HAS THE INTERNET INCREASED TRADE?

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RRH: CLARKE AND WALLSTEN: HAS THE INTERNET INCREASED TRADE?

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Abstract: Developing countries export more to developed, but not other developing, countries, when internet penetration is higher. Although this could be because internet penetration stimulates exports, it could also be because trade openness encourages internet use. To test the direction of causation, we allow internet use to be determined endogenously using countries' regulation of data services as an instrument. The results suggest that access to the internet does improve export performance in developing countries, although not in developed countries. In other words, improving internet access in a developing country will stimulate exports from that country to rich countries.

I. INTRODUCTION

Much of the excitement surrounding the 'New Economy' did not survive the economic slowdown in 2001. However, two dramatic and real changes did take place in the mid-late 1990s and early 2000s. The first was a large increase in the international flows of goods, services and investment. Total world exports increased from 20 percent of gross world product in 1994 ($5.0 trillion in 2000 US$) to 24 percent of gross world product (US$8.3 trillion) in 2002.[1] This increase is substantial considering that exports had consistently varied between 18 percent and 20 percent of gross world product for the previous fifteen years. The second was a revolution in Information and Communication Technologies (ICTs). Probably the most notable component of this was the dramatic growth of the internet: the number of internet hosts soared from 17 per 10,000 people in 1994 to 231 in 2001.[2]

Although export and internet growth appear to have occurred contemporaneously, the two changes are not necessarily linked – with a relatively small number of annual observations, the timing could simply be coincidence. However, cross-country evidence also suggests a relationship between the internet and globalization: countries that export more tend to have higher internet penetration than countries that export less.[3] The cross-country correlation suggests a possible causal relationship between internet use and exports, but tells us little about the *direction* of causality. That is, even if the correlation is not spurious, we cannot determine whether trade openness encourages internet use, internet use stimulates trade, or both.

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[1] Data are from World Bank (2003a)

[2] Data are from International Telecommunication Union (2003)

[3] The correlation between exports (as share of GDP) and number of Internet users (as share of population) was 0.26 (p-value = 0.00) across countries in 2001.

This paper contributes to the literature on the effect of the internet on export behavior in two ways. First, it recognizes that the internet may affect developing and developed countries differently. We find that internet penetration is positively correlated with exports from developing countries to developed countries but not to other developing countries. Internet penetration does not appear to be correlated with exports from developed countries to other developed countries or to developing countries. Second, it assesses the extent to which internet use affects exports, taking into account the endogeneity of internet use. We do this through a two-stage approach using regulatory variables as instruments for internet penetration. These instruments are correlated with internet use, and hypothesis tests suggest that they are exogenous to aggregate exports.

Even after endogenizing internet use, we find that it is positively correlated with exports from poor to rich countries. Thus, while it is likely that trade openness also affects internet use, we find causation also runs in the other direction—improving internet access can boost a developing country's exports to high-income economies. Moreover, our instruments suggest policy implications: regulatory policies in developing countries that restrict telecommunications and internet development also indirectly restrict exports.

II. EXPORT BEHAVIOR AND INTERNET USE

Consistent with the country-level correlations, enterprises in developing and transition economies that export are far more likely than other enterprises to use the internet to communicate with their clients and suppliers, according to surveys conducted by the World Bank (see Table 1). The difference between exporters and non-exporters appears to be true both in countries with high levels of internet coverage (e.g., Slovenia, Estonia and Slovakia) and countries with very low levels of coverage (e.g., Tajikistan and Uzbekistan). Unfortunately,

these enterprise surveys do not have detailed information on the destination of exports and, therefore, we cannot determine whether enterprises that export to developing countries differ from enterprises that export to developed countries.

The striking correlation between export behavior and internet use at the enterprise level in developing countries has several plausible explanations. One possibility is that enterprises that are already exporting are more likely to connect to the internet. Exporters might connect to the internet because it provides a relatively cost-effective method for international communications relative to international telephone calls or faxes: the local or domestic long-distance charges necessary to connect to the internet are far lower than international rates, especially in developing countries.[4] A second possibility is that the benefits of internet access increase as the firm's customers and suppliers connect (i.e., there are network externalities). Because internet use is nearly universal among firms in most developed countries, firms in developing countries that do business in developed economies might benefit more from internet access than would firms that do business only domestically. For both these reasons, internet access might be higher for enterprises that export (especially those that export to developed countries).

Several recent studies have suggested that trade stimulates internet use. For example, Onyeiwu (2002) suggests that the 'extent to which a country is integrated into the global economy can play a role in its access to ICT. Countries with greater contact, either via trade, tourism, or geographical location, with the outside world, are more likely to be advanced in

[4] In 2001, the average (median) cost of a three-minute call from an OECD country to the United States (average does not include US or Canada) was US$0.61 (US$0.33) for countries for which data were available, whereas the average for developing countries was US$11.35 (US$3.67). In contrast, on average a 3-minute local call cost US$0.07 (US$0.05) in developing countries and US$0.11 (US$0.11) in OECD countries. Data is from World Bank (2003a).

digital technology than other countries.' Similarly, Caselli and Coleman (2001) argue that countries open to imports from high-income Organization for Economic Co-operation and Development (OECD) economies will benefit from knowledge spillovers and, hence, be more likely to adopt new technologies.

