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The Internet and International Trade in Goods

by

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Abstract

Previous studies by Freund & Weinhold (2004) and others have highlighted the trade promoting effect of the Internet. However, recent developments in structural gravity modelling emphasise the importance of controlling for multilateral resistance. We employ a gravity framework to assess the role of Internet adoption on trade within OECD countries over the period 1990-2010. We find that when multilateral resistance is controlled for, the Internet has a less clear cut effect on trade flows. Country pairs with relatively higher adoption rates trade more with one another than country pairs with lower adoption rates. However an increase in adoption within country pairs has little effect on trade. These results are robust when controlling for alternative communication technologies and comparison of dial-up and broadband connections.

JEL classification: F14; F15

Keywords: Internet; Technology; Trade; Distance; E-commerce

Outline

Non-Technical Summary

In this paper we explore the relationship between the proliferation of Internet technologies and international trade in goods. Existing research typically finds a positive and significant impact of Internet adoption. However, there are concerns that this relationship is driven by unobserved factors. Furthermore, the existing literature concerns the period before the arrival of high speed Internet and so considers only "narrowband" Internet technologies.

Recent advances in trade theory suggest trade flows are not exclusively determined by the bilateral costs of trade. Rather, countries evaluate the bilateral costs relative to the average costs of trading with all other partners. As such, these average costs represent prime candidates for unobserved factors omitted from previous research.

I take another look at the issue using data for members of the OECD for a panel 1990 to 2010.
I use the panel aspect of the data to control for unobserved factors that vary at the country level and across country pairs. I find that when one takes such factors into account, the Internet has a far more limited role to play than indicated by the literature. Country pairs with relatively higher adoption rates trade more with one another than country pairs with lower adoption rates. However I find little evidence that an increase in adoption within country pairs has a significant effect on trade.

I do not identify any effect pertaining to broadband and there is no effect of the Internet identified across the whole sample period. I find this result is robust to the inclusion of a variety of control variables, including alternative communication technologies, consideration of middle income countries and alternative specifications of our Internet variables.

On the whole this paper suggests one needs to look harder to identify the effect of Internet adoption on trade.

The Internet and International Trade in Goods

1. Introduction

In this paper we explore the relationship between the proliferation of Internet technologies and international trade in goods.

There is a relatively small existing literature examining this relationship (which we discuss further in section 3). Three salient examples find a positive and significant impact of Internet adoption (Freund and Weinhold, 2004, Clarke and Wallsten, 2006, Tang, 2006). However, recent developments in structural gravity modelling have also highlighted the importance of controlling for multilateral resistance terms and other unobserved factors (Anderson and Van Wincoop, 2003). Controlling for such resistance terms has been shown to have a substantial effect on traditional measures of trade costs, such as sharing a common border.

I re-evaluate this relationship using a panel of OECD countries for the period 1990 to 2010. We incrementally introduce fixed effects to control for these resistance terms and other omitted variables to examine the robustness of the relationship between the Internet and trade. I find the Internet has a less clear cut impact on international trade.

Country pairs with relatively higher adoption rates trade more with one another than country pairs with lower adoption rates. However I find little evidence that an increase in adoption within country pairs impacts trade over the period, with very weak evidence when considering the early years of the sample exclusively. When viewed across country pairs or in the absence of controlling for multilateral trade barriers, we therefore find a far stronger effect of the Internet both in terms of significance and economic magnitude. However, one needs to be cautious that we are not identifying some unobserved bilateral factor that is correlated with both Internet adoption and trade. Surprisingly, I do not identify any effect pertaining to broadband.

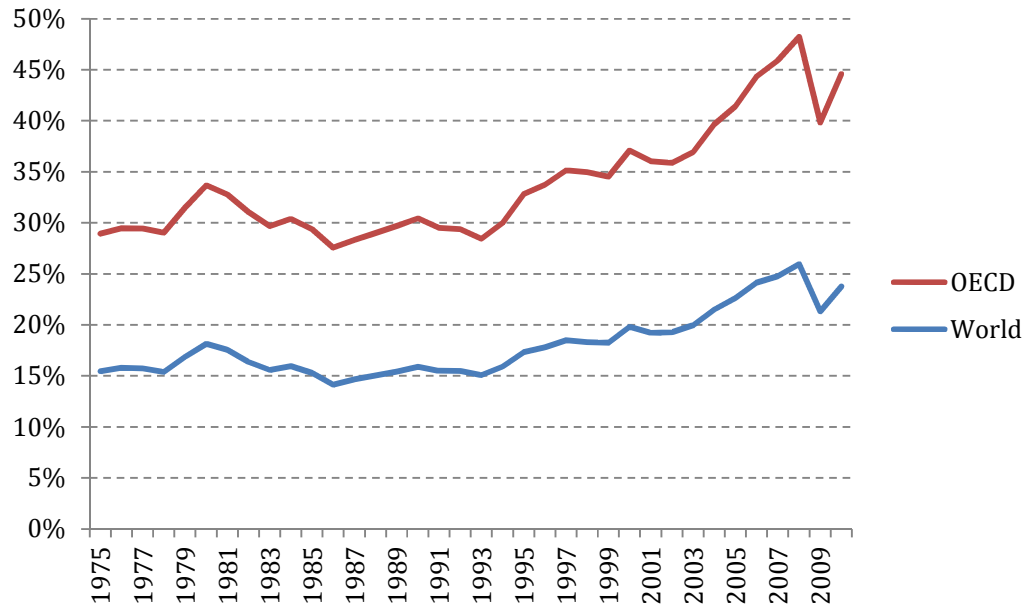
The results are robust to alternative specification of our Internet variable and measures of other communication technologies (mobile phone, fixed telephone lines and computers). I extend the sample to consider middle income countries and find diminished evidence of a relationship.

2. Motivation

One of the most striking features of the post war environment is the growth in world trade relative to output. Figure 1 shows the evolution of goods exports as a proportion of GDP for the World and the OECD.

Similar trends are observed for both country groupings. Over the 1970s and 1980s exports remain relatively flat as a proportion of GDP; however, from the 1990s onwards we witness a substantial growth in trade.

Figure 1: Goods Exports as Percentage of GDP



Source: Author's calculations from World Bank Development Indicators

Similarly, this can be illustrated by considering changes in trade costs. McGowan and Milner (2011) estimate trade costs for the period 1990 to 2006 using a theoretically consistent method advanced by Novy (2008). Figure 2 reveals the change in trade costs over time for developed and middle income countries in their sample.

It is well established that trade costs are large. McGowan and Milner (2011) estimate that across their sample average international trade costs are around 66 per cent higher than domestic costs in 2004, consistent with Anderson and Van Wincoop's (2004) estimate of 74% for the United States.

