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Disaggregating the Impact of the Internet on International Trade

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Abstract

The Internet has transformed the way countries trade by reducing the costs of exporting. This paper quantifies the impact of Internet adoption on international trade. It shows that the Internet has a positive, nuanced, impact on international trade: bilateral exports are more affected when Internet adoption increases in the exporter than importer. A 10 percent increase in the exporter's Internet adoption leads to a 1.9 percent increase in bilateral exports, largely explained by an increase in the number of goods exported. A 10 percent increase in the importer's Internet adoption leads to a 0.6 percent increase in bilateral exports, explained by an increase in the average value of existing exported goods. The analysis also finds that when both countries have high levels of Internet adoption they are more likely to trade with each other, compared with country pairs with different (high and low) or low levels of Internet adoption.

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1. Introduction

The Internet has dramatically transformed the way countries trade by reducing the costs of exporting. Firms use the Internet to market their goods, find and communicate with customers, and complete transactions. As a result, the technology has allowed countries to export more and to export new products. There are also online marketplaces that reduce the matching costs between buyers and sellers. The level of Internet adoption has increased dramatically over the last ten years and it has been argued that the growth in digital connectivity has promoted more international trade and the emergence of international production networks (Baldwin, 2014).

In this paper, we quantify the impact of Internet adoption on international trade. Beyond just evaluating the impact of the Internet on bilateral exports, we disaggregate the effects of the Internet on trade and examine how the Internet affects bilateral exports in three ways. First, we investigate how the Internet affects the average value of trade flows (the intensive margins) and the number of goods exported (the extensive margins). Second, we examine whether the Internet has additional effects on exports when both the exporter and importer have similar levels of Internet adoption. Lastly, we explore whether the Internet has a differential impact on the type of goods being traded. We employ a gravity-like estimation specification with a panel data of aggregate trade flows from 2001 to 2013 from the UN COMTRADE database. We measure the level of Internet adoption in the exporter and importer by the percentage of individuals using the Internet per 100 persons from the ITU database.

We find that the Internet has a positive impact on the international trade but the effect is nuanced. Higher Internet adoption increases bilateral exports but it is the exporter's Internet adoption level that is more important for bilateral exports. A 10 percent increase in the exporter's Internet adoption leads to a 1.9 percent increase in bilateral exports, while a 10 percent increase in the importer's Internet adoption leads to a 0.6 percent increase in bilateral exports. An increase in the Internet adoption affects the intensive and extensive margins differently depending on whether the increase occurs in the exporter or importer. When the Internet adoption increases in the exporter, it increases the number of goods being exported more than the average value of existing goods. The impact of the exporter's Internet adoption on bilateral exports occurs largely through the extensive margin. In contrast, when the Internet adoption increase in the importer, the average value of existing exported goods increase. The impact of the importer's Internet adoption on bilateral exports occurs through the intensive margin. We find that there is a pattern of positive assortative matching, where country pairs with high Internet adoption levels have higher trade outcomes. Compared to other country pairs, countries with both high levels of Internet adoption have 29.6 percent more bilateral exports, 21.7 percent higher intensive margins and 6.5 percent higher extensive margins.

We show that the estimation results are robust with an instrumental variable and an alternative measure of the Internet. The estimation may be affected by the endogeneity between the Internet adoption and trade, where more trade can increase a country's income and encourage more Internet infrastructure and adoption. We use the price of broadband subscription in the country as an instrumental variable for the Internet adoption. The level of Internet adoption also may not capture the full extent of the quality and quantity of the Internet services in the country, so we use the download speeds as an alternative measure of Internet. The results in both robustness checks do not differ from our main results.

Our paper adds to the branch of literature that examines the effects of communication technology on international trade flows. The seminal paper in this literature is Freund and Weinhold (2004) that show how the growth of Internet (measured by the number of web hosts) can increase the growth of exports.

Using data from 1995 to 1999, the authors show that the growth in Internet adoption increased export growth even at the nascent stage of the technology. They find that a 10 percentage point increase in the growth of web hosts increases export growth by 0.2 percentage points. Our results on bilateral exports are similar and more importantly, we confirm their hypothesis that Internet adoption in the exporting country is more important for exports.[1] Similarly, Clarke and Wallsten (2005) use 2001 data to show that an increase in Internet adoption in developing countries can increase exports to developed countries. They control for the endogenous relationship between the Internet and trade flows by instrumenting the Internet adoption with whether there is a single monopoly over data transmission services in the country. There are other papers that employ similar technique and data to show that the Internet has a positive effect on trade flows.[2] Studies also show that the Internet has a positive impact on services exports (Freund and Weinhold, 2002; Choi, 2010). While these studies established that the Internet can increase international trade, they do so in a limited way: the studies combine the effects of Internet adoption in the exporter and importer and they only examine its effects on aggregate trade. In our paper, we examine the different effects of the Internet on trade through various angles: the Internet adoption in importer and exporter, and the extensive and intensive margins. We also deal with the endogeneity issues in the estimation through an instrumental variable.