Empirical studies of internet adoption have found that internet use is correlated with openness to trade even after controlling for other factors that are correlated with both.[5] For example, Wallsten (2005) and Baliamoune (2002) find that internet users made up a greater share of the population in developing countries that are more open to trade. Other studies have also found that additional measures of ICT use and investment are correlated with various measures of openness.[6] In general, the correlation between ICT use and openness appears to be stronger in developing countries. Several of the papers that find a positive correlation between measures of ICT use and openness, including Baliamoune (2002), Onyeiwu (2002) and Wallsten (2005), focus on developing countries while others that have looked at both developed and developing countries find stronger results for developing countries.[7] These aforementioned

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[5] In recent years, a large literature has developed that looks at the determinants of ICT use and investment. Early studies, which generally do not include measures of openness, include Dasgupta and others (2000), Kraemer and others (2000) and Kiiski and Pohjola (2002).

[6] For example, Onyeiwu (2002), which looks at the determinants of ICT use in 54 countries in Africa, find that ICT use tends to be higher in countries that are more open (i.e., that import more). The dependent variable in this study is a composite measure of 'digitalization' that is a weighted average of Internet users and hosts, personal computers, telephone lines and cell phones. Using data from a survey of 2,139 enterprises from 10 middle and high-income countries, Kraemer and others (2002) show that enterprises that are more internationalized (in terms of operations, sales and inputs) are more likely to engage in business-to-business e-commerce, but not in business-to-consumer e-commerce. Caselli and Coleman (2001) show that ICT investment is higher in countries that import more manufactured goods from countries in the OECD. Muller and Salsas (2003) find that the number of personal computers, but not the number of Internet users and hosts, is correlated with imports. Finally, Clarke (2003), which uses enterprise level data on Internet use for Eastern Europe and Central Asia, fails to find a positive correlation between openness to imports at the country level and Internet use at the enterprise level. In fact, in some model specifications, Clarke (2003) finds a negative correlation. This negative result, however, appears to be due to imports from low and middle-income countries. Imports from high-income countries are positively correlated with Internet connectivity.

[7] For example, Caselli and Coleman (2001) show that the correlation between openness and investment in ICT is

studies have assumed, either explicitly or implicitly, that causation runs from openness to ICT use and investment.

Although openness to trade might affect internet penetration, internet access might also affect export behavior. If access to the internet makes it less costly to find and communicate with potential customers in other markets, then, all else being equal, exports could be higher in countries where internet penetration is greater. In practice, if the internet merely substitutes for telephone calls or faxes, it is not likely to have a large impact on costs. Expenditures on telephone and postal services in Peru, for example, were only 1 percent of sales (or about 8 percent of labor costs) for the median enterprise in a 2002 survey of formal enterprises in Peru.[8] Since internet access does not eliminate all other communications costs (e.g., the fixed costs associated with telecommunications services or even all telephone calls or postal deliveries), the total savings from internet access will be relatively modest if it only substitutes for existing methods of communication.

But internet access might affect costs associated with exporting in other ways. In particular, Freund and Weinhold (2004) argue that the internet might help create global markets for traded goods by reducing the fixed costs associated with exporting. They argue that the internet could reduce costs by lowering "entry costs into a new market through organized exchanges with numerous buyers and sellers, and through powerful search engines, which enable sellers and buyers to find each other." Based upon the idea, Freund and Weinhold (2004) present

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stronger for countries that do not export computers – a sample that will probably include most low-income developing countries.

[8] These communications costs were only fractionally higher for exporters than for non-exporters (1.1 percent of sales for exporters compared to 1.0 percent of sales for non-exporters). Data comes from the 2002 Investment Climate Survey for Peru, which asked questions about costs associated with telecommunications services. The World Bank, in collaboration with Andean Development Corporation, conducted the 2002 Investment Climate Survey. The survey is described in World Bank (2003b).

a theoretical model with segmented markets, imperfect competition and fixed entry costs.[9] Their model predicts that internet development, by reducing fixed entry costs, is likely to increase aggregate trade.[10]

Some empirical evidence is consistent with the idea that the firms can use the internet to reduce the fixed costs of entering new markets. Freund and Weinhold (2004) provide several anecdotal examples of firms using the internet to enter new markets. Similarly, using data from a 1998 survey of enterprises in 15 low and middle-income countries, Daly and Miller (1998) show that many firms in developing countries use search engines to research market opportunities.[11] Of the 58 enterprises that reported having internet access in their survey, 26 reported using search engines to look for marketing and production information. This was the second most common use of search engines, after looking for technical and computer information. To the extent that these uses reduce the fixed costs of finding markets and buyers, internet access might therefore increase exports.

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[9] Models with imperfect competition and fixed entry costs have been used to explain other trade-related phenomenon. For example, Baldwin (1988) shows that in such a model, large exchange rate shocks can alter domestic market structure and, in so doing, have persistent real effects on import prices and quantities. Freund (2000) use a model with fixed costs to show that the pattern of trade after a free trade agreement is affected by whether participants were previously involved in regional trade agreements. She shows that trade between the six original members of the European Union remained higher even by the 1990s than a gravity model would predict, a result consistent with the theoretical model

[10] They note that world trade should increase unless the internet also results in a large increase in the average distance of exporters to markets (Freund and Weinhold, 2004). Their model also makes other predictions including that bilateral trade growth will result from increased internet connectedness between countries and that the internet might also affect the how distance affects trade.