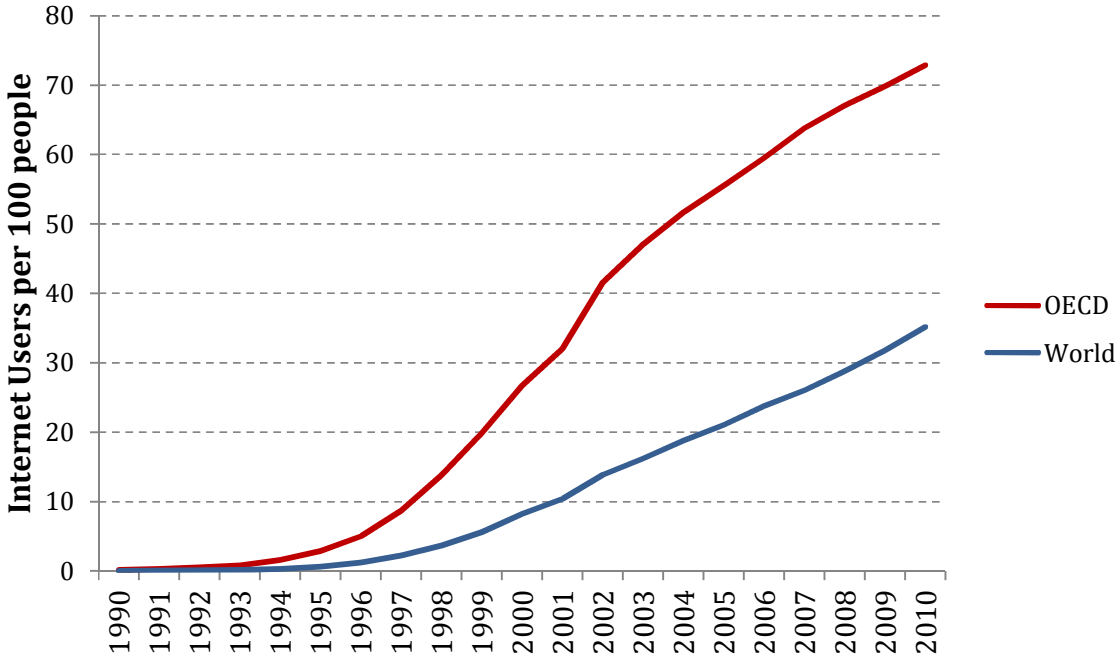
For our purposes it is more relevant to note that trade costs have fallen substantially since 1990, both among developed and middle income countries. McGowan and Milner (2011) note the average international trade cost in their sample fell from around 110 per cent to 66 per cent since 1990.

Figure 2: Trade Costs in Developed and Industrialising Economics

Source: McGowan and Milner (2011)

The 1990s and 2000s also witnessed the rapid proliferation of the Internet across the developed world (see Figure 3). In the median OECD country only 1 per cent of the population had Internet access in 1990, increasing to 27 per cent by the year 2000 and 76 per cent in 2010. From 1998 the first OECD countries introduced high speed broadband Internet connections. Broadband rapidly displaced previous narrowband technology. By 2010 the displacement is virtually complete, with 98 per cent of Internet users in the median OECD economy accessing via a broadband connection and the remaining 2 per cent via narrowband.

Figure 3: Mean Internet Adoption Rates



Anderson and Van Wincoop (2004) decompose trade costs into a variety of components including policy measures, information costs, transport and distribution costs, currency, legal and contract enforcement costs.

A growing literature in industrial organisation examines the role of the Internet in reducing search costs; that is the cost of matching buyers and sellers. Hong and Shum (2006) find the median search cost for textbooks is under $3, which as Lieber and Syverson (2011) note, is less than the cost of travelling to an offline retailer. However, it is also likely that the Internet has reduced the costs of finding overseas agents, distributors or retailers. A number of countries provide guidance on customs procedures online. For example, the EU has a freely accessible "European Customs and Information Portal" which provides step-by-step guidance to importing and exporting (European Commission, 2012a).

Local distribution costs, including wholesale and retail margins, are estimated to be equivalent to a 55 per cent ad-valorem tariff for the United States and at least 40 per cent for other countries (Anderson and Van Wincoop, 2004). E-commerce technologies have allowed in certain sectors the removal of links in the supply chain. Some online retailers distribute directly to the consumer, so called "drop shipping". Brynolfsson et al (2003) note in the context of online book retailers, that this permits expansion at the product extensive margin through reductions in the fixed cost of additional varieties. However, the portion of these costs borne similarly by both domestic and international firms will not influence bilateral trade.

The arrival of the Internet has also introduced a new advertising medium. For traditional methods such as billboards, newspapers, television it is relatively difficult to segment the market (Spulber, 2010). Traditionally advertisers rely on limited demographic information of their audience to segment the market. The Internet platform allows firms to learn far more information about consumer preferences using information revealed in the history of websites visited and terms entered into search engines. Combined with lower costs of tailoring advertisements, online advertising can be far more targeted to individual preferences than traditional methods. Viewers are more likely to receive relevant messages and hence each advert is more likely to generate sales (Evans, 2009).

One explanation for the growth in world trade that has been gathering increasing attention is that of vertical fragmentation of production. Trade flows are measured on a gross basis rather than the value added domestically. Therefore when production is internationally fragmented, trade is magnified by the number of times the intermediate good crosses borders. A number of models have been proposed that hinge on the growth in production fragmentation since the mid-1980s (the "second unbundling) being underpinned by the revolution in information communication technologies (e.g. Grossman and Rossi-Hansberg (2008), Baldwin (2011). Reductions in the cost of coordinating different production tasks permitted fragmentation across borders.

3. Related Literature

There are relatively few papers looking at the relationship between Internet adoption and international trade. Recently however, a small number of papers have revisited the issue to take advantage of the longer time series now available. These more recent papers have also attempted to address possible concerns around omitted variables and endogeneity of Internet adoption.

Freund and Weinhold (2004) is the first paper to consider the issue. Their sample consists of fifty six developed and middle income countries for the period 1995 to 1999. Their Internet measure captures the number of website domain names in each country; for example, websites ending in ".nl" are attributed to the Netherlands. The measure is somewhat unusual however they are constrained by limited contemporaneous data availability and their results are robust to using a measure of Internet users from the World Bank. Performing panel growth regressions and cross sectional traditional gravity estimation they find a ten per cent increase in the growth of internet users leads to a one per cent increase in exports. They find little evidence that the Internet has impacted the effect of distance on trade.

Tang (2006) investigates how the proliferation of a range of communication technologies impact US imports of differentiated and homogenous goods[1]. Using data from 1975 to 2000, he contrasts the impact of exporting country adoption of fixed line telephones, mobile phones and the number of computers connected to the Internet (Internet hosts). With time fixed effects, he finds the all measures of technology have a positive and significant impact on US imports of differentiated goods, but not those sold on an organised exchange. A ten per cent increase in exporter Internet connections leads to an increase in US imports of differentiated goods by approximately one per cent.

Clark and Wallsten (2006) is the first paper to attempt to address the potential endogeneity issues surrounding Internet adoption with an instrumental variables approach. Using a cross-section of 101 countries in 2001 they instrument Internet hosts with data on the level of competition in the telecommunications sector. They investigate the potential differential impact of the Internet on trade within and between developed and developing countries. Internet penetration leads to an increase in exports from developing to developed countries, but no other trade flow. The instrument is significant in predicting Internet proliferation within developing nations but not developed countries. So regressions involving high income countries are likely to suffer from the problems associated with weak instruments and should be treated with caution.

Vemuri and Siddiqui (2009) and Mattes et al (2012) take a more common approach in empirical trade research by estimating gravity regressions that control for omitted variables through the inclusion of fixed effects.

Mattes et al (2012) construct a dummy variable composite ICT index that combines measures of the Internet, broadband, mobile phones and education levels for EU countries 1995 to 2007. They control for time varying country

[1] Goods are classified into differentiated, reference priced and sold on an organised exchange according to Rauch (1999).

specific effects, but do not control for unobserved bilateral factors. They find countries with an ICT index above the mean have 52 per cent higher bilateral trade than those below the mean.

Vemuri and Siddiqui (2009) use a measure of Internet proliferation that is the minimum of the exporter and importer adoption. Their specification controls for unobserved bilateral factors only and so is closer to the traditional gravity estimation. A ten per cent increase in Internet adoption leads to a 2 per cent increase in bilateral trade.

