Does ICT Development Flatten the Globe? Evidence from International Trade Costs Data

Moussa Keita

Consultant, CERDI, 18 rue Eugène Jumin, 75019, Paris, **FRANCE**

*E-mail for correspondence: keitam09@ymail.com

Received: Aug 23, 2015; **Accepted:** Jan 17, 2016; **Published:** May 9, 2016

Source of Support: Nil **No Conflict of Interest:** Declared

ABSTRACT

This study attempts to bring new perspectives on the *death of distance* hypothesis by examining to what extent the intensification of ICT has contributed to attenuate the effect of distance on international trade issues. Our analysis is based on an extended gravity model constituted of 2827 country pairs observed from 2002 to 2012. The model is estimated by using the Hausman-Taylor instrumental variable approach to deal with specificities of the panel gravity models that cannot be treated in classical fixed-effect or random-effect models. The estimations confirm significant beneficial effects of ICT regarding trade costs reduction. We found that bilateral trade costs are significantly low between countries that have a more densified communication network. And this effect appears to be strongly heterogeneous regarding the distance. In particular, we found that the impact of ICT on trade costs is greater when the distance between the trading partners is more important. We also found that the elasticity of trade costs to distance decreases as the level of ICT increases. These results appear robust to various sensitivity and robustness checks and are consistent with other studies. Finally, the results obtained in this study suggest the existence of strong *distance-neutralizing* effect of ICT.

Keywords: ICT, Distance, Trade, Trade costs, infrastructure, Gravity model

JEL Classifications Code: F14 ; O33

INTRODUCTION

The recent upheavals in information and communications modes brought by the Internet and cellular technology coupled with progress in transport technologies have led many observers to argue that geographic distance will no longer be a major concern for international transactions. This vision marked the birth of the "*death of distance*" hypothesis (see Cairncross, 1997; Friedman, 2005). However, despite the optimistic nature of this assertion, its empirical foundations have been questioned in numerous studies. For example, Brun, Carrère, Guillaumont and de Melo (2005), using bilateral trade data for 130 countries from 1962 to 1996, found that the (negative) elasticity of trade to distance has been increasing significantly over time. Also Disdier and Head (2008), adopting a meta-analysis on 1,467 estimated gravity equations in 103 papers, observed that the magnitude of the coefficient associated with distance has been slightly on the rise since 1950. These results have even led some commentators to point out that distance is, in fact, not "dying" but "thriving" (Lendle et al., 2012), suggesting thus that the distance has not yet finished delivering its secrets.

Many authors have already shown that the information frictions inherent to distance are the main explanations of the trade reducing-effect of distance (Rauch, 1999; Chaney, 2011; Allen, 2011). For example, Allen (2011) shows that almost 93 percent of the relation between trade flows and distance are attributed to information frictions rather than transportation costs. In such a context, one of the questions one may legitimately ask is, if the relationship between distance and trade is established through information frictions, what then was the role played by the recent boom in information and communication technologies? Does questioning of the death of distance hypothesis mean that ICT development has failed in reducing information frictions? These questions constitute the motivation of this article in which we attempt, through empirical analysis, to give some pieces of answers.

The work is organized as follows. In the first section, we conduct a literature review in which we inventory the main theoretical and empirical works on trade cost problematic about to distance and the development of ICT. In the second section, we present the key hypotheses and the empirical framework which allow testing them.

In the third section, we present the data, the variables and descriptive statistics. The fourth section is devoted to the estimations and the discussion of results. The last section tries to draw some conclusion.

LITERATURE REVIEW

Geographic distance has been found, in many of studies, as a key determinant of trade through its influence on trade costs (Hummels, 1999; Limao and Venables, 2001; Fink et al., 2002; Kumar and Hoffmann, 2002).The trade-depressing effect of distance is largely explained by the fact that remoteness between countries exacerbates trade costs through high transportation costs and asymmetrical and incomplete information it generates. For this reason, the development of ICT is regarded as a mean for improving the efficiency of the transactional processes. This argument is supported by both theoretical predictions and empirical evidences (Malone et al., 1987; Rauch, 1999; Jensen, 2007, Aker, 2010; Goyal, 2010; Chaney, 2011; Allen, 2011).

On the theoretical side, ICT development helps to reduce transaction costs by allowing information to be communicated in real-time and at much lower price (Malone et al.,1987); by reducing the producers/retailers coordination and intermediation costs(Benjamin and Wigand, 1995) and by lowering the fixed costs associated to searching for international clients and suppliers (Yadav, 2014).

