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IMPACT OF THE INFORMATION AND COMMUNICATION INFRASTRACTURE ON MANUFACTURING TRADE

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Abstract

We investigate the impact of the information and communication infrastructure development (ICID) on the patterns of bilateral manufacturing trade between the developed OECD countries. More developed information and communication infrastructure provides externalities for the bilateral manufacturing trade due to a reduction in information and communication costs. We employ adapted gravity trade equations to identify the effects of the ICID on bilateral manufacturing trade. The ICID is positively associated with manufacturing trade for exporting countries, while results for importing countries are mixed. The sensitivity of the results is investigated, and the model is re-estimated estimating for the effect of the ICID on distance. The ICID causes to overcome the effects of the distance on manufacturing exports and strengthened import specialization. Gross domestic product positively effects manufacturing trade for exporters and importers. The distance cause negatively, while having a common language and regional free trade agreement membership cause positively manufacturing trade between the eighteen analyzed OECD countries.

Key Words: Information and communication, manufacturing, international trade, adapted gravity model, OECD countries

Topic Groups: Economics and business, International business

INTRODUCTION

Among possible explanation for the rise of manufacturing trade among developed countries is the decrease in transportation costs (e.g. Anderson and van Vincoop, 2004; Baier and Bergstrand, 2006). Tang (2006) offers an explanation for the increase of trade in differentiated products by the decrease in communication costs for fix telephone lines and the growing importance of mobile phones and the development of the Internet, which have changed the international communication system. Freund and Weinhold (2002, 2004) find that the development of the Internet has encouraged exports of goods and services as firms can use e-mails and websites to assist international sales at minimum cost. Bojnec and Fertő (2009, 2010) find that the development and use of the Internet have also encouraged exports of manufacturing and agro-food goods between the developed OECD countries.

This paper investigates the impact of the information and communication infrastructure development (ICID) on the patterns of bilateral manufacturing trade between the developed OECD countries. We expect that more the ICID is developed this provides also greater externalities for the bilateral manufacturing trade due to a reduction in information and communication costs. Katz and Shapiro (1985) argue that communications are subject to consumption externalities and network compatibility, while according to Harris (1995) communication costs are mainly a fixed cost. However, during the most recent years both information and communication infrastructure have developed rapidly. Tang (2006) demonstrates the decline in marginal international communication costs and its impact on the increases in the volume of trade in differentiated products. The impact of the ICID is bigger for small countries because technological advancement in information and communications allows the smaller country to overcome the existence of economies-of-scale disadvantage in communications.

The rest of the paper is organized as follows. In the next section we present the literature review on the impact of the ICID on manufacturing trade. After then we present methodology and data used focusing at the impact of the ICID on manufacturing trade in the adapted gravity regression analysis. The section, which follows, presents and discusses the regression results for alternative specifications of adapted gravity models without and with the presence of ICID. The final section gives concluding remarks and implications.

THEORY

One strand of the literature focuses on the entry costs and assumes that the ICID reduces the fixed entry cost of entering a particular market in explaining trade flows (Freund and Weinhold 2004). Baldwin (1988) argues that the fixed entry costs are sunk in explaining observed hysteresis in trade flows. Eichengreen and Irwin (1998) find the evidence that historical trade patterns play a significant role in determining current trade patterns, arguing that large entry costs are involved in setting up trade networks. The significance of sunk entry costs for export firms is argued by Roberts and Tybout (1997), and by Freund (2000) for trade flows between original members of the European Union. Quah (1999) argues that the ICID provides new way of trading information, which is changing the ways of business conduction.

Another strand of the literature focuses on the entry costs associated with imperfect information. To overcome these costs, Rauch (2001) emphasizes the importance of local networks such as the importance of family ties and Asian business groups in establishing trade links, colonial ties or a common language. Such local networks can expand the number of possible export markets in explaining trade patterns, especially for goods that do not trade on an organized exchange or have reference prices. The ICID reduces the entry costs associated with imperfect information since networks expand and improve the exchange of information. Goldberg and Knetter (1997) show the presence of imperfect competition and market segmentation in international trade. Freund and Weinhold (2004) argue that market segmentation and imperfect competition are important characteristics for markets with fixed costs. Low profits and large fixed costs discourage the export entry, but the ICIT might mitigate their effects. Fink *et al.* (2005) argue that ICID tends to reduce the marginal effort incurred in arranging the transport of any given shipment.