The rest of the paper is organized into four sections. Section 2 describes the data and the methodology in the empirical estimation. Section 3 presents the main results in three parts. The first part reports the estimates for the bilateral exports, the intensive margin and the extensive margins. The second part examines how similarities in Internet adoption affect exports. The third part presents the results for trade in differentiated and homogeneous goods. Section 4 describes the robustness checks where the instrumental variable and an alternative measure of the Internet is used. Section 5 provides the concluding remarks.

2. Empirical Methodology and Data

We examine the impact of the Internet on international trade using a gravity-like specification. The first dependent variable will be the bilateral export flows. The export flows can be further decomposed mathematically into the intensive and extensive margins: average exports and the number of products exported respectively. We will consider the following decomposition:

$$V_{ijt} = x_{ijt} \times n_{ijt}$$

where V_{ijt} is the value of bilateral export flows from country i to country j, x_{ijt} is the average bilateral export value per product exported, and n_{ijt} is the number of SITC 4 digits products exported between the countries in time t. Taking the logarithms of the left and right-hand-side of the decomposition above, we obtain:

$$\ln V_{ijt} = \ln x_{ijt} + \ln n_{ijt}.$$

As OLS is a linear operator, the coefficients for the same variable in the regressions on average exports and the number of products will add up to the coefficient in the regression on bilateral exports. For example, when $\ln V_{ijt}$, $\ln x_{ijt}$, and $\ln n_{ijt}$ are regressed on Internet adoption, the coefficients on the

[1] Freund and Weinhold (2004) argue that higher Internet adoption in the importing country allows the importer to source from a wider range of exporters and substitute away from existing exporters.
[2] For example Vemuri and Siddiqi (2009), Lin (2014) and Riker (2014).

Internet adoption variable for the intensive and extensive margins will sum up to the coefficient for exports. If $\beta_{n_{ijt}} / \beta_{V_{ijt}} = 0.7$ where β is the coefficient of the Internet adoption and the subscripts refer to the regression of the trade variable, then 70 percent of the effect of Internet on exports is explained by the extensive margin.

The Internet can affect trade between countries by reducing the fixed and marginal costs of trade. The Internet allows firms and consumers to find each other faster and easier, thus reducing the fixed search costs. The Internet also reduces the marginal communication costs between the seller and the customer. We assume that other components also affect trade costs, such as distance, whether the two countries are contiguous and have a common language and legal origins, and colonial relationship post 1945.

The empirical specification is:

$$\ln Y_{ijt} = \beta_0 + \beta_1 \ln Internet_{it} + \beta_2 \ln Internet_{jt} + \beta_3 \ln GDP_{it} + \beta_4 \ln GDP_{jt} + \delta_t + \delta_{ij} + \varepsilon_{ijt}$$

where $\ln GDP_{it}$ ($\ln GDP_{jt}$) is the log of the nominal value of GDP and $\ln Internet_{it}$ ($\ln Internet_{jt}$) is the log of Internet adoption of country i (j) in time t. We estimate three separate regressions where the dependent variable $\ln Y_{ijt}$ is the log of each trade variable, V_{ijt}, x_{ijt} or n_{ijt}. δ_t is year fixed effects that accounts for the changes in trade that are unrelated to the changes in the annual Internet adoption and GDP levels, such as the global financial crisis in 2008. δ_{ij} is country-pair fixed effects that account for variations in trade that are related to the idiosyncratic relationships between two country pairs. An alternative set of fixed effects is to include separate exporter and importer fixed effects, which will allow us to control for contiguity, common language, common legal origins and colonial relationship. As Baldwin and Taglioni (2006) explain, country-pair fixed effects are more suitable to deal with the estimation bias in a gravity model with panel data. A drawback of using the country-pair fixed effects is the inability to observe the effects on time-invariant bilateral variables such as distance but this will not affect the variable of interest – Internet adoption – which are time-varying and specific to exporter and importer. The underlying identification assumptions of our empirical specification are that, conditional on the GDP controls and the country-pair fixed effects, the Internet adoption is exogenous to exports and changes in Internet adoption are not correlated with other unobserved time-varying characteristics that can affect bilateral exports. Thus, changes in trade can be attributable to changes in the levels of Internet adoption.

