

ICTs quality and quantity and the margins of trade

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ABSTRACT

Given the importance of the fixed costs of exporting, we investigate how information and communication technologies (ICTs) relate to the extensive and intensive margin of trade (the fraction of products that are exported and the market share, respectively). We use a novel dataset on the quantity and quality of ICTs, namely the number of subscriptions (per capita) and the average quality of subscriptions (bandwidth). To test this relationship, we use an augmented Gravity Model of Trade with ICTs using panel data and controlling for multilateral resistance. Regression results for 150 countries over 1995–2014 provide robust evidence that ICTs matter for the extensive margin of trade. The evidence is even stronger for developing countries in terms of quality. Although the number of subscriptions matters for the extensive margin, the *quality* matters even more. While having a device helps producers and consumers access world markets, how much information these devices can share and how stable connections are also matter.

1. Introduction

Being able to communicate with our potential - and even distant in some cases- trade partners seems like one of the main and natural things that can affect trading relationships. The international economics' literature has already established the importance of institutional linkages, such as sharing a common language or past colonial relationships (Head et al., 2010; Melitz & Toubal, 2014; Nunn & Trefler, 2014). Moreover, an increasing literature has focused on the "physical" tools that ease communication. Information and communication technologies (henceforth ICTs) have had an impact on different aspects of society and the economy, especially on international trade. The effect of ICTs on trade has been considered as a "digital dividend", resulting in more growth and employment (World Bank, 2016). As a consequence of the impact of new technologies on trade, it is estimated that trade could increase between 1.8% and 2% until 2030 (WTO, 2018).

The past literature has documented that ICTs are an important tool to get producers and consumers closer, and also to make their communications more fluent and efficient. The first aspect can be related to having a positive effect on the intensive margin of trade (how much of the same products is being traded with a partner), while the second one also on the extensive margin (the fraction of all products that are exported to a specific partner¹). To the best of our knowledge, most of the existent research that focuses on the impact of ICTs mainly

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¹ As we define it later on following Baier et al. (2014), each product will be weighted by the importance which that product has in world exports to the importer. The authors suggest that alternatively an unweighted average could be used: it would be the fraction of all products exported from the exporter to the importer.

investigates on the impact of these technologies on the volume of trade (Freund & Weinhold, 2004; Abeliangsky & Hilbert, 2017; Rodríguez-Crespo & Martínez-Zarzoso, 2019; among others). When the extensive margin is studied, it is mainly as a by-product of a two-step procedure to control for zero flows (Portugal-Perez & Wilson, 2012). The firm-level evidence has shown that companies report the lack of an adequate level of ICTs as an important obstacle to export (Fernandes et al., 2019; Kneller & Timmis, 2016; León, 2012).

How to measure the diffusion of ICTs has been subject to debates. The main approach, followed by international organizations and national bureaus of statistics, has been to collect the quantity of ICTs subscriptions. These usually evolve with the number of inhabitants and may be subject to reach its potential saturation levels, while the bandwidth levels have demonstrated to be dynamic (Hilbert, 2019). Hence, the number of subscriptions as an explanatory variable to measure ICTs diffusion may be subject to critiques, as the digital divide has shown that the capacity to access ICTs differs between countries (Billon et al., 2009). Hence, it is necessary to focus on measuring the quality of ICTs, besides the standard approach of only focusing on the number of subscriptions.

Although the reasons previously stated pose the importance of measuring the quality of ICTs, the main problem is the absence of statistics for this variable. Hilbert (2019) provides the only available source of the quality of subscriptions by collecting the kilobits per second (kbps) of installed bandwidth potential. This measure may be more accurate to assess the magnitude and implications of the digital divide. Using this data, Fig. 1 shows the evolution of the (natural logarithm) of average quality (kbps per equipment of data and voice) and the (natural logarithm) of average quality (subscriptions per capita). While we see that the quantity is reaching saturation levels, the quality is increasing steadily.

This paper aims to fill the gap in the literature by looking at whether ICTs affect total trade in the first place (updating past studies, like Liu and Nath (2013) who analyze total exports and imports; and Abeliangsky and Hilbert (2017) who focus on bilateral trade), and whether there is a differential effect for both the intensive and extensive margin. The extensive margin captures the fraction of products that are exported, while the intensive margin measures the market share. Moreover, given the lags in ICTs' adoption in developing countries, we provide further disaggregation by exporter country groups (in terms of income). In contrast to previous studies, we disaggregate the effects of ICTs on trade not only by the quantity of ICTs – number of subscribers (per capita) – but also by the (average) quality of these subscriptions. After analyzing a sample of 150 high and low- and middle-income countries during the period 1995–2014, our results suggest that ICTs quality and quantity have a positive relationship with international trade, with the coefficients of ICTs quality being slightly higher than those of ICTs quantity. We also find that these results vary by income group, being low- and middle-income countries those who benefit the most from ICTs to export a larger bundle of goods. In contrast, ICTs seem to diminish the volume of trade to a specific country.

The paper is structured as follows. Section 2 reviews the related literature. Sections 3 and 4 describe the empirical model and the data and estimation strategy, respectively. Section 5 explains the results and Section 6 concludes.

2. Literature review

2.1. Trade margins

As mentioned in the previous section, Hummels and Klenow (2005) can be considered as the seminal empirical contribution to the study of the extensive and the intensive margin of trade. Using export data for a big sample of countries and 5000 product categories, they found that the extensive margin explained two-thirds of exports of the largest countries. Therefore, this finding extends the idea that trade margins may be an important measure to explain trade specialization and complement the results provided by trade theories.

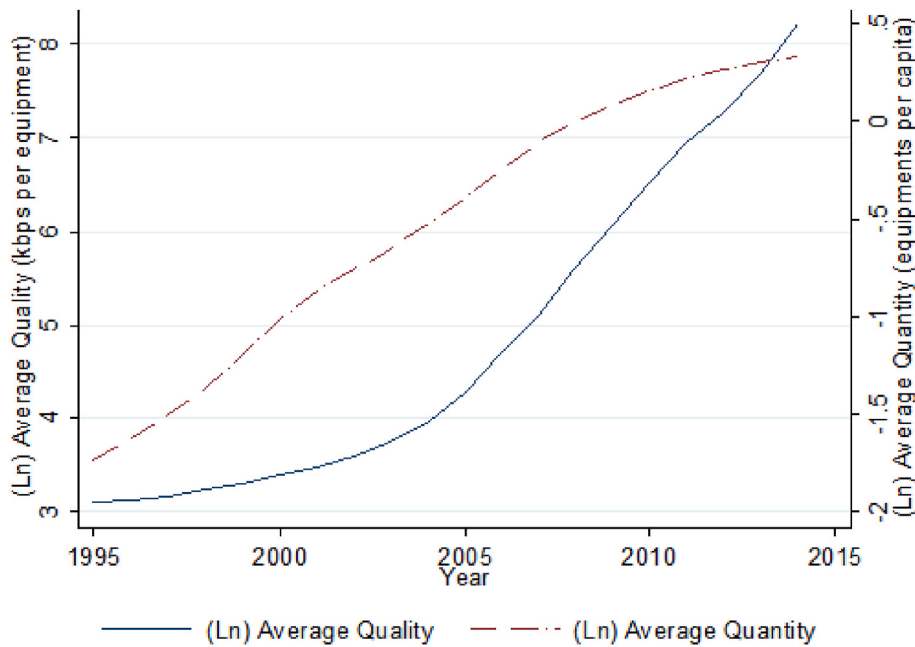
Other contributions have analyzed the extensive and the intensive margins of trade in different contexts and scenarios, or have defined other types of trade margins. At the country level, Felbermayr and Kohler (2006) describe the extensive and intensive margin as a function of trade relationships. For them, the extensive margin is related to the ability of countries to engage in trade relationships with new trading partners. In contrast, the intensive margin refers to enhancing trade relationships with current trading partners. They find that the extensive and intensive margin contribute to the increasing evidence of the positive trade effects of the WTO membership.