Blum and Goldfarb (2006) apply a gravity model to the consumption of goods digital goods over the Internet. They show that distance has a significant effect on the websites households visit, even though there are no direct transportation costs involved. However, the effect is limited to products they classify as depending on taste; including music, games and pornography. These suggest an important role for preferences in determining the geography of trade patterns. Hortacsu et al (2009) find similarly that distance continues to be an important determinant of trade, when considering transactions on the auction sites eBay and MercadoLibre.

The role of communication costs more generally has not been covered extensively in the trade literature. A notable exception is Fink et al (2005) who introduce communication costs into a gravity model of trade. They use a novel measure of communication costs; the cost of an international telephone between the exporting and importing countries. The measure of communication costs limits the analysis to a cross section in 1999. To control for endogeneity they instrument telephone costs with measures of competition in the telecommunication sector in each country. Controlling for importer and exporter fixed effects, their results suggest a remarkably large effect for a halving of importers calling price of a 42.5 per cent increase in trade.

4. Data

4.1 Country Sample

We include thirty four countries in our sample. These consist of the current OECD members. In our robustness checks the analysis is supplemented by twenty six middle income countries (note middle income as classified by the World Bank). Throughout this paper we refer to OECD countries as "North" and the remainder of the sample as "South".

We focus on higher income countries for reasons of data quality. The twenty six countries have been selected from the set of all middle income countries on the basis of market size (as measured by GDP in 2000) and data quality. See section *Data Quality* for further discussion.

A full list of countries included in the sample is noted below:

North		South	
Australia	Japan	Argentina	Lithuania
Austria	Luxembourg	Bolivia	Morocco
Belgium	Mexico	Bulgaria	Malaysia
Canada	Netherlands	Brazil	Pakistan
Chile	New Zealand	China	Panama
Czech Republic	Norway	Colombia	Peru
Denmark	Poland	Costa Rica	Philippines
Estonia	Portugal	Dominican Republic	Paraguay
Finland	Slovak Republic	Ecuador	Romania
France	Slovenia	Egypt	Tunisia
Germany	South Korea	India	Ukraine
Greece	Spain	Kazakhstan	Venezuela
Hungary	Sweden	Sri Lanka	Yemen
Iceland	Switzerland		
Ireland	Turkey		
Israel	United Kingdom		
Italy	United States		

4.2 Data Sources

The paper draws upon four main data sources.

Measures of Internet penetration and other communication technology control variables are sourced from the International Telecommunications Union's (ITU) ICT Indicators Database 2011. These are available for the period 1990-2010 and hence determine our time period for the analysis. The core indicators above are collected mainly from telecommunication authorities in each country, household surveys and some private companies (ITU, 2010).

The measures of Internet penetrations are detailed below:

Data field	Details	Source
Internet Users	Percentage of individuals using the Internet	ITU World Telecommunication/ICT Indicators Database
Broadband Connections	Fixed Broadband subscribers per 100 inhabitants	
Any Fixed-Line Connection	Fixed Internet subscribers per 100 inhabitants	
% Broadband Connections	Percentage of Broadband subscriptions	Calculated as Broadband Connections / Any Fixed Line Connection

As part of our robustness checks, we introduce measures of alternative communication technologies, the details of which are noted below:

Data field	Details	Source
Mobile Phones	Mobile cellular telephone subscriptions per 100 inhabitants	ITU World Telecommunication/ICT Indicators Database
Computers	Percentage of households with a computer	
Telephone Lines	Fixed telephone lines per 100 inhabitants	

Bilateral aggregate export data is obtained from UN COMTRADE. GDP data is obtained from World Bank Development Indicators. CEPII GeoDist Database and Gravity Dataset is used for country-pair distances, details on joint membership of regional trade agreements and whether countries share a common border, language or colonial history.

The CEPII Gravity Dataset contains data on regional trade agreements and currency unions for the period 1948-2006 for all the countries in our sample. For the years 2007-2010 the information has been supplemented by data from the WTO RTA database. The RTA database details separately for goods and services notifications of regional trade agreements including regional trade agreements and currency unions. All agreements that are in force for at least six months of the year are classified as applying for that year; otherwise they are classified as applying from the following year.

4.3 Data Quality

Treatment of Missing Trade Flows

In principle a missing value could represent a genuine missing observation or a zero trade flow. Since we are dealing with aggregate trade flows between developed countries it seems highly likely that these are genuinely missing. As such we drop these values from the analysis.

Due to the focus on higher income countries, there are not a significant number of zero trade flows to be concerned with. Of the 23,562 possible North-North trade flows there are 22,024 non-zero observations, which represents less than seven per cent of the possible sample.

Data Controls

I have performed a number of data checks on the raw Internet and communication technology data. These checks include zero or missing values; whether adoption rates increase each year and are bounded between 0 and 100%.

The vast majority of countries have complete data for all years and data fields. Some countries have missing values for a minority of years. I could not readily identify alternative data sources for these fields. Where missing values are observed these were linearly interpolated / extrapolated between observed data points.

"Any fixed-line connection" is the most problematic field. Finland, Germany and Japan suffer from missing data for several years up to 2010. It is not possible to interpolate such data; consequently these country-year combinations are omitted from analyses involving this field.

In terms of the alternative measures of communication technology again the data deficiencies relate to missing observations. In particular, the "Computers" control variable suffers from missing data prior to the first observation. As noted above, in principle this could be genuine missing data or zero adoption rate. For virtually all countries missing observations were followed by a large positive value. For example, Australia has no recorded values prior to 1990-1995 and 36 per cent of households with a computer in 1996. As such, we treat all initial blank observations as missing and drop these from the analysis.