We will also examine how the similarities of Internet adoption affects trade by grouping the importers and exporters according to their Internet adoption levels. The countries are divided into two groups depending on their Internet adoption rates for each year: a country has high (low) Internet adoption if it is above (below) the median. Dummy variables are created for each of the pairwise combinations: if both countries in the bilateral pair have high Internet adoption, if only the exporter has high Internet adoption, if only the importer has high Internet adoption, and if both countries have low Internet adoption.

The trade data are obtained from the UN COMTRADE database for the period 2001-2013. We exclude oil products from the aggregated export flows as these products experience a lot of price volatility during the study period. [3] The gravity variables are obtained from the CEPII and the GDP data is from the World Bank World Development Indicators. The Internet adoption rate is defined as the number of individuals using the Internet per 100 persons in the country and is obtained the International Telecommunication Union (ITU). Table 1 reports summary statistics for trade, Internet penetration and GDP.

[3] We exclude all products in "Section: 3 - Mineral fuels, lubricants and related materials" of the SITC Rev 2. classification.

Table 1: Summary statistics

	Average	Std. Deviation	Min	Max
Exports (million US$)	610738.8	5408312.0	10.0	3.68E+08
Number of product traded	116.2	162.6	1.0	744.0
Sectoral Avg export	2162452.0	1.05E+08	158.8	2.49E+10
Importer Internet penetration	29.5	27.5	0.0	96.5
Exporter Internet penetration	35.4	28.2	0.0	96.5
Importer GDP (current million US$)	435183.6	1494994.0	0.0	1.68E+07
Exporter GDP (current million US$)	558413.7	1665443.0	0.0	1.68E+07

Finally we will also explore the effect of the Internet adoption on different types of goods. The Internet reduces the information and communication costs between exporters and importers and this effect is most relevant for goods that are differentiated and/or customized. We employ the classification from Rauch (1999) which allows us to classify the products into homogeneous and differentiated goods. In order to match trade date with the Rauch classification and to construct bilateral trade for each type of good, we use disaggregated data at the 4 digit SITC level from COMTRADE.

3. Results

(a) Bilateral Exports, Intensive and Extensive Margins

We examine the effects of the Internet adoption on bilateral export flows and the results are presented in Table 2. Column (1) contains the results of the OLS regression with year, importer and exporter fixed effects and while it is not the preferred specification, it affirms the relationship between the usual gravity variables and exports. The signs of the gravity variables are as expected in column (1): distance exerts a negative effect on exports similar to the results in the literature.[4] Other gravity variables, such as GDP, common language and contiguity, exerts a positive effect on exports. Column (2) contains the results from the preferred specification with year and country-pair fixed effects. As discussed above, the drawback of using country-pair fixed effects is that the non-time-varying bilateral variables such as distance are absorbed in the country-pair fixed effects. The estimation results show that by omitting factors specific to the country pairs in column (1), the effect of the exporter's Internet adoption is biased downwards and the effects of the importer's Internet adoption is biased upwards. Column (3) contains the results from the Pseudo-Poisson Maximum Likelihood (PPML) regression, which accounts for the zero trade flows (Santos-Silva and Tenreyro, 2006). The PPML regression is only performed with the year, importer and exporter fixed effects because including country-pair fixed effects was technically unfeasible. The results of the PPML regression are very similar to the OLS results.

The level of Internet adoption in the exporter has a larger effect on export flows than Internet adoption in the importer. The coefficients on the Internet adoption variable are the elasticities of exports with respect to Internet adoption. From column (2), a 10 percent increase in the exporter's Internet adoption increases bilateral exports by 1.9 percent, while a 10 percent increase in the importer's Internet adoption increases bilateral exports by 0.6 percent. The coefficients of Internet adoption in the exporting and

[4] See Blum and Goldfarb (2006) who show that even online transactions are reduced by the effects of distance.

importing countries are statistically different from each other.[5] The results suggest that the Internet is more beneficial to the exporters as it reduces the fixed costs of trade: the Internet provides a channel to market their products and allows sellers to communicate with foreign customers. The impact of the Internet that we find here is very similar to Freund and Weinhold (2004), where a 10 percent increase in the growth of Internet increases export growth by 0.2 percent.

The decomposition of export flows into the intensive and extensive margins provides further information about whether the Internet increases the intensity of trade or encourages new products to be exported. The regression results using the trade margins with country-pair fixed effects are presented in Table 3, and the results of total exports are also presented for completeness. As OLS is a linear operator, the additive properties ensures that the coefficients in the intensive and extensive margin regressions (column 2 and 3) add up to the coefficient for bilateral export flows (column 1).