The study of trade margins is still far from being conclusive. According to Lucio et al. (2018), the literature has found differences across exporters, the extensive margin of trade (the number of traded products, the destination and the routine of firm-level transactions) and the intensive margins of trade (export intensity). Concerning previous studies on the effect of ICTs on trade, they have mainly focused on aggregate trade and ignored the existence of trade margins. As a consequence, the results may not be totally reflecting changeable trading patterns.

2.2. The effect of ICTs on trade

The literature on the effects of ICTs on trade presents certain similarities: firstly, a large part of the studies has traditionally focused on country-level data, analyzing the number of subscriptions. Moreover, they mostly consisted of cross-country regressions. Recent contributions have progressively introduced panel data to capture the evolution of ICTs across time. Secondly, a large number of past studies considered a bilateral trade framework that allows the inclusion of additional variables to partial out the effects of geographical determinants. Thirdly, variables measuring the number of subscriptions are the most common indicator to proxy for ICTs, as well as some subjectively composed indices.

To this date and, given the degree of data availability, the cross-country level analysis is the one with the greatest number of contributions. Although the firm level is more desirable for the analysis because firms are the agents who make the export decision, studies at the country level have followed the theoretical setting proposed by Freund and Weinhold (2004). Their theoretical model (which includes firms) provides an empirical relationship to be tested at the country-pair level, which has been used as the literature's



Source: Own elaboration based on data from Hilbert (2019).

Fig. 1. ICTs quantity and quality across time.

baseline.

Therefore, most of the past literature on the effects of ICTs on trade has been conducted at the country level. Freund and Weinhold (2002, 2004) find a positive effect of ICTs on trade, while Clarke and Wallsten (2006) find the same but with the greatest impact on exports from low to rich countries. Xing (2018) studies the effects of three ICTs variables, Internet, mobile phones and fixed phones, together with e-commerce, on trade flows, finding that both ICTs and e-commerce affects trade flows positively.

Studies using panel data tend to focus exclusively on variables measuring the subscriptions instead of the quality of ICTs or consider trade between a selected group of countries. Vemuri and Siddiqi (2009) select three ICTs variables, telephone lines, personal computers, and Internet users, to analyze their effects on trade finding a positive impact, while Lin (2015) using newer data reinforces these results. Portugal-Perez and Wilson (2012) focus on the effect of ICTs infrastructure on trade. Other panel studies introduce different novelties related to ICTs variables or the criteria to group countries. Liu and Nath (2013), using data for 40 emerging markets economies during the period 1995–2010, find that the positive effect of ICTs on trade depends on the use of ICTs (the number of internet subscriptions and internet hosts) and not on the infrastructure or capability (annual investment in telecommunications and international Internet bandwidth). Abeliánsky and Hilbert (2017) introduce both the quantity and quality of ICTs to test their effects on trade for a sample of developed and developing countries during the period 1995–2008. They find that the quality of subscriptions is more relevant for exports of developing countries, while the number of subscriptions matters more for trade between developed countries. Gnangnon and Iyer (2018) compute the distance in Internet use between a country and the world average and find that this distance is positively associated with trade in services. Rodríguez-Crespo et al. (2018) analyze the effect of three different technologies on exports: internet, mobile phones, and broadband, finding a positive effect of ICTs on trade, which varies by type of ICTs and income level. Rodríguez-Crespo and Martínez-Zarzoso (2019) find that the relationship between internet users and trade differs by income level and the degree of product sophistication.

As mentioned above, analyzing firms' ICTs levels and their export decisions would be an ideal setting for the study. However, the literature has encountered certain limitations, as data tend to be based on surveys designed for specific sectors, countries, or time periods, making difficult cross-country and time comparisons. Contributions at the firm level are scarce compared to the country level. Clarke (2008) considers firms located in developing countries, finding that telephone lines increase exports. Moreover, León (2012) highlights the importance of improving ICTs adoption as a way of removing one of the bottlenecks of the development of small and medium enterprises (henceforth SMEs) in Latin America, but no statistical analysis is conducted. Kneller and Timmis (2016) obtain a positive relationship between broadband and exports of firms in the United Kingdom. Finally, Fernandes et al. (2019) find a positive correlation between Internet and exports, even before the rise of e-commerce platforms. None of these few studies has been able to document the differential effects exerted by "quantity" and "quality" of ICTs at the firm level.

Prior studies have analyzed the effect of ICTs on total trade, without differentiating by trade margins, except for Kneller and Timmis (2016) at the firm-level for the United Kingdom. To the best of our knowledge, no studies have analyzed the effect of ICTs on trade

considering trade margins at the country-pair level. In addition, the empirical studies have not distinguished differentiated effects for the quality and quantity of ICTs on trade with a few exceptions: Liu and Nath (2013), who focus on emerging countries' aggregate exports and imports; and Abeliensky and Hilbert (2017) who look at bilateral trade flows (i.e. between countries). Hence, given the importance of disaggregating the effect of ICTs on trade by trade margins, and distinguishing between the quality and quantity of ICTs, the aim of this paper is to fill this gap in the literature.

3. Empirical model and computation of trade margins

3.1. The gravity equation of trade

The gravity model of trade is the most used tool to assess the importance of trade barriers and/or other factors explaining trade flows (Allen et al., 2020; among others). In its early use, it lacked theoretical foundations by just assuming that trade depended on the exporter's and importer's country gross domestic products (GDPs) and bilateral distance (Tinbergen, 1962). This changed with the seminal paper of Anderson and Van Wincoop (2003), who used the model to explain the "border puzzle" – why regions tend to trade more with geographical closer regions. After this seminal contribution, the regression equation derived from the model became the standard in the empirical trade literature.² Although gravity models are commonly estimated at the country level, they are micro-economically grounded at the firm level (Allen et al., 2020; Anderson, 2011; Chaney, 2008), with a representative firm capturing well the average behavior of the distribution of firms in the economy.

We define equation (1) as the baseline gravity equation for this study. In contrast to previous studies, we follow an alternative specification of the gravity equation that includes only importer-year fixed-effects.

$$\ln X_{ijt} = \beta_0 + \beta_1 \ln ICT_{it} + \beta_2 \ln GDP_{it} + \beta_3 \ln DIST_{ij} + \beta_4 RTA_{ijt} + \beta_5 CONTIG_{ij} + \beta_6 CLANG_{ij} + \beta_7 COL_{ij} + \phi_{jt} + \varepsilon_{ijt} \quad (1)$$

Subscripts i, j , and t refer to the exporter, importer country and year, respectively, while \ln denotes the natural logarithm. We define the variables as follows. X_{ijt} is the value of exports from i to j at time t (which will be replaced by EM_{ijt} for the extensive margin of trade and IM_{ijt} for the intensive margin). $\ln ICT_{ijt}$ is the logarithm of the ICTs variables at the origin country in year t . This variable is created for both the quality ($QUAL_{it}$) and the quantity of ICTs ($QUAN_{it}$). $\ln GDP_{it}$ is the GDP of the exporter country, while $\ln DIST_{ij}$ is the bilateral geographical distance that separates i and j .