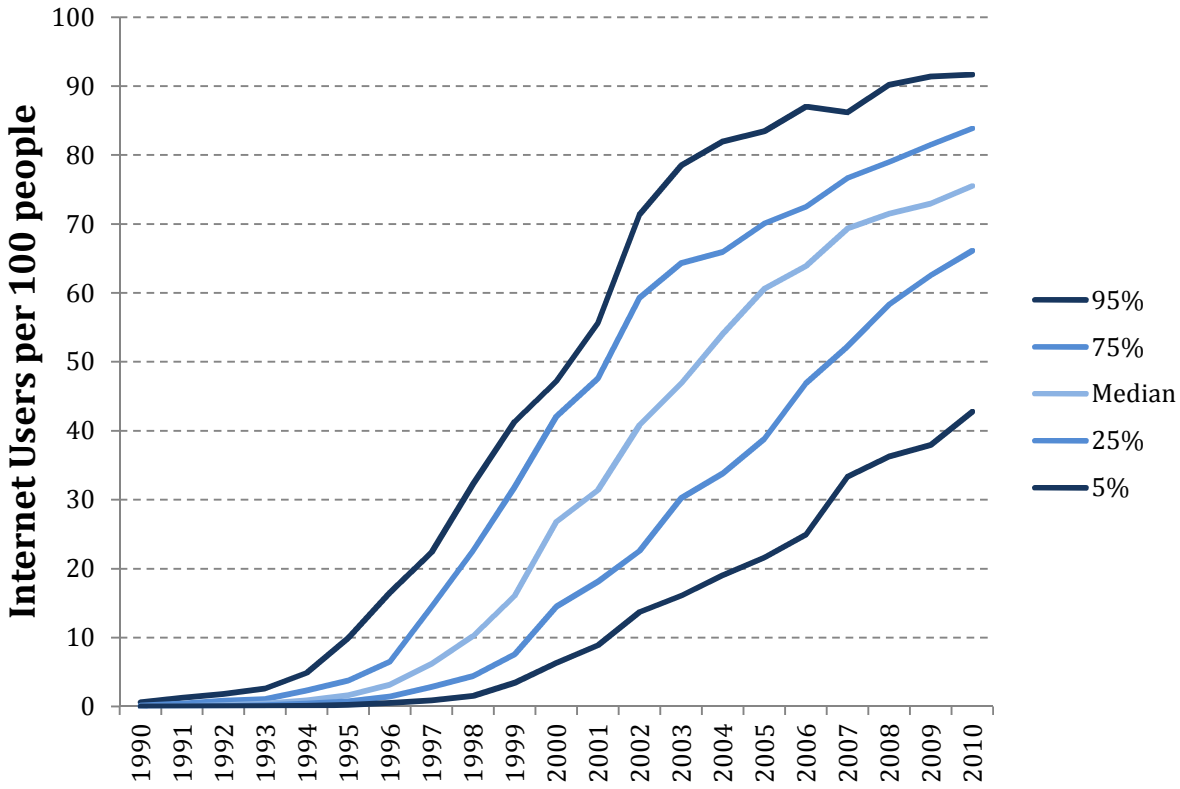
4.4 Summary Statistics

Internet Users

The following figures outline how the proportion of Internet Users has evolved over time for each country. The graphs reveal how the most and least connected countries develop by depicting the adoption rates of countries at different percentiles. Specifically, we show the median, 75th, 95th, 25th and 5th percentile adoption in any given year.

Figure 4 shows the adoption rates for the OECD. Adoption follows the typical S-curve pattern observed by a number of studies of technology diffusion (such as Andres et al (2010)). Internet adoption is near zero at the start of the 1990s for all countries in our sample. However, in the late 1990s adoption Internet proliferates rapidly. By 2010, the median country has over 70% of Internet users. Over time all countries exhibit a growth in the number of Internet users as one would expect, however the growth rates differ across countries and there is also considerable cross-sectional variation within the sample. For example, in 2010 the most connected countries have over 90 per cent adoption rates and the least connected around 40 per cent.

Figure 4: Internet Users in OECD

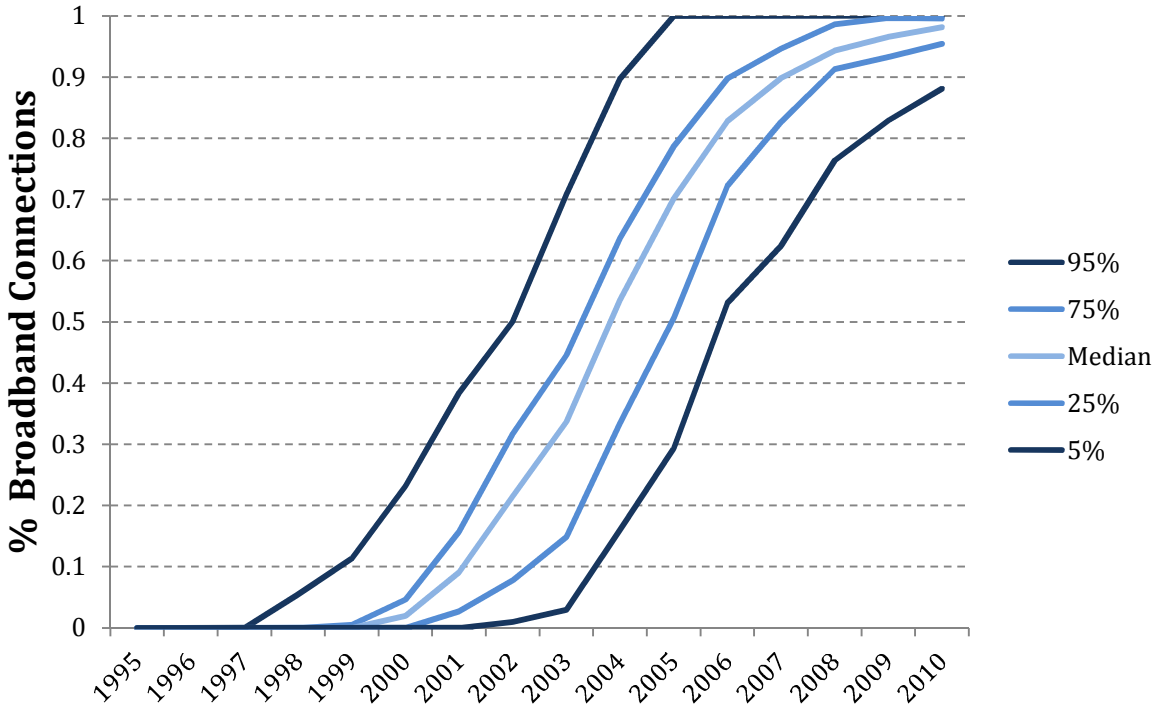


Percentage Broadband Connections

The following figures outline how the proportion of broadband connections has evolved over time. The graphs reveal how the most and least connected countries evolve over time by depicting the adoption rates of countries at different percentiles.

Figure 5 depicts the percentage of broadband relative to narrowband connections for the OECD. The first countries adopt broadband in 1998, with a rapid proliferation that displaces existing dial-up and ISDN narrowband technologies as a means of Internet access. The majority of countries in the sample have over 98 per cent of connections that are broadband by 2010. There is considerably less cross-sectional spread in the data compared to Internet User data. Although there is variation in initial adoption date, the majority of countries follow a similar adoption trend thereafter.

Figure 5: Percentage of Broadband Connections in OECD



5. Specification

5.1 Empirical Approach

We assume that bilateral trade costs t_{ijt} contain two components; Internet technology variables $Internet_{ijt}$ and a range of non-technology variables Z_{ijt}. Taking logs of equation 1.5, we have the following empirical model:

$$\ln X_{ijt} = \beta_0 + \beta_1 Internet_{ijt} + \beta_2 Z_{ijt} + \beta_3 \overrightarrow{FE}_{ijt} + \varepsilon_{ijt} \qquad [1.1]$$

where ε_{ijt} is the disturbance term and $\overrightarrow{FE}_{ijt}$ represents a variety of importer, exporter and time fixed effects.

As is common in the literature, non-technology variables are captured by a measure of distance between countries, a dummy variable if the countries share a common border. Additional dummy variables are included for whether the countries speak the same language, share the same currency or colonial history or are both members of a regional trade agreement. For further information, see section 4.2.

Inclusion of fixed effects is common in the estimation of recent gravity models (see Feenstra (2004), pg 161). Importer and exporters fixed effects are a widespread method to account for unobservable multilateral resistance terms. We allow for time varying importer and exporter fixed effects to account for variation in multilateral resistance terms over time. The fixed effects also account for any other sources of heterogeneity at the country level, such as the quality of institutions, local distribution costs, customs procedures and so on. The downside of this of course is that the fixed effects also account for observed country level heterogeneity; as such the economic mass variables are not identified.

Similarly, country pair fixed effects account for any bilateral time-invariant factors. Only time varying bilateral variables are identified. As a consequence, variables such as distance, contiguity, sharing a common language and colonial origins drop out of the regression.

Throughout the analysis we report standard errors that employ the Huber-White correction for heteroskedastic robust standard errors. In reality, each observation may not be independent, particularly within country pairs. Cameron and Miller (2010) emphasise that failure to account for this can lead to understated standard errors and overstatement of statistical significance. We assume the standard errors are clustered at the country pair level to allow for correlation of standard errors within each bilateral relationship.