A market-specific fixed entry cost such as finding out information about the market, advertising the products, and establishing a distribution network, varies by foreign firms. Some firms are likely to have special information about a particular market due to the

manager contacts, relatives, friends or other unique market familiarities (Rauch and Trindade, 2000). The ICID improves market familiarities and increases trade.

This current paper aims to investigate the impact of the ICID as the determinants of the bilateral manufacturing trade flows between the eighteen OECD countries. We employ adapted gravity trade equations to identify the effects of the ICID on bilateral manufacturing trade. First, we investigate the relationship between ICID and manufacturing trade performance in the OECD countries by applying the baseline adapted gravity equation model. Second, we investigate the sensitivity of the results to the choice of ICID variable by the investigation of the ICID effects on distance. Finally, we check for the robustness of the results by comparing panel regression analysis with cross-section analysis by individual years.

METHODS

Traditional gravity trade theory points that bilateral trade (X) between host *i* and destination *j* countries in year *t* are to be positively associated with their national incomes and negatively associated with their geographical distance (e.g. Frankel and Rose, 2002). In our adapted gravity model we apply standard gravity model variables including market size (real gross domestic product (GDP)) of host *i* and destination *j* countries from the World Bank, World Development Indicators (WDI) database, geographical factors like the distance between capital cities (Distance) from the CEPII database, common cultural linkage (Language), and a dummy variable for Regional Free Trade Agreement (RFTA) membership as explanatory variables. We specify the following baseline adapted gravity model:

$$\ln X_{ij,t} = \beta_0 + \beta_1 \ln GDP_{i,t} + \beta_2 \ln GDP_{j,t} + \beta_3 \ln Distance_{ij} + \beta_4 Language_{ij} + \beta_5 RFTA_{ij} + u_t \quad (1)$$

where u_t is the stochastic element. Particularly, we are interested in for the role of the ICID variables on manufacturing trade between developed OECD countries. We employ an adapted gravity model with the ICID proxy variables:

$$\ln X_{ij,t} = \beta_0 + \beta_1 \ln GDP_{i,t} + \beta_2 \ln GDP_{j,t} + \beta_3 \ln Distance_{ij} + \beta_4 Language_{ij} + \beta_5 RFTA_{ij} + \\ + \beta_6 ICID_{i,t} + \beta_7 ICID_{j,t} + u_t \quad (2)$$

The sensitivity of the regression results on the ICID variables is investigated in two steps (Freund and Weinhold 2002, 2004). First, the model is re-estimated estimating for the effect of the ICID on the distance:

$$\ln X_{ij,t} = \beta_0 + \beta_1 \ln GDP_{i,t} + \beta_2 \ln GDP_{j,t} + \beta_3 \ln Distance_{ij} + \beta_4 Language_{ij} + \beta_5 RFTA_{ij} + \beta_6 Longdistance_{ij} + \\ \beta_7 ICID_{i,t} + \beta_8 ICID_{j,t} + \beta_9 ICID_{i,t} * Longdistance_{ij} + \beta_{10} ICID_{j,t} * Longdistance_{ij} + u_t \quad (3)$$

where a dummy variable, $Longdistance_{ij}$, equals one if the distance between countries *i* and *j* exceeds the average distance between all countries in the data sample.

Second, we specify cross-section adapted gravity model across OECD countries to check sensitivity of results:

$$\ln X_{ij,t} = \beta_0 + \beta_1 \ln Internet_{i,t} + \beta_2 \ln Internet_{j,t} + \beta_3 \ln Internet_{i,t} * Longdistance + \\ \beta_4 \ln Internet_{j,t} * Longdistance + \beta_5 \ln Fixlines_{i,t} + \beta_6 \ln Fixlines_{j,t} + \beta_7 \ln Fixlines_{i,t} * Longdistance + \\ \beta_8 \ln Fixlines_{j,t} * Longdistance + \beta_9 \ln Mobile_{i,t} + \beta_{10} \ln Mobile_{j,t} + \beta_{11} \ln Mobile_{i,t} * Longdistance + \\ \beta_{12} \ln Mobile_{j,t} * Longdistance + u_t \quad (4)$$

The trade data used is supplied by the OECD Bilateral Trade Database at the two-digit level of the ISIC in US dollars. We use data for the manufacturing trade. The sample contains 18 OECD countries[1] between 1995 and 2003 resulting 6,975 observations.