We now proceed with the description of the control variables of the gravity equation. RTA_{ijt} takes value 1 if both countries i and j are members of a regional trade agreement in year t , and 0 otherwise. $CONTIG_{ij}$ takes the value 1 if both countries i and j share a common border, and 0 otherwise. $CLANG_{ij}$ takes the value 1 if both countries i and j share a common language, and 0 otherwise. COL_{ij} takes the value 1 if both countries i and j share former colonial linkages, and 0 otherwise. ϕ_{jt} are importer-year fixed-effects and they control for the so-called "multilateral resistance term" (henceforth, MRT (Anderson & Van Wincoop, 2003)) of the importer. Lastly, ε_{ijt} is the error term.

The distance and other control variables are standard in the gravity literature. ICTs are introduced since they are considered as a trade cost (Vemuri & Siddiqi, 2009; Abeliensky & Hilbert, 2017; among others). Distance has been included in gravity models since the early contributions of Tinbergen (1962), which considered that countries traded more with those countries less distant. Concerning the control variables, we follow Frankel (1997) and consider trade agreements (Baier & Bergstrand, 2007; Baier et al., 2014), institutional linkages (Nunn, 2007; Nunn & Trefler, 2014) and contiguity (Anderson & Van Wincoop, 2003; Eaton & Kortum, 2002).

Within the gravity model framework, importer-time effects partially respond to the consideration of MRTs, a pivotal element of the gravity equation as defined by Anderson and Van Wincoop (2003). MRTs capture the third-country effects (of, for example, trade liberalization) on the bilateral relationship between i and j . The omission of MRTs leads to biased estimators in the gravity equation (Anderson & Van Wincoop, 2003; Head & Mayer, 2014). Ideally, one would also want to include exporter-year fixed-effects (to control for MR of the exporter), but because our variables of interest are the ICTs of the exporter we are unable to do so.³

3.2. Trade margins and the gravity equation

To compute the trade margins, we follow the specifications from Hummels and Klenow (2005) and Baier et al. (2014). Hence, we define two additional equations (4) and (5) to compute the extensive and the intensive margin, which are denoted by EM_{ijt} and IM_{ijt} , respectively. Following Baier et al. (2014), (bilateral) trade margins are calculated by decomposing trade:

$$EM_{ijt} = \frac{\sum_{p \in P_{ijt}} X_{wjt}^p}{\sum_{p \in P_{wjt}} X_{wjt}^p} \quad (2)$$

² A static gravity model has been the standard framework to analyze trade patterns. Although dynamic gravity models have also been used assuming persistence in trade flows (Chen et al., 2018), this imposes a restriction, given that this framework is only desirable for those countries that traded extensively in the past (Kahouli, 2016).

³ Including exporter-year fixed-effects would become perfectly collinear with all variables that change at the exporter-year level, such as exporter GDP. It is equivalent to including time-invariant variables (i.e., latitude) in a fixed-effects growth regression.

$$IM_{ijt} = \frac{\sum_{p \in P_{ijt}} X_{ijt}^p}{\sum_{p \in P_{ijt}} X_{ijt}^p} \quad (3)$$

Where X_{ijt}^p refers to the value of world exports to country j of product p in year t (i.e. how much does country j import from the world of product p), and X_{ijt}^p is the value of exports of product p from country i to country j in year t . P_{ijt} denotes the set of products exported from the world to country j in year t (i.e. the bundle of products that country j imports from the world in year t), and P_{ijt} is the subset of products exported from i to j in year t .

Omitting the time dimension for a clearer explanation, the extensive margin of country i trading with j (EM_{ij}) is the value of the sum of the volume of world exports to j for the subset of the products that i exports to j , divided by the sum of the world exports to j of all existing products. The extensive margin captures the share of products that are exported from i to j , weighting each product by their importance in the basket of world exports to j .

The intensive margin of country i trading with j (IM_{ij}) is the value of the sum of the volume of exports from i to j , divided by the world exports to country j of the set of products that i exports to j . The intensive margin measures the market share of exports from country i over world exports to country j , within the subset of products that country i exports to country j .

Both margins range between 0 and 1. Countries that export small volumes of multiple products will tend to have larger values in the extensive margin and lower values in the intensive margin. In comparison, countries that are specialized in exporting large quantities of a small subset of products will have lower values on the extensive margin and higher values for the intensive margin.

Both margins have been incorporated into the gravity analysis, and there are several reasons to consider this framework. Chaney (2008) demonstrates that changes in transportation costs imply a change in the exporter's magnitude of exports and the number of exporters, which refer to the intensive and the extensive margin, respectively. Crozet and Koenig (2010) suggest that both margins help to explain and understand trade costs and frictions in the gravity equation.

Taking into account both margins of trade, we define two additional gravity equations: (4) and (5). We introduce two new dependent variables related to these margins, which were previously defined:

$$\ln EM_{ijt} = \beta_0 + \beta_1 \ln ICT_{it} + \beta_2 \ln GDP_{it} + \beta_3 \ln DIST_{ij} + \beta_4 RTA_{ijt} + \beta_5 CONTIG_{ij} + \beta_6 CLANG_{ij} + \beta_7 COL_{ij} + \phi_{jt} + \varepsilon_{ijt} \quad (4)$$

$$\ln IM_{ijt} = \beta_0 + \beta_1 \ln ICT_{it} + \beta_2 \ln GDP_{it} + \beta_3 \ln DIST_{ij} + \beta_4 RTA_{ijt} + \beta_5 CONTIG_{ij} + \beta_6 CLANG_{ij} + \beta_7 COL_{ij} + \phi_{jt} + \varepsilon_{ijt} \quad (5)$$

Baier et al. (2014) also show how total trade can be decomposed into these two margins, with the need to also control for country-destination fixed-effects (ideally one would also control for country-origin-year fixed-effects, but this is not possible because otherwise we would not be able to include our variable(s) of interest).

4. Data and estimation strategy

4.1. Data

We use bilateral trade flows from 150 countries over the period 1995–2014. Since some countries might not export to the same country each year, this yields an unbalanced sample. The data is gathered from standard sources of gravity studies, such as the World Bank, UN Comtrade, and CEPII. The extensive and intensive margins of trade are calculated using data from 5018 products categorized according to the Harmonized System (HS92). Table A1 in the Appendix shows the main descriptive statistics, Table A2 (also in the Appendix) displays the list of countries included in the study and Table S1 in the Supplementary Material the list of variables and their respective sources.

In addition, we use a novel dataset on the quality and quantity of ICTs (Hilbert, 2019), namely the number of subscriptions (per capita) and the average quality of subscriptions (bandwidth, measured in kbps). It is important to include both variables since one proxies for the *quantity* of the ICTs equipment (standardized by population size), while the other one for the *quality*. An increasing number of ICTs equipment could be good for trade, but if they are of extremely low quality, they cannot transmit much data and do not allow to communicate with clients efficiently. Given that these variables are available for the period 1995 to 2014, we have to restrict the analysis to these years. Nevertheless, this period is long enough to cover the cross-country ICTs diffusion over time, since ICTs variables register high adoption rates.

