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Discussion Papers

Deutsches Institut für Wirtschaftsforschung 2012

Goods Follow Bytes: The Impact of ICT on EU Trade

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IMPRESSUM

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ISSN print edition 1433-0210
ISSN electronic edition 1619-4535

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Goods Follow Bytes:

The Impact of ICT on EU trade

Anselm Mattes*, Philipp Meinen, Ferdinand Pavel*****

January 2012

Abstract

This paper empirically assesses whether the deployment and use of Information and Communication Technology (ICT) infrastructure at the national level affects trade flows within the European Union (EU) and between the EU and its main trading partners. The analysis tests the hypothesis that availability and use of ICT enhances trade by reducing transaction costs and through network effects that materialize when both trading partners are advanced users of ICT. The empirical analysis is based on the application of gravity equations in various robust specifications. The results suggest that ICT does have a significant impact on EU trade. In particular, we find trade to be enhanced if both trading partners reveal advanced ICT endowments, which supports the expected network effects. Additionally, we observe trade diversion effects from less to highly ICT developed countries.

Keywords: exports, ICT, gravity model, international trade, network effects

JEL-classifications: F1, D2

This Paper is based on a research project that DIW econ undertook on behalf of the European Commission, Information Society and Media Directorate-General (SMART N° 2007/0030). We are indebted to Dieter Schumacher, Juan Arregui Mc Gullion and participants of the 8th Conference on Applied Infrastructure Research (INFRADAY) in Berlin for useful discussion and suggestions. We gratefully acknowledge that DIW Berlin provided us with an excellent research environment. The regular disclaimer applies.

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1. Introduction

This paper analyzes the relationship between intra- and extra-EU trade and the deployment and use of Information and Telecommunication Technology (ICT) throughout the EU member states and important EU trading partners. Our central hypothesis that availability and use of ICT enhance international trade is motivated by several considerations. As ICT facilitates fast and decentralized information processing (Czernich et al 2011, Bloom and Van Reenen 2007) it should also reduce transaction costs across borders, for instance by enabling consumers and firms to better compare prices and find specific goods in different countries. From a firm-level point of view, this directly and positively affects both the decision to engage in international trade (extensive margin of trade) and the volumes of exports and imports (intensive margin). Moreover, the use of ICT is known to improve productivity levels of firms, sectors and overall economies (Stiroh 2002; OECD 2003, Jorgenson et al. 2008; van Ark et al. 2008). Since the recent literature on trade highlights the importance of productivity for the ability of firms to export (Melitz 2003), ICT can be expected to indirectly facilitate trade by allowing more firms to overcome trade-related fixed costs. Finally, it is well known that the use of ICT is subject to network effects, i.e. the value of ICT to individual users increases the more widely and the more intensively it is used (Katz and Shapiro 1985). Hence, the trade-enhancing impact of ICT can be expected to be stronger if both trading partners are advanced users of ICT.

Following more general hypotheses and building upon endogenous growth theory (Romer 1990, Aghion and Howitt 1998), a number of papers have already analyzed the impact of ICT on growth and consumer welfare. Röller and Waverman (2001) estimate a model which endogenizes investments in telecommunication infrastructure and find a significant positive effect on growth. In particular, when a critical mass of telecommunication infrastructure is reached, the causal link is confirmed. Likewise, Greenstein and Spiller (1996) find that investments in telecommunication infrastructure has significantly increased consumer surplus and business revenues in the US between 1988 and 1992. More recently, Czernich et al (2011) show that improved access to broadband infrastructure has fostered growth in

OECD countries. All these findings are consistent with our hypothesis and further motivate an empirical analysis on the impact of ICT on international trade.

In empirical analyses similar to ours, Freund and Weinhold (2002 and 2004) find that the Internet has stimulated international trade flows. In particular, based on time-series and cross-section regressions they find that an increase in the relative number of web hosts in a country has led to a significant increase in export growth in the late 1990s. While this evidence is consistent with our hypothesis, the findings are limited to the availability and use of the internet and thus, highlight the impact of connectivity. However, ICT covers a much larger array of infrastructure and applications. Moreover, the analyses of Freund and Weinhold are focussed on the late 1990s and thus, do not access the impact during the subsequent period of strong growth of both, ICT as well as internet usage. Therefore, our empirical analysis of the impact of ICT on international trade flows serves as a generalisation as well as an update of the assessments of Freund and Weinhold in economic as well as methodological terms.