Table 2: Bilateral Export Flows and Internet Adoption

	(1)	(2)	(3)
VARIABLES	OLS		PPML
Internet adoption exporter (log)	0.140***	0.191***	0.145***
	(0.0127)	(0.0108)	(0.0327)
Internet adoption importer (log)	0.104***	0.0586***	0.128***
	(0.00905)	(0.00874)	(0.0202)
GDP exporter (log)	0.144***	0.359***	0.459***
	(0.0379)	(0.0156)	(0.0454)
GDP importer (log)	0.0891***	0.0697***	0.433***
	(0.0132)	(0.0139)	(0.0639)
Distance (log)	-1.573***		-0.869***
	(0.0190)		(0.0299)
Contiguity	0.867***		0.522***
	(0.100)		(0.0790)
Common language	0.583***		0.0686
	(0.0411)		(0.0733)
Colony	1.188***		0.281
	(0.135)		(0.238)
Common legal origin	0.349***		0.188***
	(0.0269)		(0.0517)
Observations	215,796	215,796	407,352
R-squared	0.773	0.862	0.899
Year FE	Yes	Yes	Yes
Importer and exporter FE	Yes	No	Yes
Country-pair FE	No	Yes	No

Standard errors are clustered at the country-pair.
*** p<0.01, ** p<0.05, * p<0.1

[5] The p-value of the F-statistic for equality of coefficients is equal to 0.

The levels of Internet adoption in the exporter and importer have a different effect on the intensive and extensive margins. Internet adoption in the exporter has a larger impact on the extensive margin than the intensive margin, while it is the reverse for Internet adoption in the importer.[6] The result suggest that higher Internet adoption allows the exporter to find more overseas buyers for their products and increases the range of products exported. A 10 percent increase in Internet adoption in the exporter increases the extensive margin by 1.5 percent and the intensive margin by 0.4 percent. Riker (2015) also finds a similar result where higher Internet adoption in the exporter increases the probability of product entry into the U.S. market. Conversely, higher Internet adoption in the importer increases the intensive margin but decreases the extensive margin. A 10 percent increase in Internet adoption in the importer increases the intensive margin by 0.7 percent and decreases extensive margin by 0.15 percent. While the negative effect of the Internet on the extensive margin is puzzling, the aggregate trade data do not allow us to explore this further. Our intuition is that there is a substitution effect: higher Internet adoption in the importing country reduces the search and communication costs so buyers are able to purchase from a larger set of exporters, thus the number of products being exported between a given bilateral pair reduces.[7] This supports the intuition laid out by Freund and Weinhold (2004), where they infer that higher Internet adoption allows the importer to find more sellers and the equilibrium amount that each exporter will sell to the importer decreases.

Table 3: Intensive and Extensive Margins and Internet Adoption

VARIABLES	(1) ln (Total exports)	(2) ln (Average value of exports)	(3) ln (Number of product exported)
Internet adoption exporter (log)	0.191***	0.0424***	0.149***
	(0.0108)	(0.00883)	(0.00627)
Internet adoption importer (log)	0.0586***	0.0736***	-0.0150***
	(0.00874)	(0.00736)	(0.00496)
GDP exporter (log)	0.359***	0.0604***	0.298***
	(0.0156)	(0.0117)	(0.0112)
GDP importer (log)	0.0697***	0.0617***	0.00803
	(0.0139)	(0.0107)	(0.0101)
Observations	215,796	215,796	215,796
R-squared	0.773	0.698	0.868
Year FE	Yes	Yes	Yes
Country-pair FE	Yes	Yes	Yes

Standard errors are clustered at the country-pair.
*** p<0.01, ** p<0.05, * p<0.1

The contributions of the intensive and extensive margins to the impact of Internet on bilateral export differ depending on whether Internet adoption changes in the exporter or importer. When Internet adoption increases in the exporter, a large proportion of the increase in bilateral exports (78 percent) can

[6] The coefficients of the Internet in the exporting and importing countries are statistically different from each other for all margins of trade.

[7] An alternative explanation is that the importer is buying fewer product but of higher unit value. Buyers use the Internet to access information about sellers and purchase the goods from the better sellers with higher quality.

be explained by the extensive margin; new goods are being exported. In contrast, when Internet adoption increases in the importer, it is the intensive margin that accounts for all of the positive increase in the bilateral exports, while the extensive margins exert a negative effect on bilateral exports. An increase in the importer's Internet adoption increases the average value of existing goods that are exported.