4.2. Estimation strategy

Following Abeliantsky and Hilbert (2017), we estimate equations (1), (4) and (5) using Ordinary Least Squares (OLS). We first include the measure of ICTs quality independently for each regression (total trade, extensive and intensive margin). They will be followed by further specifications, only including ICTs quantity. Finally, both variables will be included jointly to try to assess their relative importance.

In the next step, we will try to identify whether the “type” of ICTs exerts a differential effect in the different margins according to the income level of the exporting country. To do so, we will replicate the previous setup, but interacting all of the ICTs variables with a dummy for high-income countries (as defined by the World Bank in 2014) and with one for low- and middle-income countries. Since we are not strictly identifying the ICTs of the importer, we focus on whether higher ICTs of the exporter have any association with exports.

Finally, as a robustness check, we perform the same regressions as before, but we consider alternative specifications. First, we follow [Freund and Rocha \(2011\)](#) and introduce an additional variable, the remoteness index of the exporter country in year t defined as: $REM_{it} = DIST_{ij} / \left(\sum_j GDP_{jt} / GDP_{wt} \right)$. The inclusion of the remoteness variable in the gravity equation is an attempt to control for the omitted multilateral resistance of the exporter country. Secondly, we use the fixed-effects estimator. Thirdly, we estimate [Table 1](#) with the Pseudo-Poisson Maximum Likelihood estimator, as suggested by [Santos-Silva and Tenreyro \(2006\)](#), to include zeros and control for potential heteroskedasticity issues. Finally, we modify the dependent variable with an inverse hyperbolic sine transformation, which allows us to include the zeroes in the regression analysis (the logs prevented us from doing so). This transformation was used by [Bellemare and Wichman \(2020\)](#) and by [Bahar and Rapoport \(2018\)](#), who show that it is a good alternative to the log specification. With this transformation, the new dependent variable is defined as follows (we take as an example the extensive margin): $\ln EM_{ijt} = \ln(EM_{ijt} + \sqrt{1 + EM_{ijt}^2})$. For small numbers, this formula is modified to: $\ln EM_{ijt} = \ln(2) + \ln(EM_{ijt})$.^{4 5}

5. Results

5.1. ICTs and trade margins

As we can see in [Table 1](#), the ICTs variables are positive and significant (both in economic and statistical terms) for total trade and the extensive margin (columns (1), (2), (4), (5), (7) and (8)). For example, considering column (1), a 1% increase in the quality of ICTs is associated with a 0.274% increase in bilateral trade. We can observe that the estimated coefficient for the quality of ICTs is larger for these margins, compared to the quantity of ICTs. This also holds when including both ICTs variables jointly. This suggests that the quality of ICTs is another important variable to increase trade (in line with [Abeliansky and Hilbert \(2017\)](#)), and to create markets for new products.

An unexpected result is the negative effect of ICTs on the intensive margin. While we find a positive relationship between ICTs and the extensive margin, suggesting that countries increase their bundles of exported goods, we try to rationalize the negative coefficient of the intensive margin as less intensity of exports per product to a specific country. If more countries export the same good, each country will export less to a specific country since we measure things in shares. These results are consistent with the prediction of the model of [Lawless \(2010\)](#) related to the influence of trade costs on average exports. The result of a change in trade costs on average exports in her model will hinge on the relative power with which the change diminishes the entry-barriers to the market and the sales of continuing exporters (who also saw their fixed costs reduced). For example, her model foresees that if good internet networks and phones reduce the fixed costs of exporting, then they may be linked with lower average sales of firms. In addition, [Huang et al. \(2018\)](#) also find a negative effect of the internet on the intensive margin of trade of Chinese firms. Their explanation is that the extensive margin has increased the number of products and destinations a country can export to. Therefore, the average destination intensive margin would decrease (although total trade increases).⁶ The internet allows firms to export new products and increase competitiveness. These findings are in line with what [Lawless \(2010\)](#) proposes. It should also be noted that the intensive margin models are the ones that have the lowest explanatory power (as shown by the R-squared), compared to those for the extensive margin and total trade.

Concerning the standard variables of the gravity models, GDP, and distance, both of them are in line with the expected coefficients. GDP is positive and significant, and distance presents the expected negative coefficient. Concerning the control variables, all of them show the expected positive and significant coefficients. These results are robust to alternative specifications, such as (i) the inclusion of a remoteness variable whose aim is to attempt to control for multilateral resistance of the exporter; together with the importer fixed-effects ([Table A3](#) in the Appendix), and (ii) a fixed-effects estimator that assumes the existence of heterogeneity across country pairs correlated with the regressors ([Table A4](#) in the Appendix).⁷

We have also conducted additional analyses to reinforce the robustness and consistency of our baseline OLS estimator: (i) the

⁴ We have considered the trade margins as “small values” since they are between the interval of 0 and 1.

⁵ We have also analyzed the possibility that ICTs might have non-linear effects (i.e., we have added a quadratic term) and that the ICTs and trade relationship is not stable across time. While the quadratic term is significant, it is very small (i.e., for $(\ln)ICTs$ quality it is 0.00000). Regarding the interaction term between the time-trend and the ICTs variable, the interaction is also significant but close to 0 (0.007). Therefore, since we prefer a parsimonious model and to avoid the inclusion of many collinear variables (especially for the analysis of [Table 2](#)), we have decided to keep the linear model.

⁶ [Coughlin and Bandyopadhyay \(2015\)](#) find a negative effect of phones on the intensive margin of trade but do not discuss the results.

⁷ The results obtained from [Breusch and Pagan \(1980\)](#) and [Hausman \(1978\)](#) show that differences among individuals matter and conclude that a fixed-effects model is the most suitable estimator. Nevertheless, we prefer the OLS since the between variation of the ICTs quality is of 0.59 standard deviations and the within 1.49; while that of the ICTs penetration is of 1.25 standard deviations for the between and 1.25 for the within. If we were using the fixed effects, we would not be exploiting any of the cross-sectional variations, which we believe are also important.