We use the gravity equation to assess the impact of ICT on international trade. This approach is commonly applied for analysing trade-related issues such as determining the trade potential of a country or evaluating the effect of certain policy variables on trade. Relevant policy variables may be the membership in a free trade agreement (FTA) or – like in this study – the deployment of ICT infrastructure. Our model specifications are based on the extensive discussion on appropriate specifications of the gravity equation following the seminal paper by Anderson and van Wincoop (2003). We apply two different estimation approaches to ensure the robustness of the regression results. On the one hand, we explicitly model the network effects of ICT while controlling for time-constant multilateral resistance. A bilaterally varying dummy variable for above average ICT infrastructure is used in a second estimation approach in which we also control for time-varying multilateral resistance. The findings of both estimation approaches suggest that large-scale ICT deployment does have a significant and positive effect on trade shares between countries in the EU and important partners. The effect is particularly high when both trading partners show advanced ICT development levels. Furthermore, we can observe a trade diversion effect from less developed to more ICT-advanced trading partner. This result is consistent with positive network effects of ICT as suggested by economic theory.

The rest of the paper proceeds as follows. Section 2 describes our data sources and introduces our ICT infrastructure indicator. In section 3 the gravity model and its econometric implementation are presented. Subsequently, section 4 presents the estimation results and, eventually, section 5 concludes.

2. Data

2.1 Trade data and estimation sample

Our estimations are based on a panel dataset which covers the period from 1995 to 2007 including all current EU member states except for Malta, Luxembourg, and Cyprus which are excluded due to lack of data. The dataset also includes five large trading partners of the EU: the USA, Canada, Australia, South Korea and Japan. This sample selection implies that the findings of the analysis are specific to intra-EU trade and extra-EU trade with the five non-EU countries. In total, the analysis covers trade flows of 29 countries over a period of 13 years which leads to a balanced panel of 10556 observations[1].

Our data stem from different sources. Trade data (export data) are collected from IMF Direction of Trade Statistics (DOTS) and deflated to real values by applying the US price index (2000 as basis) from IMF World Economic Outlook Database (WOE). GDP data at 2000 constant prices are taken from the World Development Indicators (World Bank). Distance data as well as data for the dummies of common border and common language are taken from the CEPII gravity dataset. In case of missing values the information has been interpolated.

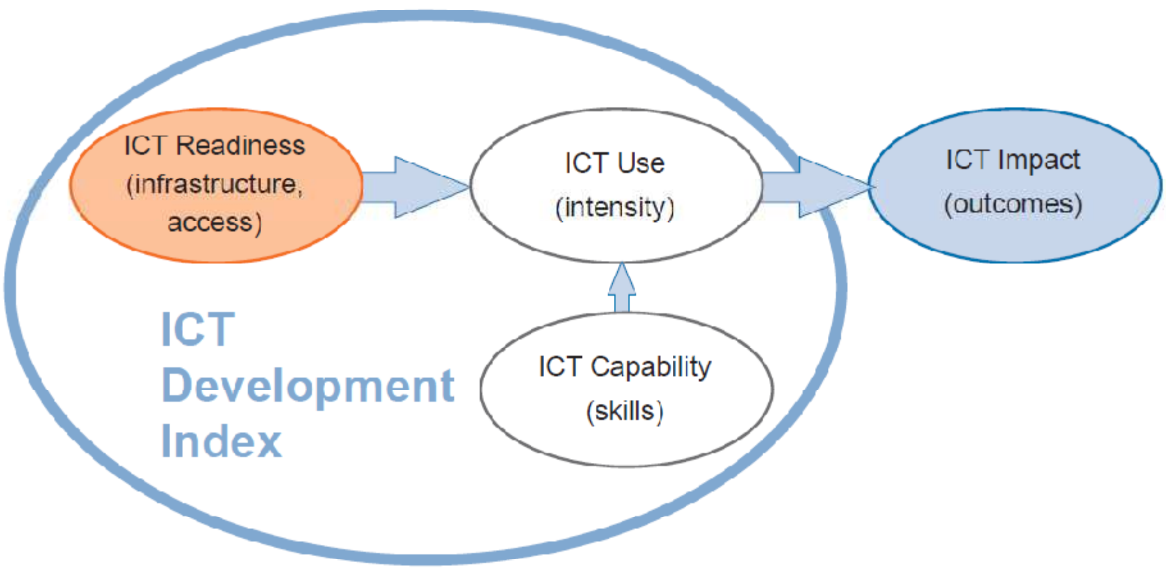
[1] As countries do not trade with themselves, the number of observations equals 28 x 29 x 13.

2.2 Data on ICT development

Including variables on ICT developments in a gravity equation does not alter its structural interpretation. In fact, our hypothesis implies that ICT can simply be considered as reducing trade costs due to lower transaction costs. In order to measure ICT developments at the national level we refer to the ICT Development INDEX (IDI) which is published by the International Telecommunication Union (ITU). This indicator aims at measuring the information society by giving "an indication of the extent to which countries have advanced in the area of ICT" (ITU 2009, p. 12). It reflects on the experience from several earlier indicators and is based on a principal component analysis that identified the most relevant factors. The IDI is constructed based on several stages as illustrated in Figure 1.