From empirical point of view, several evidences attest the beneficial impact of ICT on the trade through information costs reduction (Limao and Venables, 2001; Freund and Weinhold, 2002, Fink et al., 2002 ; Freund and Weinhold, 2004; Fink et al., 2005; Clarke and Wallsten, 2006; Vemuri and Siddiqi, 2009; Demirkan et al., 2009; Choi, 2010; Mattes et al., 2012). For example, Freund and Weinhold (2004) found that a 10% increase in the relative number of web hosts in one country leads approximately to 1% increase in bilateral trade.

In this article, we use a broadened concept of ICT that includes both telephone and internet dimensions to comprehensively capture all the effects that can pass through any individual dimension.

HYPOTHESES AND EMPIRICAL MODEL

The empirical methodology developed in this paper aims to test two main hypotheses. First, we postulate that, regardless the importance of distance, trade costs should significantly decrease as the ICT level increases. This hypothesis is based on the idea that, for a given level of the ICT development, the marginal cost of communicating at any greater distance is substantially equal to zero (see Cairncross, 1997). Secondly, we postulate that the development of the ICT capacity between two trading countries is associated with the diminishing importance of distance on their bilateral trade costs. In other words, the marginal effect of ICT on trade costs will increase as distance increases and the marginal effect of distance on trade costs will decrease as ICT increases.

In order to test these hypotheses, we build an empirical framework based on an extended version of the standard gravity model expressed by the following equation:

$$log(costs_{ijt}) = \beta_0 + \beta_1 log(distance_{ij}) + \beta_2 log(ICT_{ijt}) + \beta_3 log(distance_{ij}) \times log(ICT_{ijt}) + \beta_X X_{ij} + u_{ij} + v_t + e_{ijt} \quad (1)$$

Where $log(costs_{ijt})$ is the logarithm of bilateral trade costs between countries i and j at time t. $log(distance_{ij})$ the log of geographic distance. $log(ICT_{ijt})$ the log of ICT capacity between the two countries at time t. X_{ij} represents the vector of control variables (that we will present later); u_{ij} represents country pair specific effect, v_t the temporal effect and e_{ijt} the idiosyncratic error term. The coefficients $\beta_0, \beta_1, \beta_2, \beta_3$ and β_X are parameters to be estimated. Since all the variables in the model are in the dyadic format, the subscripts ij and ji that capture the direction of flow are symmetric and thus represent the same value.

Our main parameters of interest are β_1, β_2 and β_3. They are interpreted as elasticities since trade costs; distance and ICT are in logs. β_1 is expected to be positive ($\beta_1 > 0$) while β_2 and β_3 are expected to be negative ($\beta_2 < 0$ and $\beta_3 \leq 0$). The joint validation of these two latter conditions provides the evidence of a mitigating effect of ICT on distance. Indeed, following equation (1), the total elasticity of trade costs to distance (respectively to ICT) is expressed as follows:

$$\begin{cases} \tilde{\beta}_{distance} = \dfrac{\partial log(costs_{ijt})}{\partial log(distance_{ij})} = \beta_1 + \beta_3 log(\widetilde{ICT}) \\ \tilde{\beta}_{ICT} = \dfrac{\partial log(costs_{ijt})}{\partial log(ICT_{ijt})} = \beta_2 + \beta_3 log(\widetilde{distance}) \end{cases} \quad (2)$$

Where $\tilde{\beta}_{distance}$ and $\tilde{\beta}_{ICT}$ respectively represent the total elasticity of trade costs to distance and ICT. Equation (2) shows that the elasticity of trade costs to distance or ICT can be decomposed into two elements: an unconditional (direct) elasticity and conditional (indirect) one. The unconditional elasticity of trade cost to distance is β_1 while the conditional elasticity is β_3 because it depends on the level of ICT. Since $\beta_1 > 0$ and $\beta_3 \leq 0$, the increase in the level of $\widetilde{ICT}$ leads to a decrease of the magnitude of $\tilde{\beta}_{distance}$. In the same manner, the unconditional elasticity of trade cost to ICT is β_2 while the conditional elasticity is β_3 because it depends on distance. Since $\beta_1 > 0$ and $\beta_3 \leq 0$, the increase in the $\widetilde{distance}$ leads to increase in the magnitude of $\tilde{\beta}_{ICT}$.

DATA, VARIABLES AND DESCRIPTIVE STATISTICS

Trade costs

Broadly defined, trade costs of a good are all costs incurred in getting a good from the producer to the final user (Anderson and Wincoop, 2004). They include, in addition to policy barriers (tariffs and non-tariff), transportation costs (freight costs and time costs), contract enforcement costs, currencies use costs, legal and regulatory costs, local distribution costs and information costs. Given the generality of this definition, several indicators of trade costs have been proposed (CIF/FOB ratio, tariff or non-tariff costs, transportation costs, information costs, time costs,…). However, given the multidimensionality of trade costs, none of these single indicators can reveal the true extent of the trade costs (Chen and Novy, 2011).