Table 1
Total trade and trade margins for the period 1995–2014.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	$\ln X_{ijt}$	$\ln EM_{ijt}$	$\ln IM_{ijt}$	$\ln X_{ijt}$	$\ln EM_{ijt}$	$\ln IM_{ijt}$	$\ln X_{ijt}$	$\ln EM_{ijt}$	$\ln IM_{ijt}$
$\ln ICTquality_{it}$	0.274*** (0.013)	0.366*** (0.009)	-0.092*** (0.009)				0.258*** (0.012)	0.319*** (0.009)	-0.061*** (0.008)
$\ln ICTquantity_{it}$				0.096*** (0.009)	0.236*** (0.007)	-0.141*** (0.006)	0.072*** (0.009)	0.207*** (0.007)	-0.135*** (0.006)
$\ln GDP_{it}$	1.102*** (0.006)	0.710*** (0.004)	0.392*** (0.004)	1.120*** (0.006)	0.702*** (0.005)	0.418*** (0.004)	1.084*** (0.007)	0.657*** (0.005)	0.427*** (0.004)
$\ln DIST_{ij}$	-1.065*** (0.020)	-0.846*** (0.015)	-0.219*** (0.012)	-1.063*** (0.020)	-0.831*** (0.015)	-0.232*** (0.012)	-1.056*** (0.020)	-0.823*** (0.014)	-0.234*** (0.012)
RTA_{ijt}	0.766*** (0.038)	0.418*** (0.027)	0.348*** (0.024)	0.838*** (0.038)	0.485*** (0.027)	0.352*** (0.024)	0.753*** (0.038)	0.381*** (0.027)	0.372*** (0.024)
$CONTIG_{ij}$	1.114*** (0.091)	0.310*** (0.082)	0.804*** (0.048)	1.081*** (0.090)	0.333*** (0.083)	0.748*** (0.049)	1.153*** (0.091)	0.422*** (0.084)	0.731*** (0.049)
$CLANG_{ij}$	0.845*** (0.038)	0.636*** (0.028)	0.209*** (0.024)	0.830*** (0.038)	0.654*** (0.028)	0.175*** (0.024)	0.868*** (0.038)	0.702*** (0.028)	0.166*** (0.024)
COL_{ij}	0.660*** (0.087)	0.366*** (0.074)	0.294*** (0.056)	0.680*** (0.087)	0.366*** (0.074)	0.314*** (0.056)	0.644*** (0.088)	0.321*** (0.075)	0.323*** (0.056)
Constant	-11.158*** (0.218)	-15.543*** (0.158)	-12.057*** (0.138)	-10.253*** (0.229)	-13.568*** (0.164)	-13.127*** (0.144)	-10.638*** (0.227)	-14.044*** (0.163)	-13.035*** (0.143)
Observations	322,151	322,151	322,151	322,151	322,151	322,151	322,151	322,151	322,151
R-squared	0.717	0.574	0.434	0.715	0.574	0.438	0.718	0.581	0.438
Wald F	9660.69	6195.66	1901.53	9476.86	6121.97	1977.96	8419.05	5510.40	1735.92

Notes: Standard errors clustered at the country-pair level are in parentheses. ***p < 0.01, **p < 0.05, *p < 0.1. All regressions include importer-time effects.

hyperbolic sine transformation, which also allows for the inclusion of the zeroes (Table S3 in the Supplementary Material), and (ii) the PPML estimator that allows the inclusion of zeroes and controls for potential heteroskedasticity of a particular form (Table S4 in the Supplementary Material).⁸ Finally, other preliminary tests have been implemented and we find no evidence to assume the presence of unit roots.⁹

5.2. Disaggregation by income levels

In this section, we extend the previous analysis by adding interaction terms between the ICTs variables and a dummy that takes the value of one when the exporter is a high-income country and then another dummy variable that takes the value of one when the country is a low- or middle-income country. The purpose of these interactions is to measure the relative importance of the ICTs quality and quantity variables for the exporting country, according to their income level¹⁰. To this extent, we define the variable that will be interacted with the ICTs variables as *High income_{it}*, taking the value 1 for exports from a high-income country and 0 otherwise. Conversely, *LM income_{it}* takes value 1 for exports from a low- and middle-income country and 0 otherwise. These results are shown in Table 2.

We observe that when we consider overall trade, the quality of ICTs has a higher association with international trade for low- and middle-income countries,¹¹ since the high-income dummy is negative. Therefore, for the lower-income countries, an increase of 1% in the average quality of ICTs is associated with 0.389% higher trade (column (1)). The coefficient for quality is similar in size for the extensive margin, and negative for the intensive margin.¹² In the case of ICTs quantity, these are usually more important for developed economies (this is in line with previous studies (Abeliangsky & Hilbert, 2017; Rodriguez-Crespo et al., 2018, among others). Finally, considering columns (7) and (8), we find again that the quality of ICTs has a smaller effect on total exports and the extensive margin of high-income exporters, while the quantity has a higher effect for these income level countries. Overall, the elasticities for the quality of ICTs are higher than those for the quantity, and this pattern is identical when both variables appear in the same equation (columns (7)–(9)). The results of the intensive margin (columns (3), (6), and (9)) remain negative as before, but the coefficients are sometimes very close to zero. Moreover, as with Table 2, the model aiming to explain the intensive margin is the one with the lowest explanatory power (R-squared), so the pattern described in the previous results is not altered when controlling for differences in income levels.

For the rest of the variables, besides those related to ICTs, distance has the expected negative and significant coefficient. Trade agreements and the variables related to institutional linkages show a positive and significant effect across the different scenarios. GDP is also positive and statistically significant, as the standard gravity model of trade would predict.

Overall, these results are also robust to alternative specifications, such as the OLS with remoteness (Table A5 in the Appendix) and the fixed-effects model (Table A6 in the Appendix). Additionally, the estimations with the PPML estimator and the hyperbolic sine transformation can be found in Tables S4 and S5 in the Supplementary Material.

To sum up, the estimates of Table 2 reinforce the past results that the effects of ICTs on trade do not only depend on the type of ICTs variable used (Abeliangsky & Hilbert, 2017; Rodriguez-Crespo et al., 2018; Xing, 2018), but also on the trade margin considered, which constitutes the novelty of this study. Moreover, the effects also change when we consider the degree of economic development.

6. Conclusions

In this paper we study the impact of ICTs on trade distinguishing between quality and quantity of ICTs and we also incorporate the extensive and the intensive margin of trade. Our regression results from 1995 to 2014 show a positive relationship between ICTs quality and quantity and total trade, as well as for the extensive margin of trade. The latter means that ICTs facilitate the creation of new goods' markets and increase product diversification. Evidence on the intensive margin is modest and statistically significant, and mostly negative. We try to rationalize this fact by considering that while ICTs strongly favor the creation of markets for new goods for the average exporter country, this in turn decreases the average share of exports in terms of the intensive margin for the average exporter country to the average importer country.

When considering the development level of the exporter, we find that developing countries are the ones being able to reap the most benefits of improved ICTs quality, while high-income countries benefit from better access derived from ICTs equipment. This does not mean that lower-income countries won't benefit as well from more ICTs equipment, but in relative terms, the quality of ICTs would

⁸ We have also conducted the Manning and Mullahy (2001) test to evaluate the performance of the OLS versus the PPML estimator. We have done the test for columns (7), (8), and (9) of Table 1 and Table A4. The (plotted) residuals obtained under the OLS specification seem to behave "normally" (as expected). The result of the statistic is: 1.9 for total trade, 1.7 for the EM, and 1.57 for the IM (the statistic should be 2 to assume "normality"). For the PPML regressions, the statistics are: 1.95 for total trade, 1.57 for the EM, and 0.33 for the IM (the statistic should be 1 to assume that the model is accurate). Since the errors behave closer to what they are expected for the OLS regressions, we keep this as our baseline regression.

⁹ We follow Lin (2015) and compute the Fisher test for the presence of unit root with and without time trends. We have tested the variables $\ln X_{ijt}$, $\ln ICTquality_{it}$, $\ln ICTquantity_{it}$ and $\ln GDP_{it}$. For all the cases, the p-value is greater than 5%, which reject the hypothesis of unit roots. The only exception is $\ln ICTquality_{it}$ without time trends. Despite this isolated case, the evidence to reject the presence of unit roots is strong enough.

¹⁰ We used the classification of the World Bank of the year 2014 to classify countries as "high income" and "low- and middle-income". Please refer to Table A3 in the Appendix for further information.

¹¹ When we refer to "lower-income" countries we include low- and middle-income countries.

¹² For high-income countries one should also consider the income level dummy (0.044–0.582).