The first stage (ICT readiness) refers to infrastructure and access, the second stage (ICT use) to use and intensity of use. Evolving towards an information society and achieving measurable ICT impacts also requires a third component, ICT capability. All three components – access, use, and capability – are closely linked. For instance, access to ICT infrastructure is a prerequisite for its use which in turn depends on ICT skills as well.

Figure 1: Three stages in the evolution towards an information society



Source: ITU (2009).

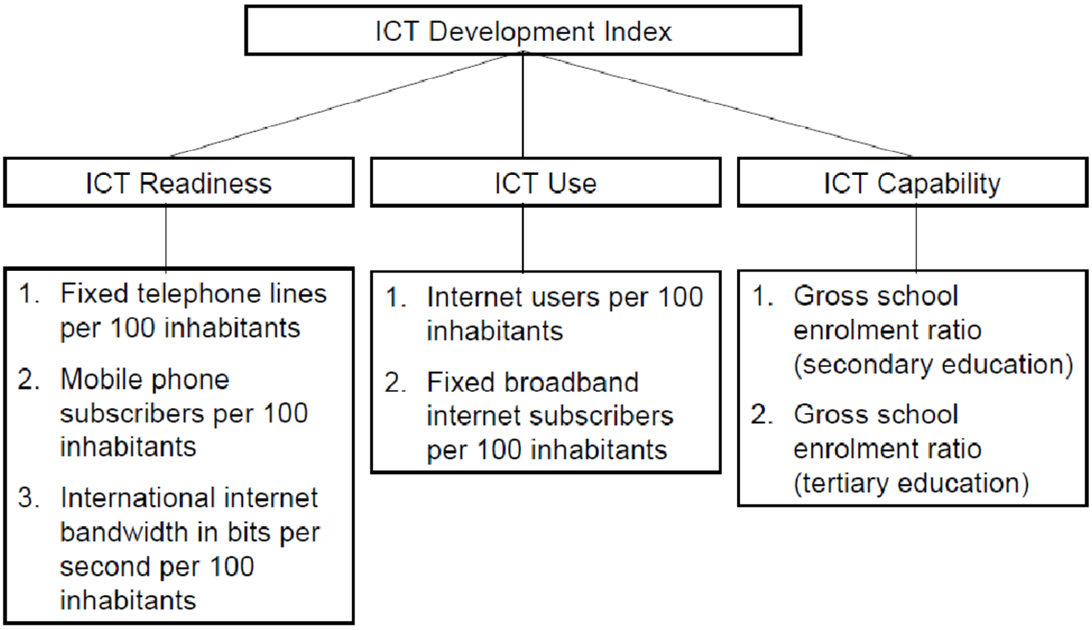
Because no single indicator is capable to capture all three components, ITU (2009) suggests a composite indicator based on three sub-indicators to measure each of the three components. Since the ITU indicator is not available for the entire time period for which we estimate the gravity model (1995-2007), we replicate the index based on the underlying data for which information over the relevant time period is available. Figure 2 displays how the overall indicator is constructed in this study. ICT infrastructure and access is measured by fixed telephone lines per 100 inhabitants, mobile cellular subscriptions per 100 inhabitants, and international internet bandwidth in bits per person.[2] ICT use and intensity of use are measured by internet users per 100 inhabitants and fixed broadband internet subscribers per 100 inhabitants.[3] ICT skills and the capacity to use ICT effectively are measured through secondary and tertiary gross school enrolment ratios. These ratios indicate the educational level of a country.[4] The data for the individual indicators is sourced from the International Telecommunication Union and World Development Indicators. Missing data points are computed by linear interpolation.

[2] ITU (2009) suggests also including the proportion of households with a computer and the proportion of households with internet access at home. However, the data for the last two indicators are not available for the required time period and countries and thus are omitted from the present study.

[3] ITU (2009) further includes mobile broadband subscribers per 100 inhabitants to this sub-indicator. However, the data is again not available for many countries and, in particular, not for the required time period.

[4] Additionally, ITU (2009) includes adult literacy rate to this sub-indicator. Since all of the considered countries have literacy rates close to 100%, this element could be omitted from the present study.

Figure 2: Composition of the ICT Development Index



Source: DIW econ based on ITU (2009).