In this article, we follow the long tradition of inferred trade costs methodology which consists in using indirect approaches to aggregate trade costs from observed trade flows (see Anderson and van Wincoop, 2004; Chen and Novy, 2008, Novy, 2013; Arvis et al., 2013a; Arvis et al., 2013b). The trade costs data used in this paper is extracted from the ESCAP-WB Database which provides bilateral trade costs for 2827 country pairs from 1995 to 2012. This database is constructed by Arvis et al.(2013b) according to Novy (2013) methodology in which bilateral trade costs is expressed as follows:

$$\tau_{ij} = \left(\frac{E_{ii}E_{jj}}{E_{ij}E_{ji}}\right)^{\frac{1}{2(\sigma-1)}} - 1 \qquad (3)$$

Where τ_{ij} denotes bilateral trade costs between country i and country j (in ad-valorem equivalent). E_{ij} denotes trade flow (exportation) from country i to country j. E_{ij} the trade flow (exportation) from country j to country i. E_{ii} denotes intra-national trade flow for country i (amount of production traded in the local market) while E_{jj} denotes intra-national trade flow for country j. σ is the elasticity of substitution between traded goods.

Our analysis sample includes 2827 country pairs constituted by 178 countries and spanning from 2002 to 2012. Because of space concerns, the list of countries is not reported here but still available upon request.

ICT variables

In the literature, ICT development has been apprehended in several approaches: ICT access, ICT use or a combination of the two dimensions in the shape of index. In this paper, we focus primarily on the ICT infrastructure indicators. As recognized by Tang (2006), the development of ICT infrastructure is an initial condition that increases the network capacity in the country, allowing to lower the marginal cost of connecting additional users and consequently to increase the ICT adoption.

To capture the ICT infrastructure dimension, we consider respectively the number of telephone mainlines per 100 inhabitants, the mobile network coverage in proportion to the population, the number of secure Internet servers per million inhabitants, the Internet bandwidth in Megabits per second and per Internet user and the number of personal computers per 100 inhabitants.

The first two variables reflect the building of ICT infrastructure while the remaining variables measure the country's technical capability for data transmission and communications. All the ICT indicators are extracted from ITU World Telecommunication/ICT Indicators database, except for the number of secure Internet servers that is obtained from the World Economic Forum annual Global Information Technology Reports. In the perspective of examining the robustness of our results, we envisage to supplement these infrastructure indicators by the use ones including mobile phone subscriptions per 100 inhabitants and the number of Internet users per 100 inhabitants.

Distance variables

Various distance measures have been proposed in the gravity models literature. But the most known and most used remain geodesic distance and the weighted distance (see Mayer and Zignago, 2006, 2011 for more details on these measures).

In this study, we privilege the geodesic distance calculated by using the great circle formula with longitude and latitude coordinates of the most important (most populated) cities. In this respect, we follow the commonly used approach in the gravity model literature. However the other distance measures (such as distance between capitals or weighted distance using most populated cities) are descriptively presented for illustrative purposes. All these distance variables are extracted from the CEPII Geo Dist Database.

Control variables

In order to control other aspects of trade costs that are not directly related to distance and to ICT, other explanatory variables are added to model. These control variables are essentially dummy variables capturing respectively country pair landlockedness, commonality of their official language, whether they are in regional trade agreement, whether they use common currency and whether they have a past colonial link. All these variables have been extracted from CEPII Gravity database. However, it should be noted that CEPII Gravity database provides information only till 2006. Additional information has been gathered from other sources to complete information for the remaining years for time-varying variables such as regional trade agreement (RTA) or common currency variables. For example, the RTA variable was updated using information from the WTO's Regional Trade Agreements Information System (RTA-IS).