Santos-Silva and Tenreryo (2006) show that in the presence of many zeros, heteroskedastic residuals may lead to inconsistent results under ordinary least squares estimation. Our dataset does not have zero trade flows, however suffers from a limited number of missing values, which we treat as genuinely

missing as described in section 4.3. As such we undertake least squares dummy variables estimation.

5.2 Specification of Internet variable

We define our key variable of interest as follows:

$$Internet_{ijt} = \frac{Internet_{it} \cdot Internet_{jt}}{\max_{a,b}(Internet_{at} \cdot Internet_{bt})} \quad [1.2]$$

The first observation is that the technology variable enters in levels rather than in logarithms. All of our technology variables are measured in percentages (see section 4.2) so we do not take logs. This offers several advantages including a more sensible interpretation of estimated elasticities and retaining observations with zero adoption. We therefore treat technology variables consistently with other binary variables such as currency unions and free trade areas that are estimated in levels in the literature.

Secondly, the technology variable enters as a product of the importer and exporter adoption rates. As noted earlier there are several reasons to suspect there are network externalities concerning Internet proliferation. The interaction term captures that the impact depends on both countries' adoption rates. This is consistent with the specification of the previous literature (e.g. Clarke and Wallsten (2006), Freund and Weinhold (2004).

Finally, we are concerned with how relative adoption rates influence trade. The work of Anderson and Van Wincoop (2003) highlight the importance of relative bilateral trade costs as determinants of international trade. The scaling by the most connected pair allows us to consider adoption relative to the technology frontier. We would expect that countries that are more connected relative to one another (i.e. closer to the technology frontier) to trade more. It also has the convenient property that it is bounded between zero and one hundred per cent. As part of our sensitivity analysis we perform robustness checks with a specification without any scaling factor, see section 7.3.

5.3 Endogeneity

In the context of regional trade agreements, Baier and Bergstrand (2007) identify three potential causes of endogeneity; omitted variables, simultaneity and measurement error. We consider each of these in turn.

We include a large range of fixed effects in our estimation approach. Unobserved country specific factors that may be correlated with countries' decisions to invest in Internet technology will be captured by time-varying country fixed effects. These include factors such as income levels, demographic factors, infrastructure variables and measures of human capital. Inclusion of bilateral fixed effects also captures any time invariant bilateral factors that may affect the Internet adoption decision, such as historic trade flows and common language. Consequently, the fixed effects approach captures the obvious

unobserved factors that could be correlated with Internet adoption. As Anderson and Yotov (2012) note "Econometric problems of exogeneity and omitted variables are demolished when fixed effects replace the theoretically indicated size and multilateral resistance variables".

Any concerns about endogeneity caused by omitted variables must therefore relate to unobserved time varying bilateral factors that are correlated with Internet adoption. As part of our robustness checks we include alternative measures of technology; such as mobile phones, computers and telephone lines.

If bilateral trade flows determine Internet adoption and Internet adoption determines bilateral trade, then there is potential for simultaneity bias. In our view it is not likely that any one bilateral trade relationship could determine Internet infrastructure decisions.

Countries that are more open with all countries may have a greater incentive to invest in communications technology. However, Chinn and Fairlie (2007) find that trade openness is not a statistically significant determinant of Internet penetration for a cross-country panel of 161 countries. In any event, our fixed effects strategy will pick up any time varying importer or exporter specific factors such as these.

Our final possible concern relates to measurement error in our technology variable. We discuss data quality in more detail in section 4.3. On the whole, the data appears to be of a reasonably good quality and comfort can be obtained from collection methods. The Internet data is collected directly from either telecommunication providers or from household surveys and there are few deficiencies obvious from the final data.

One possible approach is to utilise several different data sources. Data on Internet adoption is available from other sources, such as the World Bank and OECD. However, this data is sourced originally from ITU (the source used in this paper) and so provides no additional information. Instead, we restrict our sample to middle and high income countries to reduce the likelihood of data quality problems.

6. Results

6.1 Internet Users

In this section we measure Internet proliferation in terms of the percentage of Internet users. Table 1 provides the results for trade flows within the North. As noted earlier, previous studies do not control for multilateral resistance and hence the coefficient on Internet adoption may be biased. We incrementally add in fixed effects to our specification to provide some comparison against more traditional approaches.

The results in the first column contain time-invariant importer and exporter dummies, the second column supplements these with year dummies. In both these specifications the Internet has a positive and highly significant effect on bilateral trade. The introduction of time varying importer and exporter dummies magnifies the result. Taking the results from column three, a ten per cent increase in bilateral Internet adoption (relative to the most connected pair) leads to a ten per cent increase in bilateral trade. At first glance, the elasticities appear comparable with the effect of distance on trade. However due to the scaling of the technology variables caution should be exercised in benchmarking to the control variables as the variables are specified differently.

Turning to the control variables, it is interesting to note that the coefficients are on the whole remarkably stable across the first three specifications. Here we discuss the control variables in turn.

Distance has the expected negative effect on trade with a coefficient close to unity. The coefficient is not out of line with the existing literature surveyed by Disdier and Head (2008). We find common language has a positive and significant effect with an estimated coefficient of around 0.34, which is well in line with other studies, such as Egger and Lassman (2011). Colonial links and membership of a regional trade agreement have a positive and significant effect on trade as one would expect.

Contiguity has no significant effect upon trade flows across all specifications. One would normally expect a positive effect of sharing a common border (see for example, Baldwin and Taglioni (2007)). However, the majority of papers in the literature either do not implement a comparable fixed effects strategy or consider a very different sample of countries. Parsons (2012) finds contiguity has an insignificant effect on bilateral North-North trade using a similar sample of OECD countries.

Sharing a common currency has a negative and significant effect on trade flows. At first glance this seems quite unusual, as one would expect that eliminating the cost of currency exchange, exchange rate volatility and so on, would lead to a trade creating effect. The data relates to Eurozone membership and has been cross-checked against membership documented by European Commission (2012b). Traditionally authors, such as Rose (2000) find a significant, positive effect of currency unions. However, Baldwin and Taglioni (2007) find a significant, negative effect when controlling for bilateral and country-time fixed effects. Cipollina and Salvatici (2010) find in their meta-analysis that there is never a significant additional effect of currency unions over

and above regional trade agreements. It is also well established that variables representing currency unions and regional trade agreements are plagued by endogeneity issues which can result in biased coefficients, as argued by Glick and Rose (2002) and Baier and Bergstrand (2007). It should also be noted that this is a relationship conditional on the other variables included, such as membership of free trade areas like the Eurozone. Taken combined with EU membership there remains a net trade creating effect as one would expect.

The economic mass variables have a positive and significant effect as expected. The coefficient is close to unity that is predicted by structural gravity models.

The final column introduces bilateral dummies in addition to time varying exporter and importer dummies and is our preferred regression. Looking within country pairs the results change significantly.

Common currency and regional trade agreements have no significant effect on trade. The result is consistent with Baldwin and Taglioni (2007) when controlling for fixed effects similarly.

More importantly for our analysis, Internet users have no significant effect on trade flows. Surprisingly, country pairs that become more connected do not have an associated increase in trade. In comparison to column three, this implies the effect is purely driven across country pairs. That is to say, country pairs who are more connected relative to others tend to trade more with one another. As noted in section 4.4 there is considerable fluctuation over time in Internet adoption rates and so it seems sensible to conclude there is sufficient variation to identify any effect of bilateral adoption on trade.

Contrasting the results of columns four and three, a natural concern is that the Internet effect identified in regression three may in fact be picking up some unobserved bilateral factor that is both correlated with Internet adoption and bilateral trade. We consider the robustness of this conclusion in the next section.

