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EFFECT OF INFORMATION AND COMMUNICATIONS TECHNOLOGY ON TRADE FLOWS USING GRAVITY MODEL

Farzaneh H. Hassani[a], Taghi Torabi[b], Shahriar Gharibzadeh[c]
Department of Management and Economics, Science and Research Branch
[a & b] Islamic Azad University, Iran
[c] Amirkabir University of Technology, Iran
Corresponding Author: f.hajihassani@srbiau.ac.ir

Abstract

This paper using gravity model examines the influence of some indices in terms of information and communications technology (ICT) on trade flows. In theoretical concept, we add ICT′s indices (ICT_i and ICT_j) to Anderson and van Wincoop (A-vW) (2003, 2004) gravity model. In empirical approach, in addition to GDP, population, geographical distance and some dummy variables, we expand ICT indices into three separate indices in gravity equations: telecom services investment, percentage of individuals using internet, and international internet bandwidth. We run the model in two methods for each of these indices: generalized least squares and fixed effects. Dependent variables of our study are export values and import values. Our results show that telecom services investment is more robust than two other indices and has expected signs i.e. telecom services investment in two methods has positive effect on export and import values and coefficients are significant But for percentage of internet users, some of our estimate results do not show expected signs or coefficients are not significant. The third index, i.e. international internet bandwidth, has no significant or remarkable coefficients.

Keywords: Developing Countries, import values, export values, telecom investment, internet bandwidth, percentage of internet users

Introduction

Information and communications technology (ICT) revolution has created great changes in living style. International trade is one of the most important areas that are affected by ICT. It seems that ICT can contribute to receiving "Global Village".

The experience of East Asian countries showed that they were able to reach to high development by applying outward-oriented policies with the human resources development and effective macroeconomic policies (Page, 1994; Shirani Fakhr 2008). Therefore, the positive effect of open economic policy and then increasing trade flows has remarkable effects on the economic development of countries (Eusufzai 1996; Srinivasan and Bhagwati 1999).

In 20'Th century, followed by two new trends, fundamental economic structural changes occurred by which superior economic structures were expected to arise. These two trends include: 1) globalization, in which some new markets are being introduced, and 2) the revolution in ICT. Driving forces from ICT revolution include rapid improvement in the quality, sharp decline in the prices of ICT equipments and software, the convergence in communications and computing technologies, and the swift growth in network computing (Delong and Summers 2001; Pohjola 2002; Quah 2001).

There are some indicators for calculating ICT that are used in empirical studies. For example *infostate* that has two components including *infodensity* and *infouse* is created by ORBICOM (Sciadas 2003) and international telecommunication Union (ITU) (ITU 2010, 2011) calculates data on ICT development index (IDI). In order to evaluating impact of ICT on trade flows between IRAN and some main trade partners in long time series, from 1975 to 2010 we consider telecom services investment, percentage of internet users and international internet bandwidth.. Our approach is gravity equation. Gravity equations (Linder 1961; Linnemann 1966) relate trade flows to some factors about exporter and importer countries.

In this paper, the effect of some ICT indexes on trade flows is reviewed in selected countries, during the period 1975-2010. In section 2, we discuss theoretical and experimental concepts with regard to gravity model and ICT. Section 3 presents theoretical gravity in which we try to introduce ICT indicator as a factor in trade cost. Section four is about methodology of our research and represents empirical gravity. Data acquisition and empirical results are illustrated in sections 4.1 and 4.2, respectively. Finally we discuss the results about parameters and ICT indicators in developing world.