To combine this information to a meaningful indicator which is comparable across countries, each of the seven variables shown in Figure 2 is transformed into values between 1 and 5, where 1 indicates the lowest and 5 the highest value (across countries for a given year) while all others are distributed proportionally. In a second step, the variables for ICT readiness, ICT use, and IT capability are aggregated to separate sub-indicators by taking the weighted sum over the relevant data, again transformed into the range from 1 to 5. The weights are based on the variance of the variables in each year. Hence, variables showing strong differences across countries obtain higher weights. In this way, the indicator is trimmed to pick up differences in the variables and highlights the differences in ICT development across the observed countries. (See table A1 in the appendix for the countries' indicator values in the years 1995, 2000, 2005 and 2007).[5]

[5] Note that this weighting scheme implies that the indicator compares ICT development across countries for each given year, but cannot be interpreted as a time series for a given country. Therefore, in our estimations we control for time effects and, in a second approach, simplify the indicator in that it reports only ICT development in a given country as above or below average for a given year.

2.3 Infrastructure Data

Studies assessing the impact of transportation infrastructure on trade based on the gravity model generally find a positive effect (Bougheas et al. 1999, Limao and Venables 2001, Nordas and Piermartini 2004). This may be relevant for the present study because in the case that countries with an advanced transportation infrastructure also display a high-level ICT development, our ICT indicator may partly capture the effect of advanced transportation infrastructure. Therefore, we additionally use a transportation infrastructure variable that is constructed based on data from the IMD World Competitiveness Yearbook.[6] The indicator is aggregated from two sub-indicators. The first captures the efficiency of the basic distribution infrastructure of goods and services (transportation infrastructure as well as energy supply). The second measures the quality of maintenance and development of basic infrastructure.[7] The two individual indicators are aggregated to a single composite index using the same aggregation method as used for the ICT indicator. Table A2 in the appendix contains a list of countries with above average transportation infrastructure and ICT development.

3. The gravity equation

The gravity equation draws upon the Newtonian theory of gravitation (Newton's law). It states that the force of gravity between two bodies is positively related to the mass of the attracting bodies and negatively related to the square of their distance. In the gravity equation trade flows between any country pair are explained by the size (mass) of the two countries (usually measured by GDP) and the trade costs between the countries (Piermartini and Teh 2005).

The work of Anderson and van Wincoop (2003) has initiated extensive discussions, both with respect to integrating the gravity equation into economic trade theory as well as with respect to its specification for econometric estimation. In particular, Anderson and van

[6] See http://www.imd.org/research/publications/wcy/index.cfm.

[7] Note that the data for the transportation infrastructure variable is poor for a few countries. To keep all countries in the sample, the development of the infrastructure of countries with poor data was assumed to be comparable to countries with similar geographic conditions and GDP. This is particularly true for the Baltic countries where Latvia and Lithuania are assumed to have a development of transportation infrastructure comparable to Estonia. Moreover, some missing data points are filled by linear interpolation.

Wincoop show that trade does not only depend on absolute trade costs between a country pair but also on relative trade costs or, more generally, multilateral resistance. In other words, bilateral trade flows depend on bilateral trade barriers between two countries relative to the average trade barriers that these two countries face with all trading partners. Omitting controls for multilateral resistance in econometric estimations of the gravity equation biases the results. In the following, we discuss the specifications our regression equation.

3.1 Basic econometric specification of the gravity model

The standard gravity equation is usually specified in the following form (time subscripts omitted), which we use as basis for the specifications we estimate:

$$\ln(E_{ij}) = \beta_0 + \beta_1 \ln(GDP_i * GDP_j) + \beta_3 \ln(DIST_{ij}) + \beta_4 F_{ij} + \varepsilon_{ij} \quad (1)$$

where $\ln(E_{ij})$ represents the natural logarithm of real exports from country *i* to country *j*,[8] $\ln(GDP_i * GDP_j)$ correspond to the log of the product of real GDP of country *i* and country *j*, $\ln(DIST_{ij})$ refers to the log of distance between countries *i* and *j* which proxies trade costs between them, and F_{ij} stands for a set of bilaterally varying dummy variables. Specifically, we control whether the two countries speak the same language, share a common border, or whether they are EU members. Sharing the same language indicates cultural proximity between countries which is believed to positively affect trade between countries. Similarly, geographic proximity indicated by *a* common border is also expected to have a positive effect on bilateral trade. Likewise, membership of the EU is also expected to enhance trade. Finally, $\varepsilon_{ij}$is an error term.