[11] Daly and Miller (1998) note that their sample, comprised of International Finance Corporation (IFC) client companies, was not random. They note that IFC clients are likely to be more technologically sophisticated than other enterprises in developing countries. Given the high level of Internet connectivity they report (about 75 percent of industrial firms), it seems likely that this is the case. However, Internet connectivity has increased greatly in recent years in developing countries and the technical sophistication of the 'average' enterprise has, therefore, also likely increased since 1998.

Most empirical studies have focused on whether openness to trade affects internet penetration. However, several recent studies have asked whether internet use affects trade. Using data from 20 low- and middle-income countries in Eastern Europe and Central Asia, Clarke (2001) shows that enterprises with internet connections export more, as a share of their total sales, than enterprises without connections. In a panel growth regression, Freund and Weinhold (2004) find that (lagged) growth of internet use is significantly correlated with the growth of trade between 1997 and 1999. In cross-sectional levels regressions, they also find a statistically significant correlation between lagged internet use and exports in 1998 and 1999, although the relationship is not statistically significant before 1998. In a second paper, Freund and Weinhold (2002) find that exports of services to the United States grew more quickly for countries with greater internet penetration in a sample of 31 middle- and high-income countries. Freund and Weinhold (2002; 2004) control for the possibility of reverse causation by lagging the variable representing internet penetration by two periods. Although this significantly reduces concern about reverse causation, if enterprises' current internet use responds to their expectations about future export opportunities (i.e., if they invest in information and communications technologies now anticipating increased export opportunities in the future), some concern remains.

The benefits of internet access may be especially pronounced for firms in developing countries. Indeed, the cross-country correlation between export behavior and internet use noted above is almost entirely due to developing countries – the correlations between exports and internet use in 2001 are 0.51 (p-value = 0.00) and –0.05 (p-value = 0.81) for developing and developed countries respectively. Further, for developing countries, internet use is correlated only with exports to developed countries - the correlations between internet use and exports to

developed and developing countries are 0.52 (p-value=0.00) and 0.18 (p-value=0.14) respectively.[12] In summary, although exports from developing countries are correlated with internet use, this only appears to be true for exports to developed countries. This correlation seems reasonable. Internet access is ubiquitous among enterprises in developed countries, and small differences in country-level internet penetration probably reflect differences in access by individuals or households not businesses. In contrast, surveys reveal internet access to be less common at even the enterprise level in developing countries (see Table 1), suggesting that reported differences in internet penetration might reflect differences in coverage at the enterprise level, as well. Indeed, internet use at the individual level is highly correlated with internet use at the enterprise level in the developing countries for which we have information on both (the correlation is 0.71 with a p-value=0.00).[13]

In the next section, we test how the correlation between exports and internet use differs among developing and developed countries, and explore whether it is robust to controlling for other variables and to allowing internet use to be determined endogenously.

III. EMPIRICAL ESTIMATION

Cross-Sectional Estimation

To test whether internet use affects exports, we use country-level data to estimate equation (1) using ordinary least squares (OLS) and two-stage least squares (2SLS) estimation:

$$\text{Exports}_{ij} = \alpha + \beta\ \text{Internet Hosts}_{i} + \gamma\ \text{Control Variables} + \varepsilon_{ij} \qquad (1)$$

[12] For developed countries, the correlations between Internet use and exports to developed and developing countries are 0.01 and 0.02 respectively. Both correlations are statistically insignificant.

[13] See Table 1 for sources of data. Unfortunately, we do not have comparable information on Internet use in developed countries.

The dependent variable is exports from country *i* to country group *j*. Based upon the simple correlations, we look at exports to three different country groups: developing countries, developed countries, and total exports (i.e., to all countries). In addition, we also estimate separate regressions for high and low-income countries and test whether the two samples can be pooled into a single regression. The test is reasonable given that exports from developing countries appear correlated with internet access, whereas exports from developed countries do not. Export data comes from the United Nations Statistical Division (UNSD) Commodity Trade (COMTRADE) database. The data is for 2001 and countries for which all data were available are listed in Table 2.

The main independent variable, $Internet\ Hosts_i$, is internet hosts in country *i* per 100 persons.[14] This variable represents internet penetration and comes from International Telecommunication Union (2003). Although the variable is far from perfect, it is highly correlated with other measures of internet use, including estimates of the percentage of enterprises in developing countries with access to the internet ($\rho = 0.67$). As a robustness check, we also estimate equation (1) replacing internet hosts per 100 persons with internet users as percent of the population. The number of internet users in a country is estimated from surveys in some countries, and by multiplying the number of subscriber accounts or the number of internet hosts by a multiplier in others.

A statistical correlation between internet use and exports at the firm level may arise from omitting relevant variables that affect both of them from the analysis. For example, more efficient or technologically advanced firms might be more likely to have access to the internet

[14] The measure of Internet hosts also comes from International Telecommunication Union (2003), using data collected by the Internet Software Consortium (http://www.isc.org) and Réseaux IP Européens

because they have greater resources available for investment in information technology or because investing in ICT improves productivity.[15] Since more efficient firms in developing countries also appear to be more likely to export, the correlation between export behavior and internet access could simply be spurious.[16] If small enterprises are less likely to export and also less likely to have access to the internet, then omitting variables to control for enterprise size could lead to biased results.[17] Similarly, cross-country differences between industry structure and performance could also result in a spurious correlation in country-level correlations if the analysis does not adequately control for factors that affect both access and export behavior.