Theoretical and experimental concepts

In some empirical studies, for analyzing the effects of different factors on trade flows, economists use Gravity Model. This model was introduced by Linder (1961), Linnemann (1966) and Poyhonen (1963). It is called gravity model for its analogy with Newton's Low. They did not explain any theoretical support for gravity model. From the second half of the 1970s, many economists tried to find theoretical basis for this model. Anderson (1979) analyzed gravity equation with differentiation equations. Bergstrand (1989, 1985) introduced monopolistic competition models. A-vW (2003) emphasized endogeneity of prices. McCallum (1995) used gravity for Canadian provinces and US states. He found that because of US-Canada border, the trade flow between provinces is much more than trade between the states and provinces. A-vW (2003) found that the effect of borders on trade between US and Canada is -44%. They maximized constant elasticity of substitution (CES) preferences subject to the budget constraint. The importance of A-vW theoretical model is adding two price indices; and in comparison with McCallum model, elasticity of distance is low in A-vW model. The reason is adding the multilateral resistance terms to A-vW. They explain this difference with size of countries and omitted variables. ICT can decrease economic barrier between countries, thereby increase foreign trade. Baier and Bergstrand (2009) obtained a simple reduced-form gravity equation which includes a theoretical relationship among bilateral trade flows, incomes, and trade costs.

In 2001, Welfens and Jungmittag applied telephone connections into gravity model. Model estimated for 12 OECD countries in 1995, 1996 and 1997 separately. Then, in 2003, they added network densities of cable, mobile phones and internet to model and ran that for 27 OECD countries and for the period of 1995-2001. Kauffman (2006) estimated gravity model for 24 transition countries and 33 trading partners for them. His estimation was restricted to only 1998 and 1999. Kauffman ran two models: first without ICT, second with ICT indicators. ICT density indicators included: product of cable telephone, internet users, mobile telephone subscriber and internet hosts. Because of multi-colinearity between ICT variables these models used a common variable for them. Introducing ICT indicator to model decreased distance coefficient. But when two countries in bilateral trade both belonged to one subgroup of transition countries, influence of ICT on trade flows did not have meaningful effect. Kaufman (2006) could not estimate panel data for absence of adequate data.

In this study, we look theoretical framework at first. In empirical research, we use some common variables for gravity model (e.g. Fidrmuc 2009; Kimura and Lee 2006). Moreover, we add telecom services investment for 1975-2010. Telecom services investment according to ITU includes: 1) fixed telephone investment, 2) fixed (wired) broadband investment, 3) mobile communication investment. Second and third series similar to Liu and Nath (2012) are percentages of individuals using the internet and international internet bandwidth, respectively. Our sample includes 7 developing countries. Analysis covers the period 1975 to 2010 for first data series. Because of data availability in ITU (2011) second series is limited to the period of 1994-2010 and third series covers 1999-2010.

Theoretical background of Gravity model

A-vW (2003) paid attention to micro basic for gravity model. A-vW model (2003) which assumes that there are *N* regions and *N* goods; each good belongs to one of regions. Also, they consider a constant-elasticity-of-substitution (CES) model for preferences of consumers. They maximize utility function subject to budget constraint and yield the demand function:

$$X_{ij} = \left(\frac{P_i t_{ij}}{P_j} \right)^{1-\sigma} Y_j \tag{3.1}$$

where X_{ij} is nominal bilateral trade flow from *i* to *j* and P_i is good's price for exporter in region *i*; t_{ij} is trade cost and Y_j is GDP of country *j*. P_j (consumer price index of *j*) is given by:

$$P_j = \left[\sum_{i=1}^{N} \left(P_i t_{ij} \right)^{1-\sigma} \right]^{1/(1-\sigma)} \tag{3.2}$$

finally:

$$X_{ij} = \left(\frac{Y_i Y_j}{Y^T} \right) \left(\frac{t_{ij}}{\pi_i P_j} \right)^{1-\sigma} \tag{3.3}$$

where

$$\pi_i = \left[\sum_{i=1}^{N} \left(\theta_j / t_{ij}^{\sigma-1} \right) P_j^{\sigma-1} \right]^{1/(1-\sigma)} \tag{3.4-a}$$

$$P_j = \left[\sum_{i=1}^{N} \left(\theta_i / t_{ij}^{\sigma-1} \right) \pi_i^{\sigma-1} \right]^{1/(1-\sigma)} \tag{3.4-b}$$