3.2 Modelling ICT network effects

We estimate the effects of ICT infrastructure on trade by including the importer and exporter ICT indicator in the gravity equation. This approach also permits testing the assumption that ICT enhances trade when both countries have good ICT development by interacting the measures of ICT development of both countries. A positive and significant

[8] Due to a few zero trade relations, we add 1 to each trade value.

interaction term would indicate that trade is particularly supported if both trading partners have a high quality ICT endowment. We also include two variables controlling for the effects of transport infrastructure in the exporting and the importing country. This leads to the following regression equation:

$$\ln(E_{ij}) = \beta_0 + \beta_1 \ln\left(GDP_i * GDP_j\right) + \beta_2 \ln\left(DIST_{ij}\right) + \beta_3 F_{ij} + \beta_4 \ln(ICT_i) + \beta_5 \ln\left(ICT_j\right) + \beta_6 \left[\ln(ICT_i) * \ln\left(ICT_j\right)\right] + \beta_7 \ln(TRA_i) + \beta_8 \ln\left(TRA_j\right) + \delta_i + \delta_j + \gamma + \varepsilon_{ij} \quad (2)$$

$\ln(ICT_i)$ and $\ln\left(ICT_j\right)$ are the logs of ICT developments of country *i* and country *j*, respectively. $\ln(ICT_i) * \ln\left(ICT_j\right)$ is an interaction term between ICT developments of the two countries which accounts for a possible network effect.[9] Accordingly, $\ln(TRA_i)$ and $\ln\left(TRA_j\right)$ refer to the log of the transport infrastructure indicator.

We also include importer (δ_j) and exporter (δ_i) dummies which control for unobserved time-constant country-specific factors including time-constant multilateral resistance. Furthermore, we add year dummies (γ) which capture any bias arising from deflating trade data by the US price index (see, e.g., Baldwin and Taglioni 2006).

3.3 Controlling for Time-varying Multilateral Resistance

Controlling for multilateral resistance in a panel framework is considered the “biggest challenge” in estimating the gravity equation (Fratianni and Oh 2009). This challenge has inter alia led to suggestions to include country dummies to the basic gravity model equation (Anderson and van Wincoop 2003) or to utilize dummies that represent source (exporter) and destination (importer) countries (Feenstra 2003) as we do in equation (2). Though easily applicable and therefore seemingly attractive, adding importer and exporter dummies to the regression may be insufficient for the present study where panel data are applied. Importer and exporter dummies only control for the cross-sectional variation of multilateral resistance terms without allowing these effects to vary over time. That is, in equation (2) the bias

[9] Note that the models are estimated with cluster-robust standard errors due to the presence of heteroskedasticity as suggested by Stock and Watson (2006).

arising from the omission of controls for multilateral resistance is only partially eliminated. Baldwin and Taglioni (2006) therefore suggest adding time varying importer and exporter dummies through interaction terms between time and exporter dummies as well as between time and importer dummies. This approach has frequently been applied in order to control for multilateral resistance in a panel framework (e.g. Fratianni 2007, Baier and Bergstrand 2007, and Baier et al. 2008). Hence, we include time-varying importer and exporter dummies in our regression equation.

However, when time-varying country-specific dummies are included into the gravity equation, it is no longer possible to estimate the impact of variables that vary across countries but not bilaterally, such as population or infrastructure. Hence, it is not possible to simply include the ICT index for exporting and importing countries under this specification. We therefore model the level of ICT development in the two countries using a bilaterally varying dummy variable, which takes on unity if both countries (exporter and importer) have above average quality of ICT development and zero otherwise. In this way, we measure the impact of ICT if both countries have realized an above-average level of ICT development. The same applies to the transport infrastructure indicator.

The resulting regression equation is the following (time subscripts omitted):

$$\ln(E_{ij}) = \beta_0 + \beta_1 \ln\left(GDP_i * GDP_j\right) + \beta_2 \ln\left(DIST_{ij}\right) + \beta_3 F_{ij} + \beta_4 \ln\left(ICT\_Dum_{ij}\right) + \beta_7 \ln\left(TRA\_Dum_{ij}\right) + \delta_i + \delta_j + (\delta_i * \gamma) + (\delta_j * \gamma) + \gamma + \varepsilon_{ij} \quad (3)$$

where δ_i and δ_j, denote exporter and importer dummies and $(\delta_i * \gamma)$ and $(\delta_j * \gamma)$ are their respective interactions with a year dummy γ; i.e. time-varying country dummies capturing all time-variant exporter and importer specific effects, which also include multilateral resistance.

4. Estimation results

4.1 Basic results

The results of both estimation approaches are presented in Table 1. Column (1) presents OLS results without controls for any kind of country or time effects. Columns (2)-(4) present OLS estimation results where controls for importer-specific and exporter-specific fixed effects and year-specific effects are included. Thus, the network effects of ICT infrastructure can be modelled by country-specific and interacted variables, though multilateral resistance is only partially controlled for. Eventually, the results columns (5) and (6) include time-varying importer and exporter dummies. This addresses the bias stemming from time-varying multilateral resistance. However, the impact of ICT infrastructure can only be modelled by an interaction effect.