Table I presents the descriptive statistics on the main interest variables of the study

	Descriptive statistics					
	Mean	SD	Min	Max	Growth rate*	N Obs
ICT monadic indicators	*Statistical unit: country-year*					
ICT infrastructure indicators						
Fixed telephone lines (per 100 inhbts)	22.45	19.42	0.00	79.68	3.51	61519
Mobile network coverage (per 100 inhbts)	90.65	19.02	0.00	100	0.56	64213
Secure internet servers (per million inhbts)	176.69	385.25	0.01	3025.1	27.31	64237
Internet bandwidth (MbB/s) per Internet user	48277.96	526992.1	0.00	9617645	42.05	68060
Personal computers (per 100 inhbts)	18.55	23.03	0.00	97.6	10.54	44504
ICT use indicators						
Mobile phone subscriptions (per 100 inhbts)	69.59	47.01	0.00	209.6	21.40	61641
Internet users (per 100 inhbts)	29.23	26.49	0.00	95	17.30	61372
Bilateral trade costs indicator	*Statistical unit: dyad-year*					
Total trade cost (ad-valorem equivalent, %)	269.71	154.51	0.23	2299.741	-1.34	68112
Distance indicators	*Statistical unit: dyad*					
Distance (most populated cities, km)	6877.86	4376.35	60.77	19812.04		7085
Distance (between capitals, km)	6856.18	4375.17	60.77	19812.04		7085
Distance (cities pop. weighted distance, km)	6868.67	4383.05	60.77	19650.13		7085
Contiguity (%)	3.51					6664
Traditional variables in gravity model	*Statistical unit: dyad*					
Landlocked (%)	33.95					7343
Common official language (%)	15.33					6664
Regional trade agreement (%)	16.25					6664
Common currency (%)	2.20					6664
Past colonial relation (%)	2.38					6664
* Mean average annual growth rate (in %) from 2002 to 2012						

Construction of the dyadic values of the variables

Since they are measured at individual country level, all the ICT indicators presented in Table I are in *monadic* format. These monadic values have to be transformed in dyadic ones to be able to represent the extent of bilateral communication possibilities.

In the literature, it is customary to calculate the dyadic indicator for each country pair by using the product of their monadic values (e.g Freund and Weinhold 2004; Kurihara and Fukushima, 2013, etc.). The advantage of this approach is that it allows capturing the network-effect in the ICT development. Taking for example the case of two hypothetical countries, if there exist 3 million phones in the first country and 5 million in the second country, then the number of phone call possibilities between the two countries is 15 million. One can easily notice that these 15 million phone calls need not to be simultaneous since all international phone call transactions are not necessarily realized at the same time. They are delayed in the time. Hence, the real communication capacity between two countries is the product of their individual capacity. This argumentation is thus contrary to that of Vemuri and Siddiqi (2009) who advance the simultaneity argument to justify the use of the minimum value between the two countries to capture the communication possibilities.

In this study, we derive the dyadic variables as the cross-products of the monadic indicators of each pair of countries. Hence, the variable ICT_{ijt} in equation (1) is calculated as follows:

$$ICT_{ijt} = ICT_{it} \times ICT_{jt} \qquad (4)$$

Where ICT_{ijt} is the dyadic ICT indicator between country i and country j at time t while ICT_{it} and ICT_{jt} represent respectively the monadic ICT indicator in country i and j at time t. This formula is applied for each of the five ICT infrastructure variables presented in table I.

However, we take some precautions to avoid information redundancy and multicollinearity problems in the data. In this regard, we perform multicollinearity tests on the ICT variables by using the Variance Inflation Factor indices (VIF). The high correlations between *personal_computers_ij* and the other variables combined with the high VIF on this variable have led us to exclude this variable from the analysis. The remaining variables are used in the estimations after taking them in logarithm.

ESTIMATIONS STRATEGY

Our empirical strategy is based on a panel gravity model to control for the unobservable heterogeneities that potentially bias the results. As illustrated in equation (1), the unobserved heterogeneities are captured by u_{ij} and v_t which respectively represent the country pair and the time-specific effects. Given the limitations of the classical fixed-effect and random-effect estimators, we use the Hausman and Taylor (1971) approach to estimate equation (1). The HT estimator is an instrumental variable method that allowing not only to control for the potential correlation between explanatory variables and the specific effects but also to identify the parameters of time-invariant variables. This estimator has been used in number of gravity model studies such as Brun et al.(2005), Carrère and Grigouriou (2008) or Vemuri and Siddiqi (2009).

Results

The results of our estimations are presented in Table II below. The column (1) corresponds to the results of our base estimation obtained without any interaction between ICT variables and the distance. The columns (2), (3), (4) and (5) correspond to the estimations of equation (1) by sequentially including regressors to see their individual contribution. In fact, columns (2), (3) and (4) are obtained by sequentially including interaction terms for each ICT indicator with distance. Column (5) represents the results of the final estimation in which all interaction terms are jointly included. This column constitutes our reference column since it presents the results of the full model (see Table II below).