GDP is a proxy for the market size for both host exporter and destination importer countries. The $Distance_{ij}$ variable measure the geographic distance between the countries capital *i* and *j*, whereas the other dummies reflect whether *i* and *j* share: a primary language (Language) and membership in a RFTA. The variables of particular interest are the proxy variables for the ICID: Internet, fix telephone lines, and mobile phones. The data for the ICID variables are from the World Bank WDI dataset. The data on the ICID includes three proxy explanatory variables: the number of the fixed telephone lines per 1000 persons, the number of the mobile phones per 1000 persons, and the number of the Internet hosts per 1000 persons from the WDI database, respectively. We expect that the development of information and communication technology and its use have a positive impact on the bilateral manufacturing trade between the OECD countries.

FINDINGS AND DISCUSSION

Summary statistics

Table 1: Summary statistics for 28 OECD countries

	Exports (USD)	Internet	Mobile	Fixlines
1995	3,275,123	32.1	74.8	455.3
1996	3,364,382	54.9	115.1	469.1
1997	3,506,367	95.2	167.3	491.0
1998	3,684,359	145.4	249.7	501.0
1999	3,856,899	215.1	386.7	513.6
2000	4,089,174	278.7	541.7	520.7
2001	3,944,070	321.0	651.3	517.5
2002	4,074,986	369.7	710.5	508.9
2003	4,606,636	413.3	775.0	510.4

Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, South Korea, Mexico, the Netherlands, New Zeeland, Norway, Poland, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States of America.

Source: Own calculations on the basis of the World Bank World Development Indicators.

Manufacturing trade between the OECD countries has increased over time in nominal and real terms when evidence in Table 1 is deflated for the USD inflation. Among the ICID variables, the rapid increase is seen for the Internet hosts and the number of mobile phones per 1000 persons, while the number of fix telephone lines per 1000 persons have stabilised. This implies that mobile phones have also substituted the use of fix telephone lines.

The baseline adapted gravity model estimations

The equation (1) in Table 2 shows the baseline adapted gravity trade model for manufacturing trade between the 18 OECD countries, which is specified without the ICID

[1] List of 18 OECD countries that are included in the data sample: Australia, Belgium, Canada, the Czech Republic, Finland, France, Germany, Ireland, Italy, Japan, South Korea, the Netherlands, Norway, Poland, Spain, Sweden, the United Kingdom, and the United States of America.

variables. The baseline adapted gravity trade model indicates that the OECD country's size of GDP has a positive and statistically significant association with the bilateral manufacturing trade for exporting and importing OECD countries. The size of the economy and its growth over time encourages bilateral manufacturing trade between the OECD countries. The Distance between the OECD countries' capitals has a negative and statistically significant impact on bilateral manufacturing trade between the OECD countries. A transport cost increases with distance, because it is more costly to ship manufacturing goods over long distances. Therefore, the empirical results confirm the importance of geographical proximity and trade costs in conducting international manufacturing trade businesses. The regression coefficients pertaining to the Language and RFTA dummies are of a positive sign and statistically significant confirming the importance of cultural proximity and the importance of bilateral and multilateral trade agreements for increases in bilateral manufacturing trade between the OECD countries.

Table 2: Effect of the information and communication infrastructure development on manufacturing trade

	(1) Baseline	(2) Fixlines	(3) Mobile	(4) Internet
ln GDP exporter	0.907***	0.895***	0.909***	0.909***
ln GDP importer	0.936***	0.917***	0.928***	0.931***
Language dummy	1.053***	0.722***	1.032***	1.009***
RFTA dummy	0.988***	0.676***	0.922***	0.938***
ln Distance	-0.817***	-0.868***	-0.832***	-0.809***
ln ICID exporter		1.099***	0.152***	0.086***
ln ICID importer		0.690***	-0.065***	-0.009
Constant	-29.756***	-39.269***	-29.729***	-29.884***
N	6975	6975	6975	6975
R^2	0.9866	0.9881	0.9862	0.9859
Rho	0.983	0.9836	0.9985	1

Notes: * p<0.1; ** p<0.05; *** p<0.01. Parameters are estimated by the Prais-Winsten estimator. The common AR(1) parameter is denoted by rho. The z values are computed from standard errors that are corrected for heteroscedasticity and contemporaneous correlation of error terms across panels.