Table 1: Estimation results

	1	2	3	4	5	6
ln(GDPi*GDPj)	0.879***	1.188***	1.234***	1.238***	0.881***	0.884***
	(0.014)	(0.104)	(0.102)	(0.100)	(0.028)	(0.032)
ln Distance	-1.106***	-1.392***	-1.354***	-1.354***	-1.386***	-1.388***
	(0.038)	(0.065)	(0.062)	(0.063)	(0.066)	(0.065)
ICT dummy					0.417***	0.326***
					(0.070)	(0.066)
ln ICTi (exporter)			-0.656***	-0.694***		
			(0.151)	(0.151)		
ln ICTj (importer)			-1.003***	-0.995***		
			(0.149)	(0.147)		
ln(ICTi)*ln(ICTj)			0.861***	0.862***		
			(0.135)	(0.135)		
ln TRAi (exporter)				0.062***		
				(0.021)		
ln TRAj (importer)				-0.015		
				(0.021)		
Transport dummy						0.261***
						(0.072)
Common language	0.424***	0.241	0.212	0.211	0.201	0.170
	(0.159)	(0.161)	(0.157)	(0.157)	(0.162)	(0.167)
Common border	0.525***	0.333**	0.303**	0.303**	0.338**	0.320**
	(0.148)	(0.152)	(0.148)	(0.148)	(0.154)	(0.153)
Common EU membership	0.377***	0.088	0.077	0.075	-0.104	-0.124
	(0.048)	(0.059)	(0.058)	(0.058)	(0.091)	(0.091)
Constant	-31.160***	-42.736***	-45.303***	-45.765***	-29.229***	-28.810***
	(0.660)	(4.684)	(4.953)	(4.751)	(1.308)	(1.700)
Country dummies	no	yes	yes	yes	yes	yes
Year dummies	no	yes	yes	yes	yes	yes
Country-year dummies	no	no	no	no	yes	yes
Number of observations	10 556	10 556	10 556	10 556	10 556	10 556
R2	0.845	0.908	0.910	0.911	0.916	0.917

*** p<0.01, ** p<0.05, * p<0.1

Source: DIW econ.

The results in column (1) indicate that all variables are statistically significant and behave as expected. Moreover, the magnitudes of the coefficients are within the common range. In columns (2) to (4), exporter- and importer-specific fixed effects and time-fixed effects are included as controls in the regression. They are generally individually significant and always jointly highly significant.

Before analyzing the coefficients of interest, i.e. transport and ICT variables, the results of the other coefficients in column (2) are shortly discussed. The distance variable has a negative sign and is highly significant, as usually found in gravity models. The size of the coefficient is rather large, but still close to the common range. The border dummy also has the expected positive and significant impact. The common language dummy has the expected positive sign but is insignificant. The EU membership loses significance if country-fixed effects are included.

Comparing columns (5) and (6) with the results from columns (2) to (4) shows that most variables are not affected by possible omitted variable bias due to time-varying multilateral resistance. Including time-varying exporter and importer dummies and thus controlling for time-varying multilateral resistance lets the coefficients of the variables for distance, common border and common language virtually unchanged. Also, the coefficient for common EU membership stays insignificant. However, the coefficient for economic mass (the product of exporter and importer GDP) decreases to about 0.88, but stays within a common range. This indicates that the results in column (2) to (4) without time-varying country dummies are not heavily biased and therefore provide robust estimations.