Table II: Estimation results; dependent variable: log of total trade cost

	(1)	(2)	(3)	(4)	(5)
log(distance_ij)	0.424**	0.472**	0.756**	0.809**	0.812**
	(0.013)	(0.020)	(0.088)	(0.088)	(0.088)
fixed_phone_lines_ij	-0.069**	-0.072**	-0.070**	-0.108**	-0.117**
	(0.021)	(0.021)	(0.021)	(0.021)	(0.022)
fixed_phone_lines_ij × log(distance_ij)		-0.008**	-0.008**	-0.013**	-0.014**
		(0.002)	(0.002)	(0.002)	(0.002)
mobile_network_coverage_ij	-0.001	-0.001	-0.271**	-0.335**	-0.344**
	(0.006)	(0.006)	(0.083)	(0.083)	(0.083)
mobile_network_coverage_ij × log(distance_ij)			-0.031**	-0.039**	-0.040**
			(0.010)	(0.010)	(0.010)
secure_internet_servers_ij	-0.023**	-0.022**	-0.023**	-0.083**	-0.068**
	(0.001)	(0.001)	(0.001)	(0.004)	(0.007)
secure_internet_servers_ij × log(distance_ij)				-0.007**	-0.005**
				(0.000)	(0.001)
internet_bandwidth_ij	-0.001*	-0.001*	-0.001*	-0.002**	-0.015**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.005)
internet_bandwidth_ij × log(distance_ij)					-0.002**
					(0.001)
landlocked_ij	0.285**	0.287**	0.288**	0.287**	0.288**
	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)
common_official_language_ij	-0.019**	-0.020**	-0.021**	-0.021**	-0.022**
	(0.001)	(0.001)	(0.005)	(0.005)	(0.008)
regional_trade_agreement_ij	-0.064**	-0.064**	-0.064**	-0.047**	-0.046**
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
common_currency_ij	-0.182**	-0.183**	-0.178**	-0.163**	-0.162**
	(0.053)	(0.054)	(0.054)	(0.054)	(0.054)
past_colonial_relation_ij	-0.418**	-0.425**	-0.428**	-0.420**	-0.422**
	(0.045)	(0.045)	(0.045)	(0.045)	(0.045)
Constant	6.430**	6.015**	3.553**	3.110**	3.085**
	(0.135)	(0.184)	(0.770)	(0.769)	(0.769)
Times dummies	yes	yes	yes	yes	yes
sigma_u	0.591	0.593	0.594	0.593	0.593
sigma_e	0.163	0.163	0.163	0.163	0.163
Wald chi2	5873.6	5867.5	5869.2	6105.2	6107.1
Prob > chi2	0.000	0.000	0.000	0.000	0.000
Observations	5066	5066	5066	5066	5066
Number of dyads	9315	9315	9315	9315	9315

*Robust heteroscedasticity-consistent standard errors in parentheses, Significance levels ** p<0.01, * p<0.05*

Before moving to the discussion of the results concerning our hypotheses, a brief discussion is first done on the results obtained from the control variables. As one can see from the bottom part of Table II, the coefficients on the control variables appear, in most cases, significant and with expected sign. For example, the figures confirm that trade costs are significantly high between two countries where, at least, one is landlocked. In contrast, the variables such as common official language, regional trade agreements, common currency and past colonial relationship show negative effect suggesting that trade costs are significantly low between countries sharing strong cultural and economic ties.

Concerning the results on our main interest variables, we found that the elasticity of trade costs is about 0.8, which means that a 10 percent increase in distance between two trading partners increases trade costs by about 8%.

On the effects of ICT variables, as expected, the results show that ICT development contributes significantly to reduce bilateral trade costs. All the ICT variables included in the regressions have expected signs and significance. In the column (5) which corresponds to the results of the full model, it appears that a 10 percent increase in bilateral fixed phone capability decreases trade costs by about 1.1%. It also appears that a 10 percent increase in bilateral mobile network coverage possibility decreases trade costs by almost 3.4%. On the Internet side, we found that enhancement of internet connection capability through the number of secure servers or the bandwidth capacity significantly reduces trade costs. The elasticity of trade costs to these two ICT infrastructure indicators are respectively -0.068 and -0.015.

Concerning the existence of a mitigating effect of ICT, one can see from Table II that all the interaction terms linking ICT variables to distance appear negative and significant. These results have a double interpretation. First, they indicate that the impact of ICT on trade costs is greater when the trading distance is important (i.e. when countries are more distant from one another). Indeed, in the light of equation (2), given that the direct and indirect elasticity of trade cost with respect to ICT have the same sign (negative), then the total elasticity of trade cost increases with distance. In this sense, the distance appears as an amplifying factor for the effects of ICT. Second, the significance of the interaction terms also means that ICT play a mitigating role on the effect of distance on trade costs. Indeed, given that the direct and indirect elasticity of trade costs to the distance are of opposite signs, the total elasticity of trade costs to distance diminishes when the level of ICT increases. These results tend therefore to confirm our second hypothesis.