(b) Similarities in Internet Adoption

The network nature of the Internet requires both buyers and sellers to have the Internet to communicate with each other. With similar levels of Internet adoption, the exporter and importer are more likely to have matches between buyers and sellers. We find that there is a pattern of positive assortative matching, where country pairs with high Internet adoption levels have higher trade outcomes. The regression results presented in Table 4 show that it is more important for the exporter to have high Internet adoption as it increases bilateral exports. Column (1) to (4) present the results for each pairwise combination compared to the other combination. We find that bilateral exports are higher when the exporter has high Internet adoption, regardless of whether the importer has high or low Internet adoption. In contrast, when the exporter has low Internet adoption, bilateral exports are lower than all other bilateral pairs.

This result persists when we compare all the different pairwise combinations together in Columns (5) to (7). A higher Internet adoption in the exporter is associated with higher trade outcomes: bilateral exports flows, the intensive margin, and the extensive margin. Compared to other bilateral pairs, pairs with both high Internet adoption have 29.6 percent more bilateral exports, 21.7 percent higher intensive margins and 6.5 percent higher extensive margins. We also find that the negative effect of the Internet on the extensive margin only applies when the exporter has low Internet adoption and the importer has high Internet adoption. This provides further confirmation of our previous proposition that when the importer has more information, they are able to search for more sellers and the number of products exported between that bilateral pair lowers.

Table 4: Effects of High and Low Internet Adoption

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES			ln (Total Exports)			ln (Average Value)	ln (Number of products exported)
=1 if both high Internet adoption	0.0790***				0.259***	0.196***	0.0626***
	(0.0126)				(0.0205)	(0.0179)	(0.0111)
=1 if exporter high and importer low Internet adoption		0.280***			0.354***	0.118***	0.236***
		(0.0195)			(0.0207)	(0.0172)	(0.0118)
=1 if exporter low and importer high Internet adoption			-0.287***		-0.0406*	0.132***	-0.172***
			(0.0228)		(0.0228)	(0.0191)	(0.0131)
=1 if both low Internet adoption				-0.184***			
				(0.0165)			
GDP exporter (log)	0.409***	0.378***	0.395***	0.397***	0.367***	0.0643***	0.302***
	(0.0155)	(0.0155)	(0.0158)	(0.0152)	(0.0153)	(0.0114)	(0.0104)
GDP importer (log)	0.0952***	0.0875***	0.105***	0.0836***	0.0861***	0.0729***	0.0132
	(0.0144)	(0.0143)	(0.0148)	(0.0142)	(0.0140)	(0.0107)	(0.00940)
Observations	221,581	221,581	221,581	221,581	221,581	221,581	221,581
R-squared	0.859	0.860	0.860	0.859	0.860	0.696	0.863
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country-pair FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors are clustered at the country-pair.
*** p<0.01, ** p<0.05, * p<0.1

(c) Trade in Differentiated Goods

The Internet also has differential effects on different types of goods. Certain goods require more communication between the buyer and the seller before a transaction happens. Oftentimes these goods are differentiated goods and require more customization by the buyers. In contrast, other goods are more standardized and buyers do not need to communicate as much with sellers before purchasing the products. We distinguish the products into homogeneous and differentiated goods using the classification proposed by Rauch (1999) at the 4 digit SITC level. We use Rauch's classification of differentiated goods and we combine Rauch's classification of goods traded on the organized markets and those with reference prices to identify homogeneous goods. We estimate the coefficients of Internet adoption in the importing and exporting countries on exports of homogeneous and differentiated good using the seemingly unrelated regression (SUR) methodology. The SUR methodology is used, instead of two separate OLS regressions, as the error terms between the two regressions can be correlated.[8] The SUR methodology allows us to easily compare the coefficients of Internet adoption across the two sets of goods.

Table 5 reports the estimated coefficients using importer and exporter fixed effects and controlling for importer and exporter GDPs and a set of standard gravity variables.[9]

Higher adoption of Internet in the importer is associated with higher trade of both homogeneous and differentiated goods. A 10 percent increase in Internet adoption in the importer increases trade in homogeneous and differentiated goods by 1.3 and 1.2 percent respectively. The SUR framework allows us to test the equality of these coefficients. The results indicate that the effect of Internet adoption in the importer is not statistically different for homogeneous and differentiated goods.