Table 1

Dependent Variable: Log Exports	**N-N Internet Users (1990-2010)**		**N-N Internet Users (1990-2010)**	
	(1)	(2)	(3)	(4)
Internet Users	0.262***	0.497***	1.020***	0.081
	(0.095)	(0.112)	(0.237)	(0.097)
Log Distance	-1.198***	-1.200***	-1.203***	-
	(0.059)	(0.059)	(0.063)	
Common Language	0.329***	0.336***	0.344***	-
	(0.099)	(0.099)	(0.101)	
Colonial Link	0.415**	0.411**	0.392**	-
	(0.162)	(0.162)	(0.167)	
Adjacency	0.003	-0.008	-0.022	-
	(0.128)	(0.127)	(0.130)	
Common Currency	-0.176***	-0.110**	-0.149**	-0.048
	(0.052)	(0.053)	(0.073)	(0.038)
RTA	0.336***	0.310***	0.266***	0.050
	(0.053)	(0.054)	(0.084)	(0.040)
Exporter GDP	0.747***	1.351***	-	-
	(0.079)	(0.098)		
Importer GDP	0.733***	1.324***	-	-
	(0.078)	(0.100)		
Time FE		**Y**		
Importer / Exporter FE	**Y**	**Y**		
Importer-Time / Exporter-Time FE			**Y**	**Y**
Country Pair FE				**Y**
R-squared (# - within group)	0.896	0.899	0.910	0.747#
Observations	22,024	22,024	22,024	22,024

(Robust clustered standard errors in parentheses)

6.2 Broadband

In this section we consider the role of broadband adoption on trade flows. Table 2 provides the results for trade flows within the North for the period from which broadband was first available; 1998 onwards[2].

Columns five and six mirror the analysis of Table 1 restricted to the period 1998 to 2010. As one would expect, the conclusions drawn in the previous section are robust to consideration of a restricted number of years and the control variables have a similar sign, size and significance.

Columns seven and eight show the impact of the proportion of broadband connections (relative to any Internet connection) and supplement regressions five and six. We do not identify any additional effect of countries that have a greater proportion of broadband connections on bilateral trade. This holds when viewed either across countries or within country pairs (see columns five and six respectively). The sign on the coefficients is not consistent across regressions, being positive within country pairs and negative across country pairs. The economic magnitude is also very small, with a ten per cent relative increase in broadband connections having an effect on trade flows of less than a tenth of one per cent.

The finding is somewhat surprising. However, we cannot necessarily conclude that broadband does not impact bilateral trade, however controlling for multilateral resistance we do not observe its effects. If the effect of broadband operates purely through price indices, i.e. impacts trade costs with all countries proportionally, then this would be captured by the exporter and importer fixed effects and would not be observed.

Note that the reduced sample size for the latter two columns results from the omission of Finland, Germany and Japan for the years that the percentage of broadband connections is not available. For further discussion see section 4.3.

We have also performed analysis with broadband connections specified as absolute values, rather than percentage of all fixed Internet connections. These results also suggest there is no significant effect of broadband technology (the results are not reported here for space considerations).

[2] Our technology variable is defined relative to the maximum bilateral adoption rate. There is no meaningful scaling before the first country pair adopts and hence the sample is restricted to the period from 1998 onwards.

Table 2

Dependent Variable: Log Exports	**N-N Connection Type (1998-2010)**			
	(5)	(6)	(7)	(8)
Internet Users	1.263***	-0.148	1.270***	-0.131
	(0.325)	(0.146)	(0.330)	(0.147)
% Broadband Connections			-0.043	0.013
			(0.264)	(0.121)
Log Distance	-1.190***	-	-1.202***	-
	(0.063)		(0.059)	
Common Language	0.333***	-	0.336***	-
	(0.103)		(0.102)	
Colonial Link	0.346***	-	0.401***	-
	(0.161)		(0.153)	
Adjacency	0.020	-	0.047	-
	(0.127)		(0.129)	
Common Currency	-0.162***	0.021	-0.163**	0.021
	(0.073)	(0.038)	(0.077)	(0.037)
RTA	0.404***	-0.027	0.388***	-0.028
	(0.094)	(0.043)	(0.097)	(0.045)
Importer-Time / Exporter-Time FE	**Y**	**Y**	**Y**	**Y**
Country Pair FE		**Y**		**Y**
R-squared (# - within group)	0.911	0.710#	0.909	0.706#
Observations	14,506	14,506	13,350	13,350

(Robust clustered standard errors in parentheses)

7. Robustness

7.1 Middle Income Countries

In this section we consider the robustness of the previous conclusions to consideration of middle income countries. The adoption rates of the South differ substantially from high income countries, with adoption generally lower and commencing later. There are other reasons to suspect that the results concerning the South may differ, notably, the higher existing levels of trade costs (McGowan and Milner, 2011).

Appendix 10.1 Table 3 extends the analysis to consider trade-flows within the South and between the South and North. Again we incrementally add in fixed effects, with the first column containing time varying importer and exporter dummies and the second column adding country pair dummies.

Internet adoption has little significant effect on trade involving the South. The only (marginally) significant coefficient relates to exports from the South to the North in column seven. A ten per cent relative increase in bilateral Internet adoption leads to an eight per cent rise in trade. This result is consistent with Clarke and Wallsten (2006) who find Internet penetration magnifies exports from the developing to developed countries, but has no effect upon exports to other developing countries or the exports of developed nations. The coefficients are generally much smaller that North-North trade. As noted above for Table 1, there is no significant effect of Internet penetration when considering within country pairs.

Results for trade involving the South also suggest no significant effect of broadband over and above Internet access. The interested reader is directed towards Appendix 10.1 Table 4.

7.2 Alternative Communication Technologies

The timing of the arrival of Internet technology overlaps with the development of mainstream mobile phone technology and adoption of household computers. It could be argued that previous regressions are in fact suffering from omitted variables bias, and that the effects attributed to Internet adoption are in fact due to some alternative technology omitted from the previous regressions.

To mitigate this critique, in Appendix 10.2 Table 5 we re-perform regressions 3 and 4 controlling for alternative technologies.

In view of Table 5 the most salient observation is that inclusion of these control variables does not change the conclusions from section 6.1. In the absence of bilateral dummies, conditional on the level of other technologies, the effect of Internet users on bilateral trade is strengthened. When all alternative technology measures are included, only telephone lines remains statistically significant. It is interesting to note this has a negative sign. Clearly this is a relationship conditional upon the other variables in the model and does not per se imply that higher fixed telephone infrastructure is associated with lower trade flows.

These results contrasts sharply with Tang (2006) who finds that combining telephone lines and mobile phone penetration together has a similar positive and significant effect. It is not reported whether these coefficients are statistically different from one another and so it is difficult to judge the additional impact of mobile phones. However at first glance the coefficients appear similar (approximately two per cent different) suggesting the additional impact of mobile phones is small, which is consistent our findings here.

As in section 6.1, the inclusion of country pair fixed effects implies all included technology variables have no statistically significant effect.

7.3 Alternative Ratios

In the previous analysis we have be concerned with adoption rates relative to the most connected country pair. Here we examine the sensitivity to this definition by considering adoption without any scaling factor. We report results with respect of North-North trade in Appendix 10.3 Table 6.

Focusing first on Internet users, the conclusions from section 6.1 are altered somewhat. As before, across country pairs Internet use has a positive and significant effect on trade. The interesting difference relates to within country pair estimation.

The proliferation of Internet within country pairs now leads to a positive and significant increase in bilateral trade. In the absence of scaling, the coefficient on our Internet variable is more readily comparable. Notice that Internet use has an economic effect on trade far larger than membership of a free trade area. Increasing bilateral Internet adoption rates 10 per cent leads to an 8 per cent increase in trade.