Table 2
Total trade and trade margins for the period 1995–2014 and exporter by income group.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	$\ln X_{ijt}$	$\ln EM_{ijt}$	$\ln IM_{ijt}$	$\ln X_{ijt}$	$\ln EM_{ijt}$	$\ln IM_{ijt}$	$\ln X_{ijt}$	$\ln EM_{ijt}$	$\ln IM_{ijt}$
$\ln ICTquality_{it}$	0.346*** (0.013)	0.342*** (0.010)	0.004 (0.009)				0.381*** (0.015)	0.366*** (0.011)	0.016 (0.010)
* $High\ income_i$	0.389*** (0.018)	0.441*** (0.013)	–0.052*** (0.013)				0.344*** (0.017)	0.368*** (0.013)	–0.024* (0.012)
* $LM\ income_i$									
$\ln ICTquantity_{it}$				0.423*** (0.030)	0.580*** (0.021)	–0.157*** (0.018)	0.129*** (0.031)	0.324*** (0.022)	–0.194*** (0.019)
* $High\ income_i$				0.131*** (0.011)	0.232*** (0.008)	–0.101*** (0.007)	0.163*** (0.012)	0.254*** (0.009)	–0.091*** (0.008)
$\ln ICTquantity_{it}$				–0.153*** (0.031)	0.044** (0.022)	–0.197*** (0.019)	–0.630*** (0.062)	–0.237*** (0.047)	–0.393*** (0.043)
* $LM\ income_i$				1.115*** (0.006)	0.688*** (0.005)	0.428*** (0.004)	1.085*** (0.007)	0.657*** (0.005)	0.429*** (0.004)
$High\ income_i$	–0.036 (0.044)	0.545*** (0.034)	–0.582*** (0.031)	–1.067*** (0.020)	–0.828*** (0.015)	–0.239*** (0.012)	–1.070*** (0.020)	–0.829*** (0.014)	–0.240*** (0.012)
$\ln GDP_{it}$	1.109*** (0.006)	0.696*** (0.005)	0.413*** (0.004)	0.812*** (0.038)	0.434*** (0.027)	0.378*** (0.024)	0.756*** (0.038)	0.380*** (0.027)	0.376*** (0.024)
$\ln DIST_{ij}$	–1.074*** (0.020)	–0.837*** (0.015)	–0.237*** (0.012)	1.095*** (0.038)	–0.828*** (0.027)	–0.239*** (0.024)	–1.070*** (0.038)	–0.829*** (0.027)	–0.240*** (0.024)
RTA_{ijt}	0.778*** (0.038)	0.419*** (0.028)	0.359*** (0.024)	0.812*** (0.038)	0.434*** (0.027)	0.378*** (0.024)	0.756*** (0.038)	0.380*** (0.027)	0.376*** (0.024)
$CONTIC_{ij}$	1.081*** (0.090)	0.335*** (0.083)	0.746*** (0.049)	1.095*** (0.091)	0.380*** (0.084)	0.715*** (0.049)	1.123*** (0.091)	0.410*** (0.084)	0.714*** (0.049)
$CLANG_{ij}$	0.841*** (0.038)	0.648*** (0.029)	0.193*** (0.024)	0.835*** (0.038)	0.664*** (0.028)	0.171*** (0.024)	0.878*** (0.038)	0.707*** (0.028)	0.172*** (0.024)
COL_{ij}	0.685*** (0.087)	0.356*** (0.075)	0.328*** (0.057)	0.676*** (0.088)	0.338*** (0.075)	0.339*** (0.056)	0.673*** (0.088)	0.335*** (0.075)	0.339*** (0.056)
Constant	–11.676*** (0.225)	–15.635*** (0.162)	–12.482*** (0.143)	–10.014*** (0.230)	–13.275*** (0.165)	–13.180*** (0.145)	–10.71*** (0.231)	–14.072*** (0.165)	–13.08*** (0.147)
Observations	322,151	322,151	322,151	322,151	322,151	322,151	322,151	322,151	322,151
R-squared	0.718	0.575	0.438	0.716	0.577	0.439	0.719	0.583	0.440

Notes: Standard errors clustered at the country-pair level are in parentheses. ***p < 0.01, **p < 0.05, *p < 0.1. All regressions include importer-time effects.

exert higher benefits in terms of export potentials. deployment.

These results pose important policy recommendations: policymakers should also factor in the potential benefits on the trade sphere derived from improving the ICTs infrastructure – the number of subscriptions *and* the quality of these subscriptions. Developing countries may promote two types of policies. On the one hand, those policies oriented to increase the number of subscribers, which require to implement educational policies and training programs at firms, tailored to Small-and Medium-Sized enterprises. On the other hand, they should also favor a greater deployment of ICTs infrastructure since rural areas located in developing countries might benefit more from having them, and the returns from this usage may be higher. Increasing the usage and quality of ICTs may be helpful to raise gains from trade and hence from globalization. These greater trade gains would contribute to reducing the economic inequalities between developing and developed countries.

To conclude, we show preliminary evidence on the importance of ICTs for the extensive margin of trade, and total trade. Further research shall consider exploring this relationship at the firm-level, with surveys including a vast number of countries and years, and delve deeper into the relationship between ICTs and the intensive margin of trade. Other lines of research shall contemplate trade in services given the strong connection between markets of goods and services (Ariu et al., 2019) and, more importantly, that ICTs increase the tradability of services (Baldwin & Forslid, 2020; WTO, 2019).

Declaration of competing interest

The authors have no competing interests to declare.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.telpol.2020.102056>.

Appendix

Table A1
Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
X_{ijt}	447,000	417843.90	4329288	0	4.54E+08
$\ln X_{ijt}$	322,151	8.36	3.73	0	19.93
$\ln X_{ijt}^*$	447,000	6.52	5.15	0	20.63
EM_{ijt}	447,000	0.12	0.21	0	1.00
$\ln EM_{ijt}$	322,151	-3.47	2.56	-17.90	0.00
$\ln EM_{ijt}^*$	447,000	-2.00	2.50	-17.21	0.69
IM_{ijt}	447,000	0.04	0.11	0	1.00
$\ln IM_{ijt}$	322,151	-4.61	2.10	-16.09	0.00
$\ln IM_{ijt}^*$	447,000	-2.82	2.50	-15.39	0.69
$\ln ICTquality_{it} * High\ income_i$	447,000	1.71	2.66	0	10.28
$\ln ICTquality_{it}$	447,000	4.49	1.60	2.85	10.28
$\ln ICTquantity_{it} * High\ income_i$	447,000	0.01	0.45	-5.17	0.94
$\ln ICTquantity_{it}$	447,000	-1.18	1.77	-7.80	0.94
$\ln GDP_{it}$	447,000	23.99	2.34	17.85	30.49
$\ln REMOTENESS_{it}$	447,000	18.92	0.25	18.64	19.56
$High\ income_i$	447,000	0.33	0.47		
$\ln DIST_{ij}$	447,000	8.71	0.78	2.35	9.90
RTA_{ijt}	447,000	0.11	0.31		
$CONTIG_{ij}$	447,000	0.02	0.14		
$CLANG_{ij}$	447,000	0.14	0.35		
COL_{ij}	447,000	0.01	0.11		

Note: * Denotes that the variable has been transformed using the hyperbolic approximation.