Internet adoption in the exporter also increases trade in differentiated good. A 10 percent increase in Internet adoption in the exporter increases exports of differentiated goods by 3.2 percent. This result is consistent with previous literature that shows that lower communication costs is important for differentiated goods (Fink et al., 2005; Tang, 2006). In contrast, higher Internet adoption in the exporter reduces the exports of homogeneous goods. This suggest that exporters with better Internet adoption have lower exports of goods that are less information intensive as they are traded on exchanges or have reference prices.[10] The signs of the other regressors are as expected. The GDP of both importers and exporters are positively related to exports and they seem to be more important for exports of homogeneous goods. Distance has a negative effect on trade and it matters more for differentiated goods. Contiguity, common language, colonial relationship and common legal origins have positive and significant coefficients.[11]

[8] In principle, SUR allows for the estimation of valid linear regressions with different dependent variable and different sets of exogenous explanatory variables. In our case, where the two equations contain the same set of regressors and will be equivalent to OLS if the error terms in the two regressions are uncorrelated.

[9] The inclusion of more appropriate country-pair fixed effects poses computational challenges.

[10] An alternative explanation may be that higher income countries produce and export differentiated goods and are more likely to have higher Internet adoption levels.

[11] Similar results hold for the intensive and extensive margins of trade so the results are not presented here. The only difference is that the Internet use in the exporter country is also positive and significant for the extensive margin of trade in homogeneous goods. The results can be shared upon request.

Table 5: Impact of Internet on Homogeneous and Differentiated Goods (SUR results)

VARIABLES	(1) Homogeneous	(2) Differentiated
Internet adoption exporter (log)	-0.028***	0.317***
	(0.005)	(0.005)
Internet adoption importer (log)	0.129***	0.119***
	(0.006)	(0.006)
Distance (log)	-1.181***	-1.388***
	(0.007)	(0.006)
GDP exporter (log)	0.888***	1.118***
	(0.003)	(0.003)
GDP importer (log)	0.735***	0.639***
	(0.004)	(0.004)
Contiguity	1.311***	1.031***
	(0.029)	(0.027)
Common language	0.439***	0.563***
	(0.016)	(0.014)
Colony	0.976***	1.049***
	(0.041)	(0.038)
Common legal origin	0.475***	0.264***
	(0.011)	(0.003)
Observations	160,592	160,592
R-squared	0.60	0.69
Year FE	Yes	Yes
Importer	Yes	Yes
Exporter	Yes	Yes

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

4. Robustness Checks

(a) Instrumental Variables

There may be a concern that the results are subject to an endogeneity bias. The extent of Internet adoption in a country can be influenced by international trade, given that a country with higher trade and higher income can afford more telecommunications infrastructure and promote more Internet adoption. A suggested method to circumvent this issue is to lag the Internet adoption variable, as is commonly done

in the literature.[12] We perform the same regression with the lag variable and find a similar positive relationship with Internet and trade. The results are presented in the appendix.

A more robust method to address the endogeneity issue is to find an instrumental variable for the Internet adoption. We use the price of an entry-level broadband subscription as an instrument for Internet adoption. The price of broadband access affects the share of people that uses an Internet connection. Conditional on the Internet infrastructure, lower prices will result in a higher number of Internet users in a country. The price of a broadband subscription fulfils the exclusion restriction as it affects the adoption and use of Internet within the country but does not affect the level of exports. It is also unlikely that the price of broadband subscription will affect trade directly or through indirect channels other than the actual use of the Internet. This instrument is correlated with Internet adoption and the results of the first stage suggest that it is a relevant instrument.[13] The price data covers the period 2008-2013 and comes from various years of the ITU "Measuring the Internet Society" reports.[14] In the report, an ICT price basket is constructed to provide information on the cost and affordability of fixed telephones, mobile cellular and fixed broadband. In the analysis, we will use the price of fixed broadband in purchasing power parity (PPP) terms.[15]

We present the results of the regressions in Table 6 with country-pair and year fixed effects for total trade, average trade and the number of products. The results of the OLS regressions are presented for comparison as the time period of the data used is different from Table 3 due to the data availability of the broadband subscription prices.

The two-stage least squares (2SLS) regressions confirm the results in the previous table. Internet adoption in the exporter increases bilateral exports, intensive margin and extensive margin. The 2SLS results are higher than the OLS results, suggesting that the endogenous relationship between Internet and trade may have biased the coefficients downwards. Moreover, the relationship between Internet adoption in the exporter and the intensive margin is no longer statistically significant, suggesting that most of the effect of Internet adoption on exports happens through the extensive margin. This could also be an artifact of the time period under study, which covers the financial crisis. Similarly, Internet adoption in the importer increases bilateral exports and the intensive margin, and decreases the extensive margin. The relationship between the importer's Internet adoption and bilateral exports is not statistically significant, highlighting the larger role of the Internet adoption in the exporter in increasing exports.