Sensitivity analysis and Robustness check

We conduct two sensitivity tests to examine the credibility of the results of the base estimations. In the first test, we replace the distance variable by the border contiguity variable. This is a binary variable that takes 1 if the country pair shares common border and 0 otherwise. This variable has been extracted from the CEPII Gravity database. The main idea behind the first sensitivity test is the following. If it turns out that the effect of ICT is important for more distant countries than for less distant countries, then the significances of the interaction terms would disappear for countries sharing common borders. That is to say that, for adjacent countries, the effect of ICT on trade costs should only be limited to the direct elasticity. The results of this test are presented in Table III below.

Table III: Sensitivity analysis, distance replaced by border contiguity

Dependent variable is log of total trade cost					
	(1)	(2)	(3)	(4)	(5)
contiguity	-0.896**	-0.833**	-0.994**	-1.105**	-1.105**
	(0.041)	(0.063)	(0.362)	(0.362)	(0.362)
fixed_phone_lines_ij	-0.005*	-0.004*	-0.004*	-0.005*	-0.005*
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
fixed_phone_lines_ij × contiguity		0.014	0.014	0.007	0.009
		(0.011)	(0.011)	(0.011)	(0.011)
mobile_network_coverage_ij	-0.112**	-0.101**	-0.113**	-0.120**	-0.120**
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
mobile_network_coverage_ij × contiguity			0.018	0.031	0.033
			(0.040)	(0.040)	(0.041)
secure_internet_servers_ij	-0.023**	-0.023**	-0.023**	-0.023**	-0.023**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
secure_internet_servers_ij × contiguity				0.024	0.021
				(0.034)	(0.034)
internet_bandwidth_ij	-0.001*	-0.001*	-0.001*	-0.002*	-0.014**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
internet_bandwidth_ij × contiguity					0.001
					(0.002)
Control variables	yes	yes	yes	yes	yes
Time dummies	yes	yes	yes	yes	yes
sigma_u	0.641	0.641	0.641	0.640	0.640
sigma_e	0.163	0.163	0.163	0.163	0.163
Wald chi2	5069.3	5072.1	5072.1	5169.7	5170.2
Prob > chi2	0.000	0.000	0.000	0.000	0.000
Observations	5066	5066	5066	5066	5066
Number of dyads	9315	9315	9315	9315	9315

*Robust heteroscedasticity-consistent standard errors in parentheses; Significance levels ** p<0.01, * p<0.05*

The first interesting aspect of this sensitivity analysis is the negative and significant association between contiguity and trade costs. It appears that trade costs are significantly low between countries sharing common border. In column (5) for example, the semi-elasticity of the trade cost with regard to contiguity is almost -1.10, indicating that trade costs are 1.10% lower when countries are contiguous. However, beyond the strong significance of the contiguity variable, no noticeable significance is observed on the interaction terms involving contiguity and ICT variables. These results tend therefore to reinforce the initial results.

The second sensitivity test we conduct is to compare the magnitude of the coefficients of ICT by stratifying sample into quintiles of distance. This test is based on the following idea. If it turns out that the effect of ICT is important for more distant countries than for less distant countries, then the coefficients that will be obtained for the top distance quintile must be significantly higher than the coefficients obtained for the lowest distance quintile. To examine this hypothesis, we divide the initial sample according to distance quintiles. Then we retain the two "more remote" subsamples namely the lowest quintile sub-sample (i.e. the quintile corresponding to the bottom 20% of country pairs) and the highest quintile sub-sample (i.e. the quintile corresponding to the top 20% of country pairs). The intermediate quintiles have been discarded to eliminate the possible non-monotonous effects of ICT according to the intermediate values of distance. The first quintile contains all country pairs for which distance is less than 2,640.1 Km while the fifth quintile contains all country pairs for which distance is greater than or equal to 10,681.5 km. The estimation results based on these two groups are presented in Table IV below.