where Y^T is total income of all regions and θ_i (θ_j) is equal to Y_i / Y^T (Y_j / Y^T) and they define $\theta_j / t_{ij}^{\sigma-1}$ as the "economic density". With another assumption that is $t_{ij} = t_{ji}$ their model changes to a simple system of equations. They assume gross trade cost as: $t_{ij} \equiv DIS_{ij}^{\rho} e^{-\alpha EIA_{ij}}$ where DIS_{ij} is distance between two regions and $e^{-\alpha EIA_{ij}} = 1$, if two regions belong to an economic integration. Finally, the econometric A-vW model is:

$$\min\left(\ln\left[X_{ij} / \left(GDP_i . GDP_j \right) \right] = a_0 + a_1 \ln DIS_{ij} + a_2 EIA_{ij} - \ln P_i^{1-\sigma} - \ln P_j^{1-\sigma} + \varepsilon_{ij} \right) \tag{3.5}$$

subject to $\left(P_i^{1-\sigma} = \sum_{k=1}^{n} P_k^{1-\sigma} \left(GDP_k / GDP^T \right) e^{a_1 \ln DIS_{ij} + a_2 EIA_{ij}} \right)$ (3.6)

Where $a_0 = -\ln GDP^T$, $a_1 = -(\sigma - 1)$, and $a_2 = \alpha(\sigma - 1)$ and *n* is the number of regions. Approach of this study is entering ICT into gravity model.

Our purpose in this paper is analyzing impact of ICT on trade flows. Thus we add ICT indices to gravity model. Subject to unknown role of distance and trade costs in gravity models, we consider ICT can reduce trade costs because it is effective to reduce borders between countries. First we redefine trade costs, t_{ij}, with existence of ICT. We expect that ICT infrastructures reduce trade costs. Thus we can rewrite bilateral trade costs as $t_{ij} \equiv DIS_{ij}^{\rho} /(ICT_i.ICT_j)e^{-\alpha EIA_{ij}}$, thus Eq. (3.5) is replaced by:

$$\ln\left[X_{ij} / \left(GDP_i.GDP_j\right)\right] = \\ = a_0 + a_1 \ln DIS_{ij} - a_1 \ln ICT_i - a_1 \ln ICT_j + a_2 EIA_{ij} - \ln P_i^{1-\sigma} - \ln P_j^{1-\sigma} + \varepsilon_{ij} \quad (3.7)$$

Empirical Gravity model

We introduce the following model in which lT_{ij} isthe logarithm of nominal bilateral trade between country *i* to country *j*:

$$lT_{ij} = \beta_0 + \beta_1 lGDP_i + \beta_2 lGDP_j + \beta_3 lPOP_i + \beta_4 lPOP_j + \beta_5 lICT_i + \beta_6 lICT_j \\ + \beta_7 lDIS_{ij} + \beta_8 B_{ij} + \beta_9 LAN_{ij} + \beta_{10} MTA_{ij} + \varepsilon_{ij} \quad (4.1)$$

$lGDP_i$, $lGDP_j$: Logarithm of GDP for country *i* as importer partner and country *j* as exporter;

$lPOP_i$, $lPOP_j$: Logarithmic form of population for *i* and *j*;

$lICT_i$, $lICT_j$: Logarithm of information and communications technology for importer and exporter country respectively;

$lDIS_{ij}$: Logarithm of geographical distance between two countries;

B_{ij}, LAN_{ij}, MTA_{ij} : Dummy variables that are respectively common border, common official language and membership in a trade agreement;

ε_{ij} : Residual factor.

We use Generalized Least Square (GLS) method because of the fact that estimating with Ordinary Least Square (OLS) method shows low R^2. Residual tables and graphs indicate that cross-section residuals are serially correlated. Then $\operatorname{var}\lceil \varepsilon | x \rceil \neq \sigma^2 I$ and OLS estimators are not Best Linear Unbiased (BLU). We run also gravity model in a panel approach.