Thus, in addition to the main independent variable (internet use), we also include several additional variables to control for natural openness. These include population, area, per capita GDP, per Capita GDP squared and a dummy variable representing whether the country is a major oil exporter. Pritchett (1996) uses similar variables, without a measure of internet use, in regressions explaining trade openness.[18]

(http://www.ripe.net). It is based upon the country code in the Internet host address (rather than actual physical location).

[15] Using enterprise-level data from Eastern Europe and Central Asia from 1999, Clarke (2003) shows that better performing enterprises were more likely to have Internet access.

[16] Many studies have found that enterprises that export are more efficient than enterprises that do not – see Tybout (2000) for a summary of the literature. This result could be because efficient enterprises self-select into exporting (i.e., the *self-selectivity hypothesis*) or because the discipline of exporting directly improves efficiency (i.e., the *learning-by-exporting hypothesis*).

[17] Several studies show small manufacturing enterprises in developing countries are less likely to export than larger enterprises. Biggs (2003) provides a summary of this literature.

[18] In addition to adding Internet use, we also omit one variable used in Pritchett (1996), the cost, insurance and freight/free on board ratio, since this was not available for most countries in the sample.

Area and population are included as measures of country size.[19] Intuitively, they are included to control for the possibility that small countries might engage in trade more than large countries because firms and consumers in small countries might have less opportunity to engage in intra-country trade.[20] Further, smaller countries might be more likely to trade because they are less likely to have a sufficient national resource base (e.g., they might need to trade for certain natural resources or types of agricultural produce) or might engage in trade because economies of scale prevent them from producing a wide range of goods. Per capita GDP is included as a measure of wealth (and potentially economic size), while the oil exporter dummy is included as a measure of natural resource dependence. Since previous empirical analyses (without internet use) have found a non-linear relationship between per capita GDP and exports, we include a squared term to allow for this.[21] As discussed below, the results are not highly dependent upon this functional form specification. These variables come from World Bank (2003a). Table 3 shows means and variances for the dependent and independent variables.

As discussed previously, even if export behavior is correlated with internet use, the direction of causality remains unclear. We use an instrumental variables approach to address this issue. Our main instrument for internet access is a variable obtained from International Telecommunication Union (2002) representing whether a single company has a legal monopoly over data transmission services in a given country. One drawback of this instrument is that until there is significant policy change over time within individual countries, it will be difficult to use

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[19] These variables are often included in aggregate and bilateral trade regressions. For example, Frenkel and Romer (1999) include both variables in a gravity model of trade arguing that theory does not clearly suggest the better measure; Rose (2004b) includes area directly and population indirectly because he includes both logs of both per capita GDP and logs of GDP in a gravity model.

[20] Frenkel and Romer (1999) argue: "Intuitively, smaller countries may engage in more trade with other countries simply because they engage in less within-country trade."

this approach in a dynamic analysis.[22] Hence, we restrict our analysis to a cross-sectional analysis using data from a single year.

We believe the instrument is appropriate. If companies with legal monopolies over data transmission restrict access to data lines, as we would expect a monopoly to do (i.e., by setting prices above the competitive price), internet access might be lower in those countries. One extreme example of this is in Malawi. Prior to telecommunications reform in 1998, the monopoly telecommunications provider in Malawi, Malawi Post and Telecommunications Corporation, had a monopoly of both data and leased lines.[23] It used this monopoly to prevent Internet Service Providers (ISPs), including companies that had managed to get licenses to act as ISPs, from entering the market by refusing to provide them with the lines that they requested.[24] Moreover, regulatory rules regarding entry into communications services are unlikely to affect exports other than through their effect on exporting firms' communications with their customers.

This instrument also performs well statistically. Because we are able to reject the null hypothesis that samples of developing and developed countries should be pooled in the regressions of exports on internet use and other control variables (see below), we present separate regressions for developing and high income countries. In first-stage regressions of internet access on the instrument and the other included variables the coefficient on the regulatory variable is negative and significant at the 5 percent level for the sample of developing countries, although it is not significant in the smaller sample of developed economies (see Table

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[21] See, for example, Pritchett (1996) and Chenery and Syrquin (1975).

[22] See for example, the analysis in Freund and Weinhold (2004) for a dynamic analysis.

[23] Clarke and others (2003) describes telecommunications reform in Malawi

[24] See Article 19 (1998)

4). In other words, as we expected, internet access is lower in countries with monopolies over data lines at least in developing economies.

While we believe this variable to be a good instrument, we also use alternate instruments to test over-identifying assumptions and as a robustness check. In particular, we use two additional dummies; one indicating whether a single firm had a legal monopoly over Internet Service Provision, and another indicating whether a firm had a legal monopoly over leased lines. Although the first variable is intuitively appealing, it does not perform as well as the dummy representing monopoly provision of data lines; in a first-stage regression, the coefficient on the dummy variable representing monopoly provision of Internet Service Provision is statistically significant only at a 10 percent level (see Table 4).[25] One plausible reason for the lower significance is that ISPs are monopolies in only a few countries in our sample (10 percent of the sample). In contrast, data lines are monopolies in 24 percent of the countries in our sample. Further, the ISP information is available for fewer countries than is the information on data lines (82 and 97 countries respectively).