[12] See for example Freund and Weinhold (2004).

13 As a rule of thumb, the F-statistic of a joint test of whether all excluded instruments are significant should be bigger than 10. The F-statistics of the first stage are equal to 2177 and 2037 for the price of broadband access in the exporting country and the importing country respectively.

[14] The sources are the ITU reports "Measuring the Information Society" published in 2014, 2013, 2012, 2011, 2010 and 2009 for the data in 2013, 2012, 2011, 2010, 2009 and 2008 respectively.

[15] The PPP terms was used to avoid any exchange rate distortions and the price of fixed broadband refers to the price of a monthly subscription for an entry-level broadband. See ITU (2014) for details.

Table 6: Instrumental Variable Regressions

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
	ln (Total export)		ln (Average value of exports)		ln (Number of product exported)	
	OLS	2SLS	OLS	2SLS	OLS	2SLS
Internet adoption exporter (log)	0.157***	0.203***	0.0282	0.00174	0.129***	0.201***
	(0.0209)	(0.0487)	(0.0193)	(0.0457)	(0.0112)	(0.0272)
Internet adoption importer (log)	0.0395*	0.0429	0.0701***	0.154***	-0.0305***	-0.111***
	(0.0214)	(0.0495)	(0.0193)	(0.0461)	(0.0114)	(0.0268)
GDP exporter (log)	0.561***	0.543***	0.420***	0.417***	0.141***	0.126***
	(0.0325)	(0.0382)	(0.0291)	(0.0353)	(0.0176)	(0.0202)
GDP importer (log)	0.249***	0.242***	0.396***	0.365***	-0.146***	-0.123***
	(0.0326)	(0.0385)	(0.0292)	(0.0356)	(0.0177)	(0.0206)
Observations	81,311	81,031	81,311	81,031	81,311	81,031
R-squared	0.887	0.885	0.757	0.755	0.887	0.883
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Country-pair FE	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors in parentheses are clustered at the country-pair.
*** p<0.01, ** p<0.05, * p<0.1

(b) Alternative Measure of the Internet

An additional concern about the above results is that the regressions do not control for the quality of the Internet access, resulting in an omitted variable bias. The level of Internet adoption may be the same in two countries but one country may have faster broadband Internet that allows them to communicate more and transfer information faster compared to the other country with slower fixed line connection. We control for the quality of Internet access in a country in the regression by using data on download speeds. The data is obtained from the Net Index dataset based on the Ookla Speedtest and provides information about the download speed measured in kilobytes per second for a wide set of countries starting from 2008.[16] The logs of the download speed in the importing and exporting countries is used an alternative measure of the Internet in our baseline regressions. In order to facilitate comparison of estimates, given the different time period available in the Net Index dataset, we also report the OLS estimate of our baseline regressions using Internet adoption for the same time period 2008-13 where data are available for the download speed. The results are reported in Table 7.

The results are similar to the baseline regressions with Internet adoption as the measure of the Internet. Faster Internet in the exporting country increases bilateral exports. A 10 percent increase in download

[16] The dataset provides daily measures of the speed of download and upload. The daily value is calculated as the average of the last available 30 days of test. For our purpose, we construct a yearly variable by averaging the speeds of the last day of each month. See http://www.netindex.com/ for additional information about the available indexes.

speed increases trade by 1.9 percent. On the contrary, the results suggest that faster Internet in the importing country is associated to lower trade. These results are driven mainly by the decrease in the extensive margin of trade. In fact, in contrast with the Internet adoption of the importer and exporter, download speeds do not significantly affect the intensive margin of trade as measured by the average value of exports. The coefficients in column (4) are not significantly different from zero. The results for the extensive margin of trade are in line with the main results presented above. The estimates in column (6) indicate that a 10 percent increase in the download speed increases the extensive margin by 1.9 percent. On the other hand, faster Internet in the importing country induces a reduction in the number of product traded: a 10 percent increase in speed reduces the extensive margin of trade by 1.4 percent. As already explained above, the intuition for this is that faster Internet in the importing countries allows to screen better sellers of a good and import fewer products from them but larger values.