The effects of the information and communication infrastructure on manufacturing trade

The equations from (2) to (4) in Table 2 extend the baseline adapted gravity model specification by the three additional proxy explanatory variables for the ICID, which are estimated separately by the three additional regression equations: (2) with the fix telephone lines, (3) with the mobile phones, and (4) with the Internet variable. The signs of the associations and statistical significance of the regression coefficients from the baseline adapted gravity trade model estimations have remained unchanged. The regression coefficients pertaining to the GDP exporters/importers, Language and RFTA dummies in the regression for the fix telephone lines are slightly lower than in the regressions for the mobile phones and the Internet, respectively. The negative association for the Distance variable has been strengthened in the regression with the fix telephone lines as the explanatory variable and to a lesser extent in the regression with the mobile phones as the explanatory variable. The regression coefficients that are pertained to the ICID variables are mixed. They are of a positive sign and statistically significant in the regression with the fix telephone lines both for exporter and importer countries. They are statistically significant in the regression with the mobile phones as well, but of a positive sign for the exporting countries and of a negative sign for the importing countries. The similar signs are for the estimated regression

coefficients in the regression with the Internet as the explanatory variable of a positive sign for the exporting countries, which is statistically significant, while of a negative sign for the importing countries, which is statistically insignificant. The results clearly confirm a positive and statistically significant association of manufacturing trade with the ICID variables for the exporting countries. The regression coefficient is by its relative size the highest for the fix phone lines, implying its crucial information and communication role during the analyzed period of the emerging adoption of the mobile phones and Internet. For the importing countries, the empirical results are mixed. The positive association is again found as the most important for the fix telephone lines. For the mobile phones, the association is negative, while for the Internet the association is also statistically insignificant. Therefore, the adapted gravity trade models with the ICID explanatory variables confirm the positive importance of the ICID variables for bilateral manufacturing exports between the OECD countries, while the results for the OECD importing countries are mixed and vary but the type of the ICID variable for the manufacturing import specialization.

The effects of the information and communication infrastructure on distance

The effects of the ICID on distance in bilateral manufacturing trade between the OECD countries are tested by the adjusted gravity trade model specification with the full set of control variables from our regressions in Table 2 with the additional explanatory variables for: first, the Longdistance between the capitals in the OECD countries vis-à-vis the average distance between the analyzed OECD countries capitals. A dummy variable Longdistance equals one if the distance between home reporter and destination partner OECD countries exceeds the average distance between all analyzed OECD countries in the sample. Second, the interaction affects of the Longdistance and the ICID variables. If a particular ICID variable has reduced (increased) the effect of distance on manufacturing trade then the regression coefficient on the interaction ICID *Longdistance term should be positive (negative).

The set of the control variables for the GDP variables have a positive and statistically significant association with the manufacturing exports between the OECD countries. The language and RFTA dummies have also a positive and statistically significant association with the manufacturing exports between the OECD countries. The estimated associations are a bit lower in the regression with the fix telephone lines variable. The empirical estimates confirm the negative sign for the Distance variable.

The results revealed that the ICID variables have a strong negative impact on the distance and thus encouraging bilateral manufacturing trade between the OECD countries. The ICID variables for exporting countries have a positive sign of the regression coefficient, which are statistically significant. The ICID variables for importing countries are mixed: of a positive sign and statistically significant for the fix telephone lines, of a negative sign for the mobile phones, and of a positive sign, but statistically not significant for the Internet. The interaction effect of the ICID*Longdistance is of a positive sign for exporting countries, but it is not statistically significant. The interaction effect of the ICID*Longdistance is statistically significant for importing countries, but of a mixed sign by the ICID variables: of a positive sign for the fix telephone lines, and of a negative sign for the mobile phones and for the Internet, respectively. These imply that the fix telephone lines have reduced, while the mobile phones and Internet have increased the affect of distance on bilateral manufacturing trade for importing OECD countries.