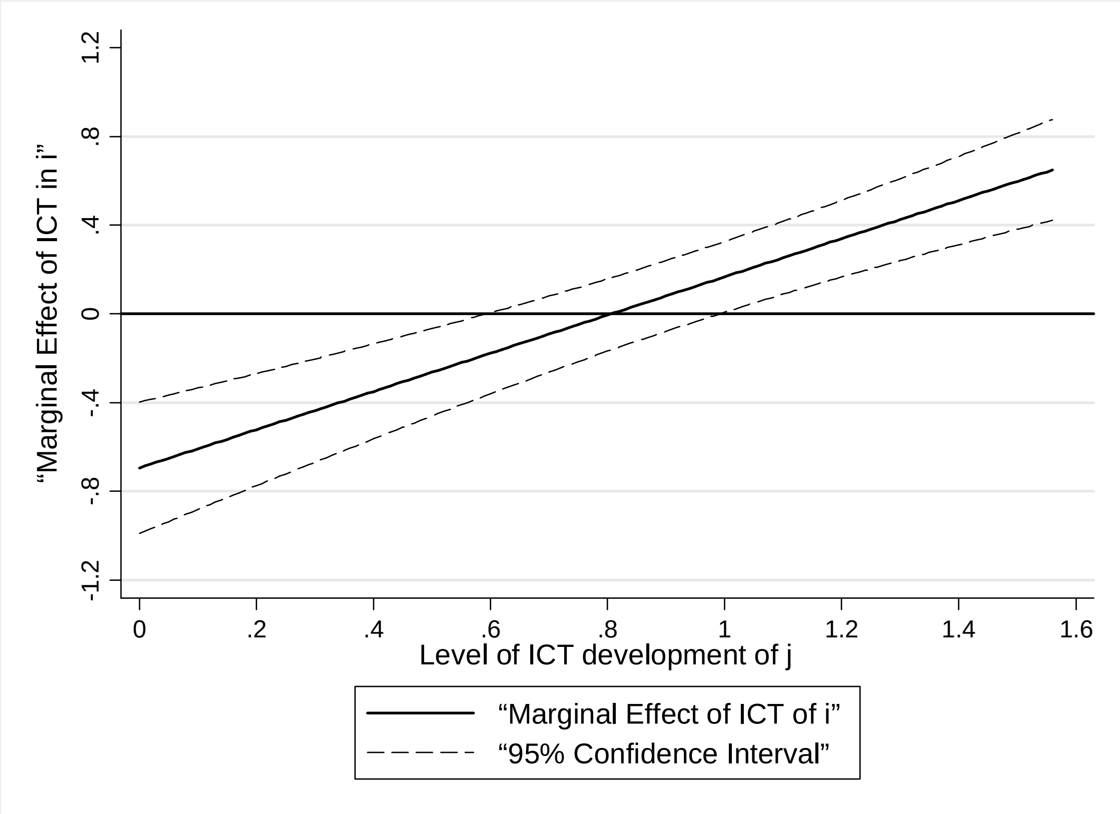
4.2 Specific results: ICT network effects

Including exporter and importer ICT indicators and their interaction permits the precise identification of ICT network effects. However, before discussing the estimation results, some issues regarding the interaction effect must be taken into consideration. Standard textbooks (e.g. Aiken and West 1991) and more recent papers (e.g. Braumoeller 2004, Brambor et al. 2005) have pointed out common mistakes in the presence of interaction terms. Thus, care has to be taken to draw correct inferences. First of all, it is important to understand that in the presence of an interaction term, the marginal effect of $\ln(ICT_i)$ in equation (2) is calculated by $\beta_4 + \beta_6 * \ln(ICT_j)$. Thus the marginal effect of $\ln(ICT_i)$ must be evaluated at appropriate values of $\ln(ICT_j)$ in order to draw inferences. The interpretation of the marginal effect of $\ln(ICT_i)$ becomes the effect of exporting country *i*'s

ICT level on its exports for given levels of destination country *j*'s ICT endowment. This also implies that in the presence of a significant interaction term, insignificant coefficients of the main effects $\ln(ICT_i)$ and $\ln(ICT_j)$ do not imply that the home country's ICT development is statistically irrelevant for trade. Notably, this model specification is perfectly suited to test for network characteristics. In the following analysis the effect of home country's ICT level on its exports is evaluated at applicable values of the importing country's ICT level and vice versa. Thus, the discussion of the estimation results is therefore based on a graphical presentation.

The interaction term between exporter and importer ICT level is significant in columns (3) and (4) of Table 1 suggesting that trade is enhanced when both trading partners display a high level of ICT endowment, confirming the network characteristics of ICT. Figure 3 permits a better understanding of the effect. Based on results from column (4), the figure shows how the marginal effect of export country's (*i*) ICT endowment on its exports changes with different levels of destination country's (*j*) ICT endowment. The solid line displays how the marginal effect of the source country's ICT endowment level changes with the level of ICT development in the destination country. The two dashed lines represent the 95% confidence interval indicating statistical significance at the 5%-level if both lines lie above or below the zero line. Thus here the effect is significant for sufficiently small and large values of the importing countries ICT development.

Figure 3: Marginal effect of exporting (i's) country's ICT level conditional on importing (j's) country's ICT level



The impact of an exporting country's (i) ICT development on its exports for different levels of destination country's (j) ICT development (figure refers to equation (2) and column (4) in Table 1).[10]

Source: DIW econ.

This figure gives some insights. Firstly, the network characteristic of ICT is confirmed by the data, i.e. the higher the ICT development level in both countries, the higher is their bilateral trade volume. Secondly, for very low levels of the importing country's ICT development, the marginal effect of ICT development in the exporting country is even negative. This could indicate a (relative) trade diversion effect. This trade diversion effect could arise from the fact that a better ICT development level leads to increased relative trade costs to countries which are less advanced regarding ICT development (as compared to the trade costs with more advanced ICT nations).