As a final robustness check, we also use an additional instrument – a dummy variable representing whether ISPs are required to get formal approval from the telecommunications regulator before starting operations. Wallsten (2005) shows that countries that require formal approval for ISPs have lower internet penetration. Unfortunately, this variable, which comes from a World Bank survey of regulatory agencies in developing countries, is available for only a

[25] Recent studies have shown that coefficients on endogenous variables can be biased when weak instruments are used (see, for example, Staiger and Stock, 1997).

small sub-sample of the countries for which export data were available (26 countries) and is not available for any high-income countries.[26]

Although the variables included in Pritchett (1996) seem to be a reasonable set of country controls, we also test whether the results are robust to including additional variables. One concern is that countries that liberalize their trade policies might also be more likely to liberalize other parts of their economies, including their telecommunications sectors, potentially leading to omitted variable bias. In particular, countries that are members of the World Trade Organization (WTO) might be more likely to liberalize their telecommunications sectors – for example by joining the optional WTO agreement on basic telecommunication services or agreeing to liberalize during accession negotiations. Further, countries that join the WTO might also export more – although recent studies have failed to find strong evidence that countries that belong to the WTO have more liberal trade policies than other countries.[27] Consequently, as a robustness check, we add a variable indicating that the country is a member of the WTO and a variable indicating that it has signed the WTO agreement on basic telecommunication services to the base regression. In addition to the dummies representing WTO membership, we also add a variable representing the average (weighted) tariff in the country as an additional measure of liberalization.

In addition to concerns about liberalization, another concern is that countries that are more politically open might be more likely to allow easy internet access, because they are less concerned about citizens accessing information critical of them that might be available on the internet, and be more open to trade and investment. Consequently, we also add a variable to

[26] Wallsten and others (2004) describe the data and the survey.

control for political openness to the base regression to check robustness. The variable is the index of 'voice and accountability' from Kaufmann and others (2003), which is a measure of political and civil rights in the country.

Another control variable that we add is an additional control for natural openness, the distance of the country from the rest of the world. This variable, constructed by Rose (2004a), is defined for country i as the inverse of the mean of log real GDP for the export partner, country j, divided by the log of the distance between countries i and j.

Finally, we include a series of variables that might be correlated with both export behavior and with economic development—which is likely to have a strong influence on internet use. Because of this, we add three additional variables that are related to development and that might also affect internet use to the base regression: the percent of the population living in rural areas, the secondary enrollment rate, and paved roads as a share of total roads. Internet use might be higher in countries with urban populations if the cost of connecting customers is lower in these countries and in countries with more educated consumers if education affects demand for internet services. These factors might also affect export behavior if they affect the types of goods or services that the country produces. Similarly, road quality might be correlated with the quality of other infrastructure (and hence internet use) but also might affect exports if transportation costs are lower in countries with better quality roads.

Empirical Results

Results from OLS Regressions. Table 5 presents results from regressions of total exports, exports to high-income countries and exports to low-income countries on internet use

[27] Rose (2004a) fails to find strong evidence that countries that are members of the WTO actually have more liberal trade policies, while Rose (2004b) fails to find evidence that membership increases trade.

and additional control variables suggested in the literature on trade openness. The table presents results from separate regressions for high- and low-income countries. Since internet use might affect enterprises in developing and transition countries differently than enterprises in developed countries, this approach seems appropriate. Furthermore, we reject at conventional significance levels the null hypothesis that the two sets of countries can be pooled in a single regression.[28]

For high-income countries, the coefficients on internet users as share of the population are statistically insignificant and small in all equations after controlling for other factors that might affect openness. The point estimates of the parameters are negative, although statistically insignificant, in the regressions for total exports and exports to high-income countries. In the regressions for exports to low- and middle-income countries, the coefficient is positive and small, but statistically insignificant. The point estimate of the parameters suggests that exports to developing countries would increase by 0.5 percent if internet hosts increased by 1 percent.[29]

For developing countries, the coefficients on internet users as share of the population are positive in the regressions for total exports and exports to developed economies, although they remain statistically insignificant. Assuming that causality runs from internet use to exports, the point estimates suggest that a one percent increase in the number of internet hosts per 100 people would increase total exports as percent of GDP by 0.05 percent and exports to high-income countries by 0.08 percent. In contrast, increased internet access does not appear to have a positive impact on exports to developing countries.

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[28] The χ^2 [7] statistics for the test of the null hypothesis that the two sets of countries can be pooled for total exports, exports to high-income countries, and exports to developing countries are 16.5 (p-value=0.02) and 17.4 (p-value=0.01) and 12.6 (p-value=0.08). Pooling is also rejected for the 2SLS regressions shown in Table 6 for total exports (χ^2[7]=20.5, p-value==0.00), exports to high income countries (χ^2[7]=16.7, p-value=0.02), and exports to developing countries (χ^2[7]=16.1, p-value==0.02). Greene (2000) describes the test used to test the hypothesis. The test does not require the variances of the disturbance terms to be equal in the two equations.