Table 3: Effect of the information and communication infrastructure development on distance in manufacturing trade

	(1) Fix lines	(2) Mobile	(3) Internet
ln GDP exporter	0.926***	0.950***	0.948***
ln GDP importer	0.907***	0.932***	0.930***
Language dummy	0.789***	1.065***	1.062***
RFTA dummy	0.692***	0.882***	0.899***
ln Distance	-0.772***	-0.663***	-0.660***
ln Longdistance	-2.746**	-0.148	-0.153
ln ICID exporter	0.999***	0.140***	0.080**
ln ICID importer	0.555***	-0.043*	0.017
ln ICID exporter * ln Longdistance	0.178	0.021	0.009
ln ICID importer * ln Longdistance	0.228**	-0.057**	-0.061**
Constant	-39.036***	-32.153***	-32.012***
N	6975	6975	6975
R2	0.9874	0.9861	0.9858
Rho	.9846	1	1

Notes: * p<0.1; ** p<0.05; *** p<0.01. Parameters are estimated by the Prais-Winsten estimator. The common AR(1) parameter is denoted by rho. The z values are computed from standard errors that are corrected for heteroscedasticity and contemporaneous correlation of error terms across panels.

Robustness test

The panel regression specifications have been chosen to minimize the possibility of omitted variable bias and to capture some of the dynamic impact of the ICID variables. The cross-section estimation eliminates the possibility of co-trending variables over time and thus provides a useful robustness check of our results. Table 4 presents our cross-section adapted gravity regression results for manufacturing exports in OECD countries. The focus is on the ICID variables by individual years and over time.

The association between manufacturing exports and the Internet is of a positive sign and significant for both exporting and importing countries. The regression coefficient has increased over time. The size of the regression coefficient is higher for the exporting than for the importing countries. The regression coefficient for the interaction effect Longdistance*Internet switch from a negative to a positive sign over time for exporting countries, but has remained statistically insignificant. The similar switch is seen for importing countries, but a positive sign has become statistically significant. This implies that the Internet has reduced the affect of distance on manufacturing trade for the importing OECD countries.

On the contrary, the positive and significant size of the regression coefficient for the fix telephone lines has declined since 2000, but the size of the elasticity coefficient has remained close to the level for the Internet for the exporting countries and higher than for the Internet variable for the importing countries. The regression coefficient for the interaction effect fix telephone lines*Longdistance has explored shifts between positive and negative values. At the end of the analysed period, it has a positive significant sign for the exporting countries, and a positive sign, which is insignificant, for the importing countries. This implies that the fix telephone lines have reduced the affect of distance on manufacturing trade for the exporting OECD countries.

Similar as for the Internet, also for the mobile phone, the regression coefficients are positive for the exporting and importing countries, and have increased over time. The size of the regression coefficient is higher for the exporting than for the importing countries, but this differential is smaller than in the case of the Internet. The interaction effect mobile phones*Longdistance is of a positive sign and significant for the exporting countries, while the results are mixed for the importing countries. This implies that the mobile phones have reduced the affect of distance on manufacturing trade for the exporting OECD countries, but the results are less clear for the importing countries.

Table 4: Cross-section estimations for the effect of the information and communication technology development on manufacturing trade