For panel approach:

$$lT_{ijt} = \beta_0 + \beta_1 lGDP_i^t + \beta_2 lGDP_j^t + \beta_3 lPOP_i^t + \beta_4 lPOP_j^t + \beta_5 lICT_i^t + \beta_6 lICT_j^t \\ + \beta_7 lDIS_{ij} + \beta_8 B_{ij} + \beta_9 LAN_{ij} + \beta_{10} MTA_{ij} + \varepsilon_{ijt} \quad (4.2)$$

where, t is time period. As Anderson (2011) mentioned, variables in gravity right hand include part of multilateral resistance that are not obvious completely; whereas, these unobservable terms are correlated with other explanatory variables. Therefore, as Anderson (2011) recommend, fixed effects model is more appropriate for this model. Expectations for the signs of parameters according to literature are as follow:

β_1 and β_2 : Positive regarding Heckscher-Ohlin theory;

β_3 and β_4 : In some studies positive and in others negative;

β_5 and β_6 : Positive for the influence of communication investment, internet users and internet bandwidth to reducing trade costs;

β_7 : Negative according to literature;

β_8 , β_9 , and β_{10} : Positive.

Data acquisition

We obtained import values from United Nations commodity trade statistics database - statistics division (UN Comtrade 2011). In this database commodities have been arranged according to "Standard International Classification" (SITC) that is promoted by United Nations to all countries. This is for comparability of statistics. Also harmonized system (HS) is used in Comtrade. UN Comtrade converts HS to SITC. We gathered total import data from "by reporter" option for extracting time series according to SITC, review 2. However about Iran, there was not any data for some years in Comtrade. Iran's import data for 1978-1996 is gathered from Commerce Company's library in Iran. Then official exchange rate series are obtained from central bank of Iran. Import values at the base of Iran currency are changed into USD ($). We use the World Development Indicators (WDI) from World Bank database (World Development Indicators 2012) to receive data on GDP and population. Data source for ICT is World Telecommunication Union indicators from International Telecommunication Union (ITU 2011). In figure 1, we can see the first twenty exporters to Iran. Between them we chose Asian countries that have potential capacity to integrate with Iran because of cultural and historical similarities.

These countries are: United Arabia Emirate, China, India, Turkey, Malaysia, Singapore and Iran.

4.2. Results

GLS and fixed effects (FE) results including telecom services investment as an independent variable are shown in table 1. Dependent variable is "total commodity imports" of the country *i* from *j* and "total commodity exports". β_1 and β_2 have positive and significant values. This is consistent with expectation for these models. Moreover, negative sign for population coefficients is in accordance with our expectation. The coefficients for telecom services investment are positive and significant. The geographical distance tends to have negative and significant coefficient. Almost of dummy variables have expected positive sign and are meaningful.

Table 2 represents estimation results for gravity model with international internet bandwidth, $lBAND_i$ ($lBAND_j$). In this model coefficients for $lBAND_i$ ($lBAND_j$) for exporter country is negative but insignificant.

Table 3 represents the percentage of internet users, $lINT_i$ ($lINT_j$) have positive effect on trade values in our sample. There is one expectation that is internet users in exporter countries for GLS method.

Discussion

In this study, we analyzed some effective variables on trade flows. We used gravity model for this purpose and redefined the role of ICT in bilateral trade cost as theoretical viewpoint. In our empirical study, sample contains 7 developing countries. Some of our key findings are:

1) In our sample, telecom services investment′s coefficients are more robust than of the percentage of internet users and international bandwidth. Similar to Liu and Nath (2012) some coefficients are negative but meaningless. It seems that the effect of international internet bandwidth on export values for exporter country is negative but coefficients are

meaningless. . Elasticity of export value subject to telecom services investment for exporter country in GLS method is 55% that is a remarkable number and for FE method is 18%. Also, elasticity's of import value subject to telecom services investment respectively in GLS and FE are 22% and 26%. We can say that in countries in our sample, investment in telecom services including fixed telephone investment, fixed (wired) broadband investment, and mobile communication investment can increase export and import values. Iran and other countries that are main trade partners of Iran in Asian economies can benefit from trade opportunities with increasing investment in sub indexes of ICT such as fixed telephone, mobile and broadband.

2) GDP has positive effect on import value for all models and this is as expectation. This finding is accordant with other researches (McCalumm 1995).