Table IV: Sensitivity analysis, regressions for close and more remote countries

Dependent variable is log of total trade cost

	Lowest quintile (Distance < 2640.1 km)	Highest quintile (Distance >= 10681.5 km)
fixed_phone_lines_ij	-0.062**	-0.081**
	(0.004)	(0.004)
mobile_network_coverage_ij	-0.035*	-0.127**
	(0.016)	(0.012)
secure_internet_servers_ij	-0.005**	-0.021**
	(0.003)	(0.002)
internet_bandwidth_ij	-0.015**	-0.019**
	(0.002)	(0.002)
Control variables	yes	yes
Time dummies	yes	yes
sigma_u	0.728	0.538
sigma_e	0.161	0.154
Wald chi2	1729.3	946.63
Prob > chi2	0.000	0.000
Observations	10319	10062
Number of dyads	1859	1769

*Robust heteroscedasticity-consistent standard errors in parentheses, Significance levels ** p<0.01, * p<0.05*

As it appears in Table IV, the magnitude of the coefficients on the ICT variables is markedly higher for the top distance quintile sub-sample than for the bottom distance quintile sub-sample. Considering, for example, the variable *fixed_phone_lines*, the coefficient is -0.062 for countries whose distance is less than 2640.1km (lowest quintile) while it is about -0.081 for those whose distance is greater than 10681.5 km (highest quintile). The difference of magnitude of the coefficient is also striking for the other ICT variables (see Table IV). In final, all these sensitivity tests tend to consolidate our first results by supporting that the effects of ICT are significantly important for more distant countries.

In addition to the two sensitivity tests, we conduct some robustness checks to further examine the solidity of our results. The first test is to replace the ICT infrastructure (access) variables by the ICT use ones. Two ICT use variables have been selected for this purpose: the number of mobile phone subscription per 100 inhabitants and the number of internet users per 100 inhabitants. Our second robustness check consists in using principal component analysis (PCA) to aggregate the access and use indicators in a unique ICT index to replace the individual ICT indicators in the regressions. The results obtained from these estimations are not presented here. But they provide additional empirical arguments on the robustness of the results and reinforce the idea that the ICT development has undeniably a significant beneficial effect regarding trade costs reduction.

CONCLUSION

The results obtained in this study testify the predominance of the role of geographic distance on international trade issues. They show, for example, that a 10 percent increase in distance is associated with approximately 8 percent increase in trade costs. Given the multiplicity of the implications directly associated with distance (high transport costs, high time costs, high information costs as well as uncertainties and risks), the question of its neutralization remains a serious policy challenge. Although significant roles have already been played by the increasing sophistication of transport technologies, everything suggests that distance continues to "survive". However, given the significant beneficial effects of ICT in terms of trade cost reduction especially on the dimensions directly related to distance, the actual proliferation of ICT tools seems to hold all its promises. To main results obtained in this study support this argument. On one hand, it appears that the elasticity of trade costs to distance diminishes significantly when the level of ICT increases; attesting, thus, the existence of a distance-mitigating effect of ICT. On the other hand, the estimations show that the elasticity of trade costs to ICT increases with distance; meaning that the impact of ICT on trade costs is greater when distance between trading partners is more important.

Finally, the results obtained in this study bring new insights into the "*death of distance*" hypothesis by implicitly suggesting that the relationship between trade costs and distance would fade when a certain level of densification of IC networks is achieved. However, such a claim would be valid only if other factors are taken into account such as transport costs, which are intrinsically linked to distance and reduction of which will depend uniquely on the performance of transport technologies. For this reason, the mitigating effect of distance of ICT identified in this study should, first, be regarded as the *distance-neutralizing* effect instead of the *distance-killing* effect.

REFERENCES

Aker J., (2010) “Information from markets near and far: Mobile phones and agricultural markets in Niger”, American Economic Journal: Applied Economics, 2(3), 46-59.

Allen T., (2011), “Information Frictions in Trade”, Job-Market Paper, Yale University.

Anderson J. and Wincoop E. V.(2004), “Trade Costs”, Journal of Economic Literature, 42(3), 691-751.

Arvis J. F., Shepherd B., Duval Y. and Utoktham C., (2013a), “Trade Costs in the Developing World 1995–2010”, The World Bank Policy Research Working Paper 6309.

Arvis J. F., Shepherd B., Duval Y. and Utoktham C., (2013b), “Trade Costs and Development: A New Data Set”, The World Bank Economic Premise, January 2013, Number 104

Benjamin R. and Wigand R., (1995), “Electronic Markets and Virtual Value Chains on the Information Superhighway”, Sloan Management Review (Winter), 62-72.

Brun J.F., Carrère C., Guillaumont P. and de Melo J., (2002), “Has Distance Died? Evidence from a panel Gravity Model”, Working paper CERDI.

Cairncross F., (1997), “The Death of Distance. Cambridge: How the Communications Revolution will change our Lives”, Boston, MA: Harvard Business School Press, 1997-118.

Carrère C. and Grigoriou C., (2008), “Landlockedness, infrastructure and trade: new estimates for central asian countries”, CERDI, Etudes et Documents, E 2008.01

Chaney T., (2011), “The Gravity Equation in International Trade: an Explanation”, mimeo.