	1995	1996	1997	1998	1999	2000	2001	2002	2003
ln Internet									
ln Internet exporter	0.404***	0.409***	0.462***	0.464***	0.531***	0.615***	0.714***	0.731***	0.742***
ln Internet importer	0.291***	0.271***	0.286***	0.314***	0.404***	0.389***	0.436***	0.388***	0.381***
Longdistance*ln Internet exporter	-0.061	-0.026	-0.046	-0.087	-0.025	0.094	0.125	0.130	0.223
Longdistance*ln Internet importer	-0.027	-0.021	0.028	0.059	0.034	0.166	0.163	0.263**	0.253*
ln fix lines									
ln fix lines exporter	1.282***	1.176***	1.275***	1.236***	1.234***	1.211***	0.974***	0.944***	0.701***
ln fix lines importer	0.834***	0.823***	0.852***	0.948***	1.058***	0.956***	0.943***	0.830***	0.688***
Longdistance*ln fix lines exporter	0.042	0.056	-0.148	-0.216	-0.243	-0.094	0.209	0.414*	0.680***
Longdistance*ln fix lines importer	0.195	0.013	-0.089	-0.213	-0.365*	-0.292	-0.310	-0.072	0.125
ln Mobile									
ln mobile exporter	0.448***	0.440***	0.597***	0.626***	0.705***	0.815***	0.781***	0.707***	0.647***
ln mobile importer	0.252***	0.271***	0.345***	0.421***	0.560***	0.581***	0.712***	0.639***	0.597***
Longdistance*Log Mobile exporter	0.137*	0.153**	0.123	0.270**	0.502***	0.613***	0.846***	1.046***	1.106***
Longdistance*Log Mobile importer	0.212***	0.185**	0.109	0.032	0.077	0.099	0.006	-0.066	0.030

CONCLUSIONS AND IMPLICATIONS

We investigate the impact of the ICID on the patterns of bilateral manufacturing trade between the developed OECD countries. The adapted gravity models confirm the importance of the size of the exporting and importing economies for increase of trade in manufacturing goods between OECD countries. The countries proximities by having a common language and free trade agreement also encourage manufacturing trade positively. As expected, the greater distance discourages manufacturing trade between the OECD countries.

We employ adapted gravity trade equations to identify the effects of the ICID on bilateral manufacturing trade between the OECD countries. First, we investigate the relationship between ICID and manufacturing trade performance in the OECD countries. The empirical results confirm that more developed ICID provides externalities for the bilateral manufacturing trade for the exporting countries. The regression coefficient is the highest for the fixed telephone lines, followed by the mobile phones, and the Internet. These results suggest that the ICID in the exporting countries is important for a reduction in information and communication costs. However, for the importing countries the results are mixed as only the fixed telephone lines have a positive sign. Second, we investigate the sensitivity of the results to the choice of the ICID variables by the investigation of the effects of ICID on distance. The results for the exporting countries have a positive sign, but are insignificant. The results for the importing countries are mixed: the fix phone lines have reduced, while the mobile phones and Internet have increased the affect of the distance on bilateral manufacturing trade for importing OECD countries. Finally, we check for the robustness of the results by comparing panel regression analysis with cross-section analysis by individual

years. The positive association of manufacturing trade with Internet and mobile phones has increased over time for exporting and importing OECD countries, while the relatively high coefficient of elasticity for fix telephone lines has been reduced for both exporting and importing countries. Internet has reduced the distance for the importing manufacturing OECD countries, while fix telephone lines and mobile phones have reduced the effect of distance on manufacturing trade for the exporting manufacturing OECD countries.

The contribution of the paper to is the advancement of manufacturing business trade and manufacturing business-related trade analyses and practices. Among possible explanation for the rise of manufacturing trade among developed OECD countries is the decrease in transportation costs. by the decrease in communication costs for fix telephone lines and the growing importance of mobile phones and the development of the Internet, which have changed the international communication system and encouraged exports of manufacturing goods as firms can use different ICID (mobile phones, e-mails, websites, and similar) to assist communication, information and international sales at minimum cost.

The implications for theory are in explaining the importance of different determinants of the bilateral manufacturing trade flows between the OECD countries focusing on the ICID effects and employing adapted gravity trade equations. In addition to the baseline adapted gravity equation model the sensitivity of the results to the choice of the ICID variable and its effects on distance are tested as well as the sensitivity and robustness of the econometric results by comparing the panel regression analysis with the cross-section analysis by individual years are investigated. Among limitations and future research possibilities are at least the following: first, to use the panel data set for more recent years. Second, to use the combined data set for OECD and non OECD countries such as for example to compare developed OECD countries with some developing countries. Third, to use some additional proxies for the ICID variable capturing not only the ICID use, but also for example costs of their usage. Finally, to use additional model specifications for explanatory variables as well as to apply some other estimation procedures.

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