3) Population has negative influence on trade in first model that telecom services investment is a proxy for ICT. This result is in accordance with Bergestrand (1989) indicating that higher GDP per capita can increase trade. That means a negative effect from population to trade values because trade values are capital intensive.

4) Dummy variables i.e. geographical distance, common border, common official language and membership in a trade agreement show expected signs when we use telecom services investment as a proxy for ICT. Geographical distance has negative effect on trade flows that is similar to literature (Tinbergen 1962). Common border, common official language that show similarities in cultural backgrounds and membership in a trade agreement have positive effect on export and import values. When we use international internet bandwidth and percentage of internet users as dependent variable, results for dummy variables in some cases are not in expected signs but meaningless.

Obviously, results in a model which is investment in communication technologies in our sample show the most reasonable results. Trade elasticity for ICT with two other indices (*BAND*, *INT*) is low. We can consider sub indexes in ICT and see the differences between developed and developing countries. In developed countries, fixed telephone line and mobile-cellular telephony have reached saturation. However, in developing countries although fixed-line is spread, mobile-cellular telephony is increasing upward slopping (ITU 2011). The number of internet users is another important criterion for determining the amount of ICT in a country. Internet penetration was about 64 percent in the end of 2009 for developed countries, whereas in developing countries it reached 18 percent (and only 14 percent if china is excluded) (ITU 2010). One reason is limited availability of fixed broadband access (ITU 2010). The number of broadband users from organizations such as ITU has a special significance. It is important to mention that broadband has the greatest effect on people, society and the business. The first four countries that use of broadband are United States, Japan, Korea and China (UNCTAD 2005). Broadband penetration rates were 23 per 100 inhabitants in developed countries and only 4 percent in developing countries(and 2 percent excluding china) (ITU 2010). There are also large differences among developing countries. For example India started the offering of these services with very limited coverage in February 2009. In China, 3 certificates were obtained in January 2009 and the work of new infrastructure started. Thus, public and private partnerships are required to develop broadband networks and ICT infrastructures especially in developing world. Iran and its partners with increasing investment in telecom services i.e. mobile and fixed telephone lines and bandwidth internet can improve Infrastructures for ICT. This can lead to increasing trade values and more opportunities for development.

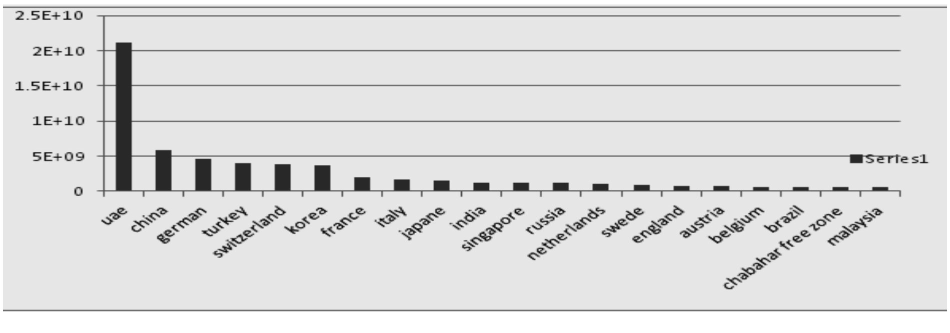

Fig.1. First twenty exporters to Iran (2010)

Table 1: Estimation results for gravity model with telecom services investment as proxy for ICT.