Table A2

List of countries (150)

Albania	Dem. Rep. of the Congo	Kuwait (*)	Rwanda
Algeria	Denmark (*)	Kyrgyzstan	Samoa
Andorra (*)	Djibouti	Lao Peoples Dem. Rep.	Saudi Arabia (*)
Angola	Dominica	Latvia (*)	Senegal
Argentina (*)	Dominican Rep.	Lebanon	Sierra Leone
Armenia	Ecuador	Liberia	Singapore (*)
Australia (*)	Egypt	Lithuania (*)	Slovakia (*)
Austria (*)	El Salvador	Madagascar	Slovenia (*)
Azerbaijan	Equatorial Guinea (*)	Malawi	Spain (*)
Bahrain (*)	Estonia (*)	Malaysia	Sri Lanka
Bangladesh	Ethiopia	Mali	Sudan
Barbados	Fiji	Malta (*)	Suriname
Belarus	Finland (*)	Mauritania	Sweden (*)
Belgium-Luxembourg (*)	France (*)	Mauritius	Switzerland (*)
Belize	Gabon	Mexico	Tajikistan
Benin	Gambia	Mongolia	Thailand
Bhutan	Georgia	Morocco	Togo
Bolivia Plurinational State of	Germany (*)	Mozambique	Tonga
Brazil	Ghana	Nepal	Trinidad and Tobago (*)
Brunei Darussalam (*)	Greece (*)	Netherlands (*)	Tunisia
Bulgaria	Guatemala	New Zealand (*)	Turkey
Burkina Faso	Guinea	Nicaragua	Turkmenistan
Burundi	Guyana	Niger	USA (*)
Cabo Verde	Honduras	Nigeria	Uganda
Cameroon	Hungary (*)	Norway (*)	Ukraine
Canada (*)	Iceland	Oman (*)	United Arab Emirates (*)
Central African Rep.	India	Pakistan	United Kingdom (*)
Chad	Indonesia	Panama	United Rep. of Tanzania
Chile (*)	Iran	Papua New Guinea	Uruguay (*)
China	Ireland (*)	Paraguay	Uzbekistan
Colombia	Israel (*)	Peru	Vanuatu
Comoros	Italy (*)	Philippines	Venezuela (*)
Congo	Jamaica	Poland (*)	Viet Nam
Costa Rica	Japan (*)	Portugal (*)	Yemen
Croatia (*)	Jordan	Rep. of Korea (*)	Zambia
Cyprus (*)	Kazakhstan	Rep. of Moldova	Zimbabwe
Czech Rep. (*)	Kenya	Romania	
Côte d'Ivoire	Kiribati	Russian Federation (*)	

(*) Refers to high-income countries according to the World Bank classification, whose total number is 48. The number of low-and middle-income countries is 102.

Table A3

Total trade and trade margins for the period 1995–2014, OLS with remoteness

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	$\ln X_{ijt}$	$\ln EM_{ijt}$	$\ln IM_{ijt}$	$\ln X_{ijt}$	$\ln EM_{ijt}$	$\ln IM_{ijt}$	$\ln X_{ijt}$	$\ln EM_{ijt}$	$\ln IM_{ijt}$
$\ln ICTquality_{it}$	0.336*** (0.013)	0.391*** (0.009)	-0.055*** (0.009)				0.319*** (0.012)	0.344*** (0.009)	-0.025*** (0.008)
$\ln ICTquantity_{it}$				0.104*** (0.009)	0.239*** (0.007)	-0.135*** (0.006)	0.075*** (0.009)	0.208*** (0.007)	-0.133*** (0.006)
$\ln GDP_{it}$	1.097*** (0.006)	0.708*** (0.004)	0.389*** (0.004)	1.122*** (0.006)	0.703*** (0.005)	0.420*** (0.004)	1.077*** (0.007)	0.654*** (0.005)	0.423*** (0.004)
$\ln DIST_{ij}$	-1.308*** (0.021)	-0.943*** (0.017)	-0.365*** (0.013)	-1.284*** (0.021)	-0.904*** (0.016)	-0.380*** (0.013)	-1.300*** (0.021)	-0.921*** (0.016)	-0.379*** (0.013)
RTA_{ijt}	0.681*** (0.038)	0.384*** (0.027)	0.297*** (0.023)	0.778*** (0.037)	0.466*** (0.027)	0.312*** (0.023)	0.667*** (0.038)	0.346*** (0.027)	0.321*** (0.023)
$CONTIG_{ij}$	0.782*** (0.091)	0.178** (0.083)	0.604*** (0.048)	0.767*** (0.091)	0.229*** (0.084)	0.539*** (0.049)	0.822*** (0.092)	0.287*** (0.085)	0.534*** (0.049)
$CLANG_{ij}$	0.665*** (0.038)	0.564*** (0.029)	0.100*** (0.024)	0.659*** (0.038)	0.598*** (0.029)	0.062** (0.024)	0.688*** (0.038)	0.628*** (0.029)	0.059** (0.024)
COL_{ij}	0.836*** (0.086)	0.436*** (0.075)	0.400*** (0.055)	0.847*** (0.086)	0.421*** (0.075)	0.426*** (0.054)	0.820*** (0.087)	0.392*** (0.076)	0.428*** (0.054)
Constant	-35.996*** (0.938)	-25.438*** (0.712)	-26.999*** (0.616)	-32.601*** (0.930)	-20.993*** (0.703)	-28.050*** (0.597)	-35.530*** (0.931)	-24.151*** (0.699)	-27.821*** (0.607)
Observations	322,151	322,151	322,151	322,151	322,151	322,151	322,151	322,151	322,151
R-squared	0.724	0.576	0.441	0.721	0.575	0.446	0.724	0.584	0.446

Notes: Standard errors clustered at the country-pair level are in parentheses. ***p < 0.01, **p < 0.05, *p < 0.1. All regressions include remoteness for the exporter country and importer-time effects.

Table A4

Total trade and trade margins for the period 1995–2014, fixed-effects estimation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	$\ln X_{ijt}$	$\ln EM_{ijt}$	$\ln IM_{ijt}$	$\ln X_{ijt}$	$\ln EM_{ijt}$	$\ln IM_{ijt}$	$\ln X_{ijt}$	$\ln EM_{ijt}$	$\ln IM_{ijt}$
$\ln ICTquality_{it}$	0.118*** (0.006)	0.028*** (0.005)	-0.022*** (0.005)				0.125*** (0.006)	0.049*** (0.005)	-0.072*** (0.005)
$\ln ICTquantity_{it}$				-0.048*** (0.009)	0.024*** (0.007)	-0.077*** (0.008)	0.015 (0.010)	0.048*** (0.008)	-0.113*** (0.008)
$\ln GDP_{it}$	0.585*** (0.018)	0.335*** (0.013)	0.044*** (0.015)	0.656*** (0.021)	0.313*** (0.016)	0.125*** (0.018)	0.568*** (0.022)	0.278*** (0.017)	0.176*** (0.019)
RTA_{ijt}	0.005 (0.020)	-0.040** (0.016)	0.158*** (0.017)	0.043** (0.020)	-0.020 (0.016)	0.123*** (0.017)	0.007 (0.020)	-0.034** (0.016)	0.144*** (0.017)
Constant	-6.871*** (0.432)	-12.085*** (0.323)	-5.215*** (0.366)	-8.315*** (0.514)	-11.411*** (0.394)	-7.418*** (0.439)	-6.441*** (0.541)	-10.681*** (0.410)	-8.494*** (0.457)
Observations	322,151	322,151	322,151	322,151	322,151	322,151	322,151	322,151	322,151
R-squared	0.203	0.069	0.044	0.201	0.068	0.045	0.203	0.069	0.046
LM test	8.7e+05 (0.000)			8.7e+05 (0.000)			8.7e+05 (0.000)		
Hausman test	8347.30 (0.000)			8405.36 (0.000)			8367.86 (0.000)		

Notes: Standard errors clustered at the country-pair level are in parentheses. ***p < 0.01, **p < 0.05, *p < 0.1. All regressions include importer-time effects varying each 5 years and have been estimated using the fixed-effects Model. LM test refers to Lagrange Multiplier test. The threshold considered for LM and Hausman test to reject the null hypothesis is 5%.