Including the transport infrastructure variables for the exporter and importer country lets the coefficients of the ICT development variables by and large unchanged. A good transportation infrastructure of the exporting country has a significantly positive effect on

[10] Note that due to the log-transformation of the ICT indicator, the level ranges from 0 to 1.5.

exports. The importing country’s transport infrastructure, in contrast, seems to have no significant effect on trade.

Controlling for time-varying multilateral resistance

The estimation results in columns (6) and (7) based on equation (3) additionally control for time-varying multilateral resistance. However, country-specific variables that do not vary across trade pairs cannot be implemented in this regression approach. Therefore, the exporter and importer ICT indicator variables cannot be included. Instead, a bilaterally varying dummy variable indicating above average ICT development of both trading partners is used. The results support the first estimation approach. We observe that good ICT infrastructure of both trading partners significantly increases their trade share. In particular, if both trading partners have above average ICT infrastructure, trade between these two countries is about 1.52 times (or 52%) larger compared to the case where one or both countries have poor infrastructure quality; see column (5).[11] Second, column (6) of Table 1 shows that above average transport infrastructure in both countries also has a significantly positive effect on their trade. If the effects of transport infrastructure are controlled for, the impact of ICT development decreases to 38%, but is still highly significant.

5. Conclusion

This paper addresses the impact of ICT endowments on international trade. We apply different specifications of the gravity equation, which is frequently used in trade-related research and has proven to deliver consistent results. The choice of estimation approaches is based on insights from the extensive literature on the specification of gravity equations. We apply two different estimation approaches and several specifications to ensure the robustness of the estimation results.

In order to model country-level ICT endowment in the gravity framework, we constructed an indicator based on the ICT Development Index of the International Telecommunication

[11] The effect of a dummy variable on a log-transformed dependent variable is attained by taking the exponential of the regression coefficient. As an example, a regression coefficient of 0,417 implies an impact on trade of exp(0,417) = 1,5179.

Union. This indicator is an internationally acknowledged measure of ICT development. The estimation results indicate that country-level ICT endowment has a significantly impact on intra- and extra-European trade. In particular, the results suggest that ICT enhances trade when both trading partners have a high quality ICT endowment. This finding is in line with the substantial attention that network effects have received in the economic literature on ICT and the internet economy. The results of the first estimation approach highlight the relevance of ICT network effects for trade. A higher level of ICT development of an exporting country particularly enhances trade with other ICT-advanced countries. Furthermore, we also find a trade diversion effect of better export-country ICT development from less ICT-advanced importers to highly ICT-developed importing countries. The second estimation approach supports these findings and suggests that - after adequately controlling for transportation infrastructure - two countries with above-average ICT endowment trade about 38% more than a country pair where one country or both countries have a poor ICT endowment.

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6. Appendix

Table A1: ICT development indicator

	1995	2000	2005	2007
AUS	4.5	4.3	3.8	4.0
AUT	2.7	3.8	2.7	2.7
BEL	3.2	3.8	3.4	3.4
BUL	1.8	1.5	1.3	1.3
CAN	3.9	4.0	3.5	3.4
CZE	1.6	1.9	2.0	1.7
DNK	3.8	4.2	5.0	5.0
EST	2.0	2.8	3.1	3.2
FIN	5.0	4.2	4.5	4.4
FRA	2.9	2.8	2.9	3.2
DEU	2.7	3.4	3.3	3.9
GRC	2.2	2.3	3.1	3.2
HUN	1.5	1.8	2.4	2.3
IRL	2.5	2.9	2.7	3.1
ITA	2.3	3.0	3.0	3.3
JPN	2.8	3.1	3.0	2.6
KOR	2.5	4.4	4.4	4.3
LVA	1.6	1.7	2.6	2.0
LTU	1.5	1.7	2.8	2.7
NLD	3.7	4.6	4.0	4.7
POL	1.5	1.7	2.1	1.9
PRT	2.3	2.8	2.4	2.2
ROM	1.0	1.0	1.0	1.0
SVK	1.4	1.6	1.6	1.4
SVN	2.0	2.6	3.1	3.1
ESP	2.5	2.8	3.1	3.1
SWE	4.4	5.0	4.8	5.0
GBR	3.0	3.5	3.6	3.8
USA	4.2	3.9	3.8	3.8

Table A2: Countries with above average values of the ICT and transport indicators

Countries with above average quality of transportation infrastructure			Countries with above average level of ICT development		
AUS	FIN	POL	AUS	FIN	NLD
AUT	FRA	PRT	AUT	FRA	SVN
BEL	GBR	SWE	BEL	GBR	SWE
CAN	IRL	USA	CAN	GRC	USA
CZE	JPN		DEU	IRL	
DEU	KOR		DNK	ITA	
DNK	LTU		ESP	JPN	
ESP	NLD		EST	KOR	