For the most part the coefficients on the additional control variables are statistically insignificant. The only exceptions are the coefficients on area in the regressions for exports from high-income countries and the coefficients on area and population in the regression for exports to developing countries from developing countries. Although the coefficients on per capita GDP and per capita GDP squared are often statistically insignificant at conventional significance levels (both singly and jointly), consistent with Pritchett (1996) the coefficients on the linear terms are positive while the coefficients on the squared term are negative.[30]

Results from 2SLS Regressions. Reverse causation remains a concern. When we test the null hypothesis that the variable representing internet hosts as percent of the population is exogenous in the equations where the coefficients are statistically significant, we reject the null hypothesis in the regressions for both total exports from developing countries and exports to high-income countries from developing countries.[31] Given that Hausman-type tests are typically relatively weak in small samples, this favors the results from the 2SLS regressions and suggests that internet use is probably determined endogenously with respect to exports.

To address this issue, we re-estimate the base regression shown in Table 5 allowing variable representing internet use to be endogenous (see Table 6). To instrument for internet use, we use the regulation dummy variable discussed above, which indicates whether the government allows a single firm to maintain a monopoly over data lines. We use this variable rather than any of the other variables (or a combination of dummies) due to concerns about missing data –

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[29] Elasticities are calculated at the means of the dependent and independent variables.

[30] When per capita GDP is entered linearly, the coefficient on per capita income becomes statistically insignificant in regression for total exports for both developing and developed economies and exports from high income countries to other high income countries. The coefficients on internet hosts remain statistically insignificant in all regressions when GDP is entered linearly.

[31] The χ^2 (1) statistics are 3.3 (p-value=0.07) and 3.2 (p-value=0.07) in the regression for total exports and exports to

including additional instruments can sharply reduce sample size. In the next subsection, as a robustness check, we test other combinations of plausible instruments. This variable seems to be an appropriate instrument in that it is correlated with the endogenous variable, internet hosts, for the developing country sample. In a first stage regression, the coefficient has an expected negative sign (i.e., internet use is lower in countries where a single firm has a monopoly over data lines) and is statistically significant at a 5 percent significance level in the developing country sample (see Table 4). The point estimate of the parameter suggests that, on average, there are 0.4 fewer internet hosts per 100 people in developing countries that maintain legal monopolies over data lines.

In the 2SLS regressions, the coefficients on internet users as percent of population are statistically insignificant and relatively small in all the regressions for exports from high-income countries and in the regressions on exports from developing countries to other developing countries. In contrast, the coefficients are large and statistically significant in the regressions for total exports from low-income countries and exports from developing countries to high-income countries. The coefficients are larger in the 2SLS regression than in the OLS regressions – the point estimates of the elasticities at the sample means suggest that a 1 percent increase in internet hosts increases total exports by about 0.3 percent and exports to high income countries by 0.4 percent.

As a robustness check, we also estimated similar regressions using internet users rather than internet hosts in the main regression. The results were qualitatively similar—the coefficients were statistically insignificant in the regressions for the regressions for exports from high income countries and from low-income to low-income countries and statistically significant

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high-income countries respectively.

and positive in the regression for total exports and exports to high-income countries from developing countries. The point estimates of the elasticities at the sample means were about 0.8 for total exports and about 1.0 for exports from developing to high income economies. One possible reason for the lower elasticity estimate for internet hosts is that internet hosts might measure internet use by businesses less precisely than internet users and therefore be subject to attenuation bias. Another possibility is that the estimates of internet users are also picking up some other aspect of development and so might be biased upwards. This could be because of the way that the number of internet users is estimated. If richer countries were more likely to estimate users from surveys, this could results in estimated users being spuriously correlated with (omitted) measures of development. In the next section, we add additional measures of development to the base regression to test robustness of results.

Robustness Checks

Additional Control Variables. The variables included in the base regression, which were based upon the set of variables included in Pritchett (1996), do not include some variables that might potentially affect both internet use and trade. One concern is that countries that are especially open to trade might also be more likely to liberalize their economies in other ways, including telecommunications services. To try to reduce the possibility that the omission of variables that proxy for openness to trade might affect results, we add several additional control variables to the base regression. As a first test, we add dummy variables indicating that the country is a member of the WTO and that the country had signed the optional WTO agreement on basic telecommunication services to the base regression. The dummies are both statistically insignificant and to not appear to affect the main results (i.e., the coefficient on internet use remains statistically significant at a 5 percent level and about the same size as before – see Table

7).[32] As a second test, we add an alternative control for trade policy to the base regression – the average weighted tariff in 2001. The coefficient on this variable is also statistically insignificant and does not appear to affect the coefficient on internet use.

In addition to adding variables to control for trade policy, we add two other variables to the base regression as additional checks. The first variable is a measure of 'remoteness' – how far the country is from other markets.[33] Transportation costs will be higher for countries that are more remote and, consequently, might affect trade. The second variable is a measure of political openness – countries that are more politically open might be more likely to allow their citizens free access to the internet and also might be more open to trade and investment. Adding these variables also does not appear to affect any of the main results – the coefficient on internet use remains statistically significant at a 5 percent level in the regression for exports from developing countries to high income countries.