Parameters	Export as dependent variable		Import as dependent variable	
	GLS	FE	GLS	FE
β_0	-24.79 (-14.67)*	17.10 (2.79)	-35.27 (-14.41)	17.81 (2.88)
$lGDP_i$	1.35 (15.76)	2.19 (9.73)	1.22 (19.92)	1.90 (9.64)
$lGDP_j$	0.75 (11.24)	0.82 (3.98)	0.61 (6.33)	1.92 (10.23)
$lPOP_i$	-0.80 (-26.15)	-2.10 (-4.19)	-0.52 (-19.59)	-4.95 (-8.07)
$lPOP_j$	-0.31 (-10.16)	-2.53 (-4.53)	-0.27 (-7.88)	-1.62 (-3.09)
$** lICT_i$	0.55 (8.80)	0.18 (5.99)	0.22 (7.26)	0.26 (9.43)
$** lICT_j$	0.13 (4.12)	0.23 (8.45)	0.39 (7.89)	0.14 (5.55)
$lDIS_{ij}$	-0.59 (-19.36)	----	-0.64 (-12.49)	----
B_{ij}	0.91 (8.38)	----	0.94 (6.03)	----
LAN_{ij}	1.82 (27.17)	----	1.12 (9.93)	----
MTA_{ij}	-0.28 (-3.15)	----	0.06 (0.51)	----
R^2	0.92	0.98	0.87	0.98
F-Statistic	596.915	802.53	313.493	542.318

* t-test results are inside of parentheses
**telecom services investment

Table 2: Estimation results for gravity model with international internet bandwidth as proxy for ICT.

Parameters	export		import	
	GLS	FE	GLS	FE
β_0	-15.33 (-1.69)	-59.15 (-7.01)	-203.03 (-3.39)	-73.48 (-9.79)
$lGDP_i$	0.84 (2.84)	1.31 (5.52)	2.75 (7.50)	1.94 (8.07)
$lGDP_j$	0.92 (3.22)	1.35 (7.06)	1.64 (6.56)	1.04 (5.14)
$lPOP_i$	0.14 (0.52)	0.12 (0.39)	0.36 (0.64)	-0.06 (-0.40)
$lPOP_j$	0.19 (0.55)	0.44 (2.03)	0.88 (1.58)	0.41 (2.19)
$*lBAND_i$	-0.001 (-0.57)	-0.002 (-0.62)	0.0003 (0.13)	0.001 (0.22)
$*lBAND_j$	0.001 (0.27)	0.003 (0.63)	-0.0008 (-0.60)	-0.001 (-0.13)
$lDIS_{ij}$	-1.76 (-2.13)	-----	6.35 (0.85)	-----
B_{ij}	-0.64 (-0.46)	-----	15.13 (1.05)	-----
LAN_{ij}	-0.64 (-0.59)	-----	-20.24 (-1.58)	-----

MTA_{ij}	-0.27 (-0.26)	-----	-5.64 (-0.57)	-----
R^2	0.98	0.99	0.99	0.99
F-Statistic	2277.5	763.32	30094.19	7325.193

* international internet bandwidth

Table 3: Estimation results for gravity model with percentage of internet users as proxy for ICT.

Parameters	export		import	
	GLS	FE	GLS	FE
β_0	-16.70 (-1.72)	-34.40 (--3.84)	-225.4 (-2.32)	-53.36 (-4.78)
$lGDP_i$	0.78 (2.63)	0.42 (1.19)	2.59 (7.53)	1.75 (5.44)
$lGDP_j$	0.99 (3.51)	1.10 (3.85)	1.65 (6.48)	0.49 (1.62)
$lPOP_i$	0.41 (1.19)	0.21 (1.01)	0.41 (0.70)	-0.10 (-0.68)
$lPOP_j$	0.08 (0.22)	0.58 (3.45)	0.92 (1.70)	0.37 (2.03)
$^*lINT_i$	-0.14 (-2.06)	0.33 (3.69)	0.07 (1.00)	0.04 (0.55)
$^*lINT_j$	0.15 (2.26)	0.10 (1.17)	0.08 (1.04)	0.25 (2.67)
$lDIS_{ij}$	-1.96 (-2.01)	-----	7.13 (0.69)	-----
B_{ij}	-0.93 (-0.55)	-----	16.74 (0.79)	-----
LAN_{ij}	-0.86 (-0.78)	-----	-20.83 (-1.22)	-----
MTA_{ij}	-0.49 (-0.42)	-----	-11.43 (-0.70)	-----
R^2	0.98	0.96	0.99	.99
F-Statistic	2352.93	441.28	29212.57	7653.06

* percentage of internet users

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