Table 7: Effects of Internet Speed on Trade

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	ln(Total export		ln(Average value of exports)		ln(Number of product exported)	
Internet adoption exporter (log)	0.198***		0.0165		0.181***	
	(0.0247)		(0.0213)		(0.0134)	
Internet adoption importer (log)	0.0465*		0.0678***		-0.0214*	
	(0.0243)		(0.0212)		(0.0128)	
Exporter's download speed (log)		0.188***		-0.00304		0.191***
		(0.0171)		(0.0153)		(0.00854)
Importer's download speed (log)		-0.156***		-0.016		-0.140***
		(0.0165)		(0.0149)		(0.00816)
GDP exporter (log)	0.557***	0.595***	0.419***	0.442***	0.139***	0.153***
	(0.0353)	(0.0327)	(0.0306)	(0.029)	(0.0189)	(0.0176)
GDP importer (log)	0.237***	0.324***	0.382***	0.419***	-0.144***	-0.0953***
	(0.0353)	(0.0327)	(0.0306)	(0.029)	(0.0191)	(0.0177)
Observations	75,381	75,381	75,381	75,381	75,381	75,381
R-squared	0.885	0.888	0.764	0.764	0.881	0.89
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Country-pair FE	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors are clustered at the country-pair.
*** p<0.01, ** p<0.05, * p<0.1

5. Conclusion

The diffusion of the Internet reduced the costs of trading goods. Information about products and markets is easily accessible with a click. Thus, the Internet allows countries to export more products in larger quantities. Our paper provides empirical evidence of the positive effect of the Internet on exports.

We show that the effect of the Internet on exports is mainly driven by the Internet adoption in the exporting country. A 10 percent increase in the exporter's Internet adoption increases bilateral exports by 1.9 percent, while a 10 percent increase in the importer's Internet adoption increases bilateral exports by 0.6 percent. The intensive and extensive margins are affected by Internet adoption in different ways. Internet adoption in the exporting country affects the extensive margin more than the intensive margin while the opposite is true for Internet adoption in the importing country. When Internet adoption increases in the exporter, more goods are being exported. A large proportion (78 percent) of the positive effect of Internet in the exporter on bilateral exports can be explained by the increase in the extensive margin. The intuition for the result is that higher Internet adoption allows the exporter to find more overseas buyers for their product and increases the range of products exported. In contrast, higher Internet adoption in the importing country increases exports largely through the intensive margin, allowing buyers to purchase more from sellers but reduces the equilibrium number of products traded between a given country-pair.

We also show that the match between the levels of Internet adoption matters between exporter and importer. When both countries have high levels of Internet adoption, they have 29.6 percent more bilateral exports, 21.7 percent higher intensive margins and 6.5 percent higher extensive margins than other country pairs. Lastly, differentiated and homogeneous goods also react differently to Internet adoption. The exchange of differentiated goods requires a higher level of communication between the buyer and the seller than the exchange of standardized products. We show that higher adoption of Internet in the importer country increases trade of both homogeneous and differentiated goods. In contrast, Internet adoption in the exporter is positively related to trade in differentiated good but it is negatively related to exports of homogeneous goods.

The results are robust to a series of robustness checks. We address concerns about endogeneity of the Internet adoption measures with an instrumental variable approach. We instrument Internet adoption of both countries with the average price of broadband connection and we show that Internet adoption has a positive effect on trade mainly through the adoption in the exporting country. The results are consistent also when we lag the Internet adoption variables and when we use the download speed as an alternative measure for the Internet.

While our work provides further support on the positive effects of the Internet on international trade, there remain questions that are not explored in this paper. First the paper does not examine the channels by which the Internet increases export, due to the unavailability of micro-level data. Is the increase in exports due to the use of Internet as a communication technology or as an online platform to facilitate more matches between buyers and sellers? Second, the Internet has a positive effect on international trade but the use and provision of the Internet is not a sufficient condition. There is a role for supporting infrastructure such as logistics and payment systems that can have a complementary effect. Does the supporting infrastructure mitigate or amplify the effects of the Internet adoption on trade? We leave these questions to future research.

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Appendix

Table A1: Effects of Internet on Trade (using Lagged Internet Adoption)

VARIABLES	(1) ln (Total exports)	(2) ln (Average value of exports)	(3) ln (Number of products exported)
Lagged Internet adoption exporter (log)	0.177***	0.0425***	0.135***
	(0.0114)	(0.00954)	(0.00643)
Lagged Internet adoption importer (log)	0.0573***	0.0781***	-0.0207***
	(0.00893)	(0.00760)	(0.00496)
GDP exporter (log)	0.368***	0.0621***	0.306***
	(0.0163)	(0.0130)	(0.0107)
GDP importer (log)	0.0899***	0.0733***	0.0166*
	(0.0146)	(0.0119)	(0.00955)
Observations	181,777	181,777	181,777
R-squared	0.867	0.722	0.870
Year FE	Yes	Yes	Yes
Country-pair FE	Yes	Yes	Yes

Standard errors are clustered at the country-pair.
*** p<0.01, ** p<0.05, * p<0.1