A related concern is that the export behavior might be related to overall economic development and that economic development might affect internet use. Although including per capita GDP and per capita GDP squared should control for this, it is possible that these variables do not adequately control for all aspects of development. Because of this, we add three additional variables that are related to development and that might also affect internet use to the base regression: the percent of the population living in rural areas, the secondary enrollment rate, and paved roads as a share of total roads. Including these additional variables does not

[32] The coefficient on internet hosts also remains statistically significant in the regression for total exports from developing countries in most cases. The one difference is that the coefficient becomes statistically insignificant in the regression with weighted tariffs included.

[33] This measure comes from Rose (2004a)

affect the main result—the coefficients on internet hosts remain statistically significant, positive, and about the same size as in the base regressions.

The coefficients on the additional control variables are statistically insignificant at conventional significance levels for most of these additional variables. The one exception is the coefficient on rural population, which is statistically significant at a five percent level. Because of this, we re-ran the previous regressions with the additional variables but also including rural population in the base regression. The coefficient on internet hosts in the regression for exports from developing to high income economies remain statistically significant when we include rural population along with the other additional variables (i.e., when we add it to the regressions in Table 7).

Exclusion of GDP. Another potential concern is the endogeneity of per capita GDP. Although per capita GDP might affect openness, openness might also affect GDP.[34] To check the robustness of the results, we run the regressions omitting per capita GDP and per capita GDP squared. Dropping per capita GDP does not have a large impact on the main results—the coefficient on internet hosts remains statistically significant at a 5 percent level and about the same size as before in the regression for exports from developing to developed economies (see Table 7).[35]

Alternative Instruments. In addition to the instrument used above, we also re-estimate the 2SLS regressions using alternate sets of instruments. The main concern regarding the alternate instruments is that they are available for fewer countries and using them sharply

[34] Many studies have looked at the impact of openness to trade and investment on GDP growth. See Baldwin (2004) for a recent survey of the evidence.

reduces sample size. On the other hand, adding additional instruments allows us to test over-identifying assumptions. In the first regressions, we add additional instruments representing whether ISPs and leased lines are provided by legal monopolies in each country (see Table 7). In the regression for exports from low-income countries to high-income countries, the coefficient remains statistically significant but is smaller than when the variable representing monopoly over data lines was the only instrument.[36]

One advantage of adding additional instruments is that it becomes possible to test over-identifying assumptions. Using Hansen's J statistics as the test, the χ^2 (2) statistics is 0.6 (p-value=0.73) for the regression exports from developing to high-income countries. We also fail to reject the null hypothesis that the instruments are exogenous in similar regression for total exports, exports to high-income, and exports to developing countries for both high-income and developing countries. This strongly suggests that the instruments are appropriate.

As a final robustness check, we replace the instruments with a dummy variable from a alternative source that represents whether ISPs need formal approval to operate in the country. This sharply reduces sample size—from 72 to 29 observations. The statistical significance of the coefficient on internet hosts falls to a 17 percent significance level—something that might not be surprising given the smaller sample size.[37] The coefficient is also smaller in magnitude. The results from this regression suggest that at median levels for all variables, a 1 percent increase in the number of internet hosts per 100 people would increase exports by 0.3 percent.

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[35] When per capita GDP is dropped from the other regressions in Table 6, the coefficients on the number of Internet hosts are similar to the coefficients in Table 6. Results are also robust to dropping other single variables such as population, area and the dummy for oil exporters.

[36] The coefficient on Internet use becomes statistically significant and positive in the regression for exports from high income to developing countries

Changes. As an additional robustness check, we re-run the regressions looking at whether exports increased more after the commercialization of the internet in countries with higher internet use. Regressing changes in exports on changes in internet use and changes in other variables might reduce concern that omitted country characteristics that affect both export behavior and internet use are resulting in a spurious correlation between the two. When we take first differences of area and the oil production dummy, these variables become collinear with the constant term and have to be dropped. This approach sharply reduces sample size for the developing country sample because exports were not available in 1991 for many countries, especially those in Eastern Europe and the Former Soviet Union.

The period that we look at is the ten-year period between 1991 and 2001. We choose this period because the first period precedes the major commercialization of the internet (e.g., Netscape was not released until 1994 and e-commerce sites such as Amazon [1994] and Yahoo [1995] were not operating at this time). Because we do not have a time-series for the regulation dummy, this variable is used in levels (i.e., we assume that internet use will grow more quickly over this period in countries where regulation was most relaxed). The dummy variable is strongly correlated with internet growth over this period.

The coefficient on change in internet hosts is positive and statistically significant at a 5 percent level (see Table 7) in the regression for exports from developing countries to developed economies. In contrast to the previous results, the coefficient on this variable is also positive and

[37] In a similar regression using internet users as the measure of internet use, the coefficients remains statistically significant.

statistically significant in the regression for exports from low-income countries to other low-income countries.[38]

Although the ITU did not estimate internet users for most countries in 1991, internet use was quite low at this time, especially in developing economies. If we assume that internet use was essentially zero in 1991, then the level of internet users in 2001 will essentially be equal to the change. Making this assumption, we re-ran the analysis using this variable in place of the change in internet hosts as a further robustness check. This further reduces sample size to about 34 observations in the developing country sample. Although the coefficient on internet users remains positive, it is statistically insignificant.