The conclusions with respect to broadband discussed in section 6.2 are remarkably robust. Broadband appears to have no additional effect whether country pair fixed effects are included or not. The reader is directed to Appendix 10.3 Table 7.

The magnitude of the coefficients on the technology variables has increased compared to the previous results from section 6.1 and 6.2. Since we were previously scaling with respect to the maximum adoption this is expected. A one per cent increase in adoption relative to the maximum is greater than a one per cent increase in adoption per se, as such we would expect the estimated coefficients to be larger.

We assess the robustness of this alternative specification by introducing alternative measures of technology. The results of which are reported in Appendix 10.3 Table 8.

The effect of the Internet seems robust to the inclusion of mobile phone and telephone line technology. The coefficient on Internet users remains broadly stable and significant at conventional levels. Interestingly, as in section 7.2 mobile phone and telephone lines have a negative effect on trade and now the relationship with respect to mobile phones is statistically significant.

Inclusion of the computer variable changes matters. The coefficient on Internet adoption is now negative and insignificant. The positive coefficient on computers suggests that some of this effect may have previously been incorrectly attributed to the Internet.

An alternative explanation could be that effect of the Internet is mainly attributed to the early years of adoption, precisely those years omitted by regressions including computers.

To assess this we re-perform the regression restricting the sample to the first and last thirteen, fourteen and fifteen years (see Appendix 10.3 Table 9). In the unrestricted sample, recall the estimated coefficient of 0.810 which is significant at the ninety five per cent level (see regression twenty one). We find the results are robust to dropping latter years from the sample, with a significant and broadly consistent coefficient reported across regressions fifty nine to sixty one. The coefficient remains around the 0.7 to 0.8 mark; however the significance obviously falls with a smaller sample size.

The results are far less robust to dropping early years. The Internet is not significant in any of the regressions that drop the first thirteen, fourteen or fifteen year. The estimated coefficient has also fallen significantly compared to the unrestricted case.

7.4 Dial up versus Broadband Age

The results involving alternative ratio specification suggest that the positive effect of the Internet is limited to the earlier years in our sample. We investigate whether this is the case using our main specification (as described in section 5.2). Appendix 10.4 Table 10 reports the results of restricting the sample period to the first twelve to sixteen years.

Recall that over the full sample period (1990-2010) we find no evidence of a statistically significant effect of the Internet when controlling for unobserved bilateral factors. Here we find some evidence of a significant positive effect over the early sample years. Overall, the evidence is quite weak as the significance level is close to the ten per cent threshold. Notice that the coefficients are approximately double those identified in regression four. These suggest that a ten per cent relative increase in bilateral Internet adoption leads to a one point five per cent rise in bilateral trade.

In this section we note that if there is any significant trade-creating role for the Internet it resides in the early years of adoption, i.e. before broadband technology became widespread. Consequently, this adds further weight to the conclusions of section 6.2, namely the absence of evidence for a relationship between broadband adoption and bilateral trade.

8. Conclusions

In this paper we have explored the relationship between the proliferation of Internet technologies and international trade in goods. Previous research finds a positive and significant impact of Internet adoption (Freund and Weinhold (2004), Clarke and Wallsten (2006), Tang (2006)). However, recent developments in structural gravity modelling have also highlighted the importance of controlling for multilateral price indices. Furthermore, the existing literature concerns the period before the arrival of high speed Internet and so considers only "narrowband" Internet technologies.

In the context of the OECD I find the Internet has a far more limited role to play than indicated by the literature. Using a fixed effects approach to control for multilateral resistance and unobservable factors, I find the Internet has a less clear cut impact on international trade. Country pairs with relatively higher adoption rates trade more with one another than country pairs with lower adoption rates. However I find little evidence that an increase in adoption within country pairs has a significant effect on trade.

I do not identify any effect pertaining to broadband and there is no effect of the Internet identified across the whole sample period. I find this result is robust to a variety of controls, including alternative communication technologies, consideration of middle income countries and alternative specifications of our Internet variables.

When viewed across country pairs or in the absence of controlling for multilateral trade barriers, we therefore find a far stronger effect of the Internet both in terms of significance and economic magnitude. However, one needs to be cautious that we are not identifying some unobserved bilateral factor that is correlated with both Internet adoption and trade.

On the whole this paper suggests one needs to look harder to identify the effect of Internet adoption on trade. It is also likely that the Internet is likely to impact some sectors more than others and any sectoral reallocation of trade will not be identified in the aggregate analysis performed here.

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10. Appendix

10.1 Appendix to Section 7.1

Table 3

Dependent Variable: Log Exports	**N-S Internet Users (1990-2010)**		**S-N Internet Users (1990-2010)**		**S-S Internet Users (1990-2010)**	
	(9)	(10)	(11)	(12)	(13)	(14)
Internet Users	0.184	0.012	0.788*	0.356	0.205	0.160
	(0.363)	(0.167)	(0.443)	(0.260)	(0.597)	(0.400)
Log Distance	-1.518***	-	-1.588***	-	-1.722***	-
	(0.089)		(0.100)		(0.093)	
Common Language	0.573***	-	0.419***	-	0.513**	-
	(0.153)		(0.142)		(0.210)	
Colonial Link	0.626***	-	0.551***	-	-	-
	(0.176)		(0.195)			
Adjacency	0.347	-	0.606	-	-0.395	-
	(0.602)		(0.413)		(0.272)	
Common Currency	-1.400***	-	0.278	-	-	-
	(0.262)		(0.363)			
RTA	0.304**	0.178**	0.125	0.047	1.221***	0.360**
	(0.153)	(0.073)	(0.148)	(0.093)	(0.231)	(0.167)
Importer-Time / Exporter-Time FE	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
Country Pair FE		**Y**		**Y**		**Y**
R-squared (# - within group)	0.856	0.583#	0.818	0.441#	0.753	0.422#
Observations	16,780	16,780	14,655	14,655	10,142	10,142

(Robust clustered standard errors in parentheses)

Table 4

Dependent Variable: Log Exports	**N-S Broadband (1998-2010)**		**S-N Broadband (1998-2010)**		**S-S Broadband (1998-2010)**	
	(15)	(16)	(17)	(18)	(19)	(20)
Internet Users	0.233	0.110	1.115*	0.381	0.167	0.078
	(0.553)	(0.305)	(0.617)	(0.393)	(0.860)	(0.473)
% Broadband Connections	0.740*	-0.118	-0.010	-0.255	-0.147	-0.221
	(0.423)	(0.167)	(0.546)	(0.297)	(0.443)	(0.258)
Log Distance	-1.505***	-	-1.591***	-	-1.685***	-
	(0.101)		(0.112)		(0.100)	
Common Language	0.565***	-	0.434***	-	0.536**	-
	(0.169)		(0.149)		(0.227)	
Colonial Link	0.620***	-	0.483**	-	-	-
	(0.187)		(0.208)			
Adjacency	0.391	-	0.630	-	-0.453	-
	(0.571)		(0.447)		(0.298)	
Common Currency	-1.276***	-	0.122	-	-	-
	(0.246)		(0.373)			
RTA	0.376**	0.274***	0.178	0.073	1.292***	0.356**
	(0.181)	(0.071)	(0.177)	(0.120)	(0.250)	(0.159)
Importer-Time / Exporter-Time FE	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
Country Pair FE		**Y**		**Y**		**Y**
R-squared (# - within group)	0.858	0.520#	0.817	0.398#	0.764	0.377#
Observations	10,899	10,899	10,138	10,138	7,040	7,040