Chen N. A. and Novy D, (2011), “Gravity, trade integration, and heterogeneity across industries”, Journal of International Economics,85(2), 206-221.

Chen N. A. and Novy D., (2008), “Dennis International Trade Integration: A Disaggregated Approach” , mimeo

Chen, N. A,(2004), “Intra-National Versus International Trade in the European Union: Why Do National Borders Matter?”, Journal of International Economics 63(1), 93-118.

Choi, C., (2010), “The Effect of the Internet on Services Trade” Economic Letters (109), 102-104.

Clarke, G. R. G. and Wallsten S. J., (2006), “Has the Internet Increased Trade? Developed and Developing Country Evidence”, Economic Inquiry 44(3), 465-484.

Demirkan H., Goul M., Kauffman R.J. and Weber D.M., (2009), “Does Distance Matter? The Influence of ICT on Bilateral Trade Flows”, Proceedings of the Second Annual SIG Glob Dev Workshop, Phoenix, USA December 14.

Disdier A.-C. and Head K., (2008), “The Puzzling Persistence of the Distance Effect on Bilateral Trade”, Review of Economics and Statistics 90(1), 37-48.

Fink, C. A., Mattoo A, and NeaguI. C., (2002), “Trade in international maritime services: how much does policy matter?”, World Bank Economic Review, 16(1), 81-107.

Fink, C. A., Mattoo A, and Neagu I. C., (2005), “Assessing the impact of communication costs on international trade.” Journal of International Economics 67, 428-445.

Freund, C. and Weinhold D., (2002), “The Internet and International Trade in Services”, American Economic Review Papers and Proceedings 92 (2),236-240.

Freund, C. and Weinhold D., (2004), "The Effect of the Internet on International Trade", Journal of International Economics 62, 171-189.

Friedman, T. L., (2005), "The world is flat, A brief history of twenty-first century Farrar", Straus and Giroux.

Goyal, A., (2010), "Information, direct access to farmers, and rural market performance in central India", American Economic Journal: Applied Economics, 2(3), 22-45.

Hausman, J., and Taylor, W., (1981), "Panel Data and Unobservable Individual Effects", Econometrica 49(6), 1377-1398.

Hummels, D., (1999), "Have international transportation costs declined?" mimeographed Document, University of Chicago

Jensen, R., (2007), "The digital provide: Information (technology), market performance, and welfare in the south Indian fisheries sector", The Quarterly Journal of Economics, 122(3), 879-924.

Kumar, S. and Hoffmann, J., (2002), "Globalization – the maritime nexus", in Handbook of Maritime Economics and Business (Ed.) C. T. Grammenos, LLP, London, pp. 35–62.

Kurihara Y. and Fukushima A., (2013), "Impact of the Prevailing Internet on International Tradein Asia", Journal of Sustainable Development Studies 3(1), 1-13

Lendle A., Olarreaga M., Schropp S. and Vézina P-L., (2012), "There Goes Gravity How eBay Reduces Trade Costs", The World Bank Policy Research Working Paper 6253.

Limao, N. and Venables, A. J., (2001), "Infrastructure, geographical disadvantage and transport costs", World Bank Economic Review, 15(3), 451–479.

Malone, T.W., Yates, J. and Benjamin, R.I. (1987), "Electronic Markets and Electronic Hierarchies: Effects of information technology on market structure and corporate strategies", Communications of the ACM 30, 484–497.

Mattes A., Meinen P. and Pavel F., (2012), "Goods Follow Bytes: The Impact of ICT on EU Trade", German Institute for Economic Research Discussion Papers 1182

Mayer T. and Zignago S., (2006), "Notes on CEPII's distances measures", MPRA Paper 31243.

Mayer T. and Zignago S., (2011), "Notes on CEPII's distances measures: The Geo Dist database", CEPII Working No 2011 – 25.

Novy, D., (2013), "Gravity Redux: Measuring International Trade Costs with Panel Data", Economic Inquiry, 51(1),101-121.

Rauch J. E., (1999), "Networks versus markets in international trade", Journal of International Economics 48(1), 7-35.

Tang L., (2006), "Communication Costs and Trade of Differentiated Goods", Review of International Economics, 14(1), 54–68.

Vemuri, V.K. and Siddiqi S., (2009), "Impact of Commercialization of the Internet on International Trade: A Panel Study Using the Extended Gravity Model", International Trade Journal 23 (4): 458-484.

Yadav N., (2014), "The Role of Internet Use on International Trade: Evidence from Asian and Sub-Saharan African Enterprises", Global Economy Journal; 14(2), 189–214

--0--