	0.474*	0.453*	-0.057**	-0.057**	-0.056**	-0.057**
logGDPpci*logICTi		-0.052***	-0.049***	-0.052***		0.005	0.006	0.005		-0.082***	-0.082***	-0.082***
logGDPpcj*logICTj		-0.032***	-0.029***	-0.031***		-0.036***	-0.035***	-0.036***		-0.011*	-0.011**	-0.011*
MRdiffICTs			-0.016**	-0.012**			-0.013***	-0.012***			-0.005	-0.005
Yr. Dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Country pair FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	175,612	175,612	175,612	175,612	126,907	126,907	126,905	126,905	48,707	48,707	48,707	48,707
Number of groups	14,548	14,548	14,548	14,548	11,039	11,039	11,039	11,039	3,509	3,509	3,509	3,509
Exporter	ALL	ALL	ALL	ALL	Non-OECD	Non-OECD	Non-OECD	Non-OECD	OECD	OECD	OECD	OECD
Importer	ALL	ALL	ALL	ALL	ALL	ALL	ALL	ALL	ALL	ALL	ALL	ALL

Driscoll-Kraay robust standard errors in parentheses, adjusted for autocorrelation of a maximum of third order and cross-sectional dependence. Constant were included, not reported. *** p<0.01, ** p<0.05, * p<0.1

Chart 6 (continued)

Effects of ICTs' according to exporter type.

1995-2008

	(13) Logtrade	(14) Logtrade	(15) Logtrade	(16) Logtrade	(17) Logtrade	(18) Logtrade	(19) Logtrade	(20) Logtrade
logICTi	-0.042	1.097***	1.267***	1.103***	0.141***	0.019	0.210**	0.039
logICTj	-0.033	0.214**	0.384***	0.220**	-0.092***	-0.039	0.153	-0.019
logICTi*logICTj		0.048***		0.046***		0.049***		0.044***
logGDPpci	0.946***	1.219***	1.187***	1.218***	0.183***	0.218***	0.204***	0.217***
logGDPpcj	0.818***	0.928***	0.895***	0.927***	0.645***	0.731***	0.716***	0.729***
MRrta	0.034	0.021	0.032	0.022	0.125***	0.115***	0.119***	0.112***
MRcomcur	-0.085***	-0.083***	-0.081***	-0.081***	1.058**	1.006**	1.078**	1.015**
logGDPpci*logICTi		-0.129***	-0.119***	-0.129***		-0.010	-0.007	-0.010
logGDPpcj*logICTj		-0.048***	-0.038***	-0.048***		-0.028***	-0.024***	-0.027***
MRdiffICTs			-0.012**	-0.010**			-0.012***	-0.009**
Yr. Dummies	YES	YES	YES	YES	YES	YES	YES	YES
Country pair FE	YES	YES	YES	YES	YES	YES	YES	YES
Observations	11,368	11,368	11,368	11,368	90,071	90,071	90,069	90,069
Number of groups	812	812	812	812	8,344	8,344	8,344	8,344
Exporter	OECD	OECD	OECD	OECD	Non-OECD	Non-OECD	Non-OECD	Non-OECD
Importer	OECD	OECD	OECD	OECD	Non-OECD	Non-OECD	Non-OECD	Non-OECD

Driscoll-Kraay robust standard errors in parentheses, adjusted for autocorrelation of a maximum of third order and cross-sectional dependence. Constant were included, not reported. *** p<0.01, ** p<0.05, * p<0.1

Chart 6 (continued)

Effects of ICTs' according to exporter type.

1995-2008

	(20) Logtrade	(21) Logtrade	(22) Logtrade	(23) Logtrade	(24) Logtrade	(25) Logtrade	(26) Logtrade	(27) Logtrade	(28) Logtrade
logICTi	0.039	0.153***	0.428***	-0.203***	0.426***	-0.046*	0.717***	0.741***	0.717***
logICTj	-0.019	-0.001	0.660***	0.235	0.659***	-0.059***	0.047	0.082	0.047
logICTi*logICTj	0.044***		-0.128***		-0.128***		0.007		0.007
logGDPpci	0.217***	0.522***	0.339***	0.414***	0.339***	0.436***	0.581***	0.579***	0.581***
logGDPpcj	0.729***	0.594***	0.593***	0.638***	0.594***	0.814***	0.861***	0.856***	0.861***
MRrta	0.112***	-0.003	-0.015	-0.003	-0.015	0.070***	0.071***	0.070***	0.071***
MRcomcur	1.015**	0.116***	0.092***	0.118***	0.094***	0.167***	0.168***	0.167***	0.168***
logGDPpci*logICTi	-0.010		0.052***	0.036***	0.052***		-0.072***	-0.071***	-0.072***
logGDPpcj*logICTj	-0.027***		-0.008	-0.021	-0.008		-0.015	-0.014	-0.015
MRdiffICTs	-0.009**			-0.017***	-0.016***			-0.003	-0.003
Yr. Dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES
Country pair FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	90,069	36,836	36,836	36,836	36,836	37,339	37,339	37,339	37,339
Number of groups	8,344	2,695	2,695	2,695	2,695	2,697	2,697	2,697	2,697
Exporter	Non-OECD	Non-OECD	Non-OECD	Non-OECD	Non-OECD	OECD	OECD	OECD	OECD
Importer	Non-OECD	OECD	OECD	OECD	OECD	Non-OECD	Non-OECD	Non-OECD	Non-OECD

Driscoll-Kraay robust standard errors in parentheses, adjusted for autocorrelation of a maximum of third order and cross-sectional dependence. Constant were included, not reported. *** p<0.01, ** p<0.05, * p<0.1