(Robust clustered standard errors in parentheses)

10.2 Appendix to Section 7.2

Table 5

Dependent Variable: Log Exports	**N-N Internet Users (1990-2010)**					
	(3)	(21)	(22)	(23)	(24)	(25)
Internet Users	1.020***	0.902***	1.349***	1.320***	1.401***	0.057
	(0.237)	(0.223)	(0.320)	(0.220)	(0.324)	(0.138)
Mobile phones	-	0.434**	-	-	0.063	-0.113
		(0.219)			(0.354)	(0.187)
Computers	-	-	0.258	-	0.814	-0.027
			(0.551)		(0.522)	(0.222)
Telephones Lines	-	-	-	-1.180**	-1.662**	-0.452
				(0.515)	(0.704)	(0.463)
Log Distance	-1.203***	-1.201***	-1.134***	-1.202***	-1.139***	-
	(0.063)	(0.063)	(0.064)	(0.063)	(0.065)	
Common Language	0.344***	0.347***	0.295***	0.363***	0.318***	-
	(0.101)	(0.101)	(0.103)	(0.103)	(0.105)	
Colonial Link	0.392**	0.389**	0.402**	0.391**	0.388**	-
	(0.167)	(0.166)	(0.166)	(0.168)	(0.168)	
Adjacency	-0.022	-0.029	0.086	-0.015	0.094	-
	(0.130)	(0.130)	(0.124)	(0.131)	(0.124)	
Common Currency	-0.149**	-0.156**	-0.128*	-0.149**	-0.129*	0.053
	(0.073)	(0.072)	(0.073)	(0.073)	(0.072)	(0.039)
RTA	0.266***	0.266***	0.564***	0.259***	0.533***	0.048
	(0.084)	(0.084)	(0.095)	(0.085)	(0.097)	(0.043)
Importer-Time / Exporter-Time FE	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
Country Pair FE						**Y**
R-squared (# - within group)	0.910	0.910	0.914	0.910	0.914	0.702#
Observations	22,024	22,024	14,194	22,024	14,194	14,194

(Robust clustered standard errors in parentheses)

10.3 Appendix to Section 7.3

Table 6

Dependent Variable: Log Exports	**N-N Connection Type (1990-2010)**			
	(26)	(27)	(28)	(29)
Internet Users	2.250***	0.810**	2.332***	0.944***
	(0.731)	(0.368)	(0.761)	(0.363)
% Broadband Connections	-	-	0.377	-0.347
			(0.521)	(0.227)
Log Distance	-1.205***	-	-1.211***	-
	(0.063)		(0.060)	
Common Language	0.335***	-	0.337***	-
	(0.102)		(0.101)	
Colonial Link	0.390**	-	0.425***	-
	(0.167)		(0.160)	
Adjacency	-0.006	-	0.012	-
	0.131		0.131	
Common Currency	-0.149**	-0.047	-0.149**	-0.050
	(0.073)	(0.038)	(0.073)	(0.038)
RTA	0.257***	0.051	0.245***	0.052
	(0.084)	(0.040)	(0.085)	(0.041)
Importer-Time / Exporter-Time FE	**Y**	**Y**	**Y**	**Y**
Country Pair FE		**Y**		**Y**
R-squared (# - within group)	0.909	0.748#	0.908	0.741#
Observations	22,024	22,024	20,868	20,868

(Robust clustered standard errors in parentheses)

Table 7

Dependent Variable: Log Exports	**N-N Broadband (1990-2010)**	
	(30)	(31)
Broadband Connections	-2.620	1.766
	(4.023)	(2.061)
Log Distance	-1.223***	
	(0.063)	
Common Language	0.335***	
	(0.103)	
Colonial Link	0.400**	
	(0.170)	
Adjacency	-0.008	
	(0.132)	
Common Currency	-0.160**	-0.048
	(0.073)	(0.038)
RTA	0.222***	0.049
	(0.083)	(0.040)
Importer-Time / Exporter-Time FE	**Y**	**Y**
Country Pair FE		**Y**
R-squared (# - within group)	0.909	0.747#
Observations	22,024	22,024

(Robust clustered standard errors in parentheses)

Table 8

Dependent Variable: Log Exports	**N-N Internet Users (1990-2010)**				
	(27)	(28)	(29)	(30)	(31)
Internet Users	0.810**	0.765**	-0.039	0.665*	-0.176
	(0.368)	(0.369)	(0.300)	(0.358)	(0.289)
Mobile phones	-	-0.702**	-	-	-0.496**
		(0.275)			(0.253)
Computers	-	-	0.207	-	0.392
			(0.450)		(0.456)
Telephones Lines	-	-	-	-1.096	-1.171
				(0.878)	(0.950)
Common Currency	-0.047	-0.040	0.054	-0.046	0.053
	(0.038)	(0.038)	(0.039)	(0.038)	(0.039)
RTA	0.051	0.046	0.046	0.053	0.047
	(0.040)	(0.040)	(0.043)	(0.040)	(0.043)
Importer-Time / Exporter-Time FE	**Y**	**Y**	**Y**	**Y**	**Y**
Country Pair FE	**Y**	**Y**	**Y**	**Y**	**Y**
R-squared (# - within group)	0.702#	0.748#	0.702#	0.748#	0.702#
Observations	22,024	22,024	14,194	22,024	14,194

(Robust clustered standard errors in parentheses)

Table 9

Dependent Variable: Log Exports	**N-N Internet Users**					
	1990-2004	**1990-2003**	**1990-2002**	**1996-2010**	**1997-2010**	**1998-2010**
	(32)	(33)	(34)	(35)	(36)	(37)
Internet Users	0.673*	0.766*	0.894*	0.495	0.287	0.114
	(0.384)	(0.423)	(0.496)	(0.309)	(0.289)	(0.282)
Common Currency	-0.105***	-0.111***	-0.115***	-0.015	0.002	0.024
	(0.040)	(0.040)	(0.040)	(0.033)	(0.034)	(0.037)
RTA	0.104**	0.118***	0.140***	-0.028	-0.024	-0.021
	(0.042)	(0.045)	(0.046)	(0.045)	(0.043)	(0.043)
Importer-Time / Exporter-Time FE	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
Country Pair FE	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
R-squared (# - within group)	0.598#	0.554#	0.523#	0.717#	0.713#	0.710#
Observations	15,292	14,170	13,048	16,612	15,558	14,506

(Robust clustered standard errors in parentheses)

10.4 Appendix to Section 7.4

Table 10

Dependent Variable: Log Exports	**N-N Internet Users**				
	1990-2005	**1990-2004**	**1990-2003**	**1990-2002**	**1990-2001**
	(38)	(39)	(40)	(41)	(42)
Internet Users	0.151*	0.147	0.153*	0.155*	0.141
	(0.092)	(0.091)	(0.091)	(0.093)	(0.094)
Common Currency	-0.105***	-0.105***	-0.112***	-0.114***	-0.097**
	(0.041)	(0.040)	(0.040)	(0.040)	(0.040)
RTA	0.083**	0.106***	0.120***	0.143***	0.164***
	(0.040)	(0.042)	(0.045)	(0.046)	(0.044)
Importer-Time / Exporter-Time FE	**Y**	**Y**	**Y**	**Y**	**Y**
Country Pair FE	**Y**	**Y**	**Y**	**Y**	**Y**
R-squared (# - within group)	0.636#	0.598#	0.554#	0.523#	0.514#
Observations	16,414	15,292	14,170	13,048	11,928

(Robust clustered standard errors in parentheses)