Table A5

Total trade and trade margins for the period 1995–2014 and exporter by income group, OLS with remoteness

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	$\ln X_{ijt} (^*)$	$\ln EM_{ijt} (^*)$	$\ln IM_{ijt} (^*)$	$\ln X_{ijt} (^*)$	$\ln EM_{ijt} (^*)$	$\ln IM_{ijt} (^*)$	$\ln X_{ijt} (^*)$	$\ln EM_{ijt} (^*)$	$\ln IM_{ijt} (^*)$
$\ln ICTquality_{it}$	0.370*** (0.013)	0.353*** (0.010)	0.017* (0.009)				0.375*** (0.015)	0.363*** (0.011)	0.011 (0.010)
* High income _i									
$\ln ICTquality_{it}$	0.409*** (0.018)	0.450*** (0.014)	-0.040*** (0.012)				0.371*** (0.017)	0.378*** (0.013)	-0.008 (0.012)
* LM income _i									
$\ln ICTquantity_{it}$				0.459*** (0.030)	0.594*** (0.021)	-0.135*** (0.018)	0.193*** (0.031)	0.349*** (0.022)	-0.156*** (0.019)
* High income _i									
$\ln ICTquantity_{it}$				0.107*** (0.011)	0.223*** (0.008)	-0.116*** (0.007)	0.130*** (0.012)	0.241*** (0.009)	-0.110*** (0.008)
* LM income _i									
High income _i	0.070 (0.044)	0.592*** (0.034)	-0.522*** (0.031)	0.011 (0.031)	0.108*** (0.022)	-0.098*** (0.020)	-0.304*** (0.063)	-0.107** (0.047)	-0.197*** (0.044)
$\ln GDP_{it}$	1.098*** (0.006)	0.691*** (0.005)	0.407*** (0.004)	1.109*** (0.006)	0.685*** (0.005)	0.424*** (0.004)	1.078*** (0.007)	0.654*** (0.005)	0.424*** (0.004)
$\ln DIST_{ij}$	-1.306*** (0.021)	-0.939*** (0.017)	-0.367*** (0.013)	-1.293*** (0.022)	-0.917*** (0.017)	-0.376*** (0.013)	-1.296*** (0.021)	-0.919*** (0.016)	-0.376*** (0.013)
RTA_{ijt}	0.689*** (0.038)	0.380*** (0.028)	0.309*** (0.023)	0.726*** (0.037)	0.400*** (0.027)	0.326*** (0.023)	0.670*** (0.037)	0.346*** (0.027)	0.325*** (0.023)
CONTIG _{ij}	0.775*** (0.091)	0.201** (0.083)	0.574*** (0.049)	0.794*** (0.091)	0.261*** (0.085)	0.533*** (0.050)	0.824*** (0.091)	0.290*** (0.085)	0.533*** (0.050)
CLANG _{ij}	0.668*** (0.038)	0.572*** (0.029)	0.096*** (0.024)	0.660*** (0.038)	0.595*** (0.029)	0.065*** (0.024)	0.703*** (0.038)	0.637*** (0.029)	0.066*** (0.024)
COL _{ij}	0.844*** (0.086)	0.426*** (0.075)	0.418*** (0.055)	0.830*** (0.087)	0.398*** (0.076)	0.432*** (0.055)	0.828*** (0.087)	0.396*** (0.076)	0.432*** (0.055)
Constant	-35.77*** (0.951)	-26.207*** (0.714)	-26.008*** (0.625)	-33.450*** (0.952)	-22.521*** (0.707)	-27.370*** (0.618)	-34.29*** (0.953)	-23.461*** (0.706)	-27.27*** (0.623)
Observations	322,151	322,151	322,151	322,151	322,151	322,151	322,151	322,151	322,151
R-squared	0.724	0.577	0.444	0.722	0.579	0.446	0.725	0.584	0.446

Notes: Standard errors clustered at the country-pair level are in parentheses. ***p < 0.01, **p < 0.05, *p < 0.1. All regressions include remoteness for the exporter country and importer-time effects.

Table A6

Total trade and trade margins for the period 1995–2014 and exporter by income group, fixed-effects estimation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	$\ln X_{ijt}^{(*)}$	$\ln EM_{ijt}^{(*)}$	$\ln IM_{ijt}^{(*)}$	$\ln X_{ijt}^{(*)}$	$\ln EM_{ijt}^{(*)}$	$\ln IM_{ijt}^{(*)}$	$\ln X_{ijt}^{(*)}$	$\ln EM_{ijt}^{(*)}$	$\ln IM_{ijt}^{(*)}$
$\ln ICTquality_{it}$	0.107*** (0.006)	0.020*** (0.005)	−0.007 (0.005)				0.088*** (0.007)	0.025*** (0.006)	−0.073*** (0.006)
* $High\ income_i$									
$\ln ICTquality_{it}$	0.131*** (0.008)	0.057*** (0.007)	−0.028*** (0.007)				0.144*** (0.008)	0.070*** (0.007)	−0.043*** (0.007)
* $LM\ income_i$									
$\ln ICTquantity_{it}$				0.102*** (0.020)	0.073*** (0.015)	−0.092*** (0.017)	0.147*** (0.021)	0.117*** (0.016)	−0.049*** (0.017)
* $High\ income_i$									
$\ln ICTquantity_{it}$				−0.011 (0.009)	0.042*** (0.007)	−0.097*** (0.008)	0.013 (0.010)	0.044*** (0.008)	−0.129*** (0.009)
* $LM\ income_i$									
$\ln GDP_{it}$	0.579*** (0.019)	0.319*** (0.014)	0.041*** (0.016)	0.626*** (0.021)	0.308*** (0.016)	0.124*** (0.018)	0.532*** (0.022)	0.259*** (0.017)	0.142*** (0.018)
RTA_{ijt}	0.164*** (0.020)	0.056*** (0.017)	0.091*** (0.018)	0.187*** (0.020)	0.067*** (0.017)	0.055*** (0.018)	0.160*** (0.020)	0.058*** (0.017)	0.073*** (0.018)
Constant	−6.441*** (0.461)	−11.537*** (0.350)	−5.742*** (0.385)	−6.825*** (0.518)	−10.980*** (0.395)	−7.986*** (0.441)	−5.284*** (0.536)	−10.103*** (0.408)	−8.038*** (0.449)
Observations	322,151	322,151	322,151	322,151	322,151	322,151	322,151	322,151	322,151
R-squared	0.238	0.097	0.063	0.237	0.097	0.065	0.238	0.098	0.066

Notes: Standard errors clustered at the country-pair level are in parentheses. ***p < 0.01, **p < 0.05, *p < 0.1. All regressions include importer-time effects varying each 5 years and have been estimated using the fixed-effects Model.

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