Cross-sectional gravity model. Since we are primarily interested in the effect of the internet on a country's total exports to high-income and developing countries, we ran the main regressions in the previous section at the country level adding together all exports from a single country to all countries of each type. An alternative to this approach is to estimate a gravity model.[39] Rather than adding all exports together for a single country (i.e., making the unit of observation total exports from country I in 2001), the unit of observation is exports from country i to country j in 2001.[40]

We adopt a standard gravity model specification, similar to the one in Frankel and others (1995), that includes GDP, per capita GDP, distance between the two countries, a dummy variable indicating whether the countries share a common border and a series of dummies indicating whether both countries are in one of several regional trading blocks. The results are

[38] Results available from authors upon request.

[39] See, for example, Frankel and others (1995).

robust in terms of size and statistical significance when we use different specifications of the gravity model, including using variables similar to those included in the country-level model.[41] Since the dependent variable is exports not total trade, we allow the coefficients on country level variables (e.g., GDP) to have different coefficients for the importing and exporting countries.

Results from the gravity model are shown in Table 8. The results are broadly consistent with the results from the previous model. In the regressions for exports from developing countries to high income economies and to all countries, the coefficient on internet hosts of the exporting country is positive and statistically significant. In the regressions for high-income countries, the coefficient is never statistically significant. One difference between the results from the cross-sectional model and gravity model is that the coefficient on internet hosts is also statistically significant in the regression for exports from developing to other developing countries in the gravity model. The coefficient is about the same size as in the regression for exports from developing to high-income countries. The point estimate of the elasticity (0.3) is slightly lower than in the cross-sectional model (0.4 for exports from developing to high income countries). Consistent with results from Freund and Weinhold (2004), internet use in the exporting country is more important that internet use in the importing country—the coefficients on Internet use in the importing country are statistically significant in most model specifications.

When we re-ran these regressions using internet users as the measure of internet use, the results are similar in that the coefficients on internet users are statistically significant and positive

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[40] Since we are interested in exports between countries not total trade—and for comparability with the previous results—we continue to use exports rather than total trade as the dependent variable in the gravity model.

in the regressions for developing countries and statistically insignificant in the regressions for high-income economies. The main difference is that, as earlier, the elasticity estimates tend to be larger for internet users (about 0.8 for internet users compared to about 0.3 for internet hosts).

Overall, the results from the gravity model appear to be broadly consistent with the results from the cross-sectional model. Exports are higher in developing countries—but not high income countries—with greater internet access even after controlling for the possibility of reverse causation.

IV. CONCLUSIONS

Developing countries with higher internet penetration export more to high-income countries than do developing countries where penetration is lower. However, they do not appear to export more to other developing countries and high-income countries with greater internet penetration do not appear to export more to either developing or developed countries. These results make intuitive sense. First, internet access is so common among manufacturing enterprises in high-income countries that differences in the number of internet users (or hosts) as a percent of the population probably reflects differences at the consumer, rather than the enterprise, level in developed countries (i.e., most manufacturing enterprises will be connected to the internet in developed countries). In developing countries, contrarily, many manufacturing enterprises remain unconnected (see Table 1). Second, because internet access is less common in developing countries than in developed countries, being connected to the internet would seem to be a greater advantage for enterprises in developing countries with respect to exporting to

[41] In addition to estimating the base model and a model similar to the country level model, we also added the Internet variables to the base model in Rose (2004b), which includes additional variables representing a variety of other characteristics including trade agreements, physical characteristics, and colonial heritage; and the basic model in Freund and Weinhold (2004), which includes GDP, population and two dummies indicating that the countries

developed countries (i.e., to countries where their counterparts are likely to have access). Finally, because of strong regional differences in income, and taking into account the fact that most exports from developing countries to other developing countries will be within the same region, communication costs will presumably be greater (and therefore internet access a greater benefit) for exports to distant developed countries than it would be for exports to neighboring developing countries.

In the analysis, we control for the possibility that internet use is endogenous (i.e., that causation also runs in the opposite direction). We use a dummy variable representing whether data lines are a monopoly in the country as an instrument for internet access. Wallsten (2005) has shown that regulation has a significant impact on internet access in developing countries. Since Hausman tests confirm that internet use is endogenous in some specifications and the instrument is negatively correlated with internet use, even after controlling for other factors that might affect internet use, the two-stage approach appears to be appropriate. As a robustness check, we re-run the regressions using additional instruments related to the regulatory environment. In these regressions, tests of over-identifying assumptions confirm that the regulatory variables are valid instruments. These results strongly suggest that the correlation between internet use and aggregate exports from developing countries to developed countries is not simply due to enterprises and individuals being more likely to use the internet in countries that are more open to trade.

The results in this paper do not necessarily imply that causation runs in only one direction (i.e., they do not imply that openness to trade does not affect internet penetration). Although greater internet use appears to result in increased exports at the country level, it is possible that

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have a colonial link or a common language. Data for these additional variables come from Andrew Rose's website

causation also runs in the opposite direction. Indeed, the results from the Hausman test for endogeneity suggest that this is the case: internet use appears to be endogenous in the estimated model.

While trade openness is likely to affect internet development, our results suggest that causality also runs the other direction. Even when we endogenize internet use, we find that internet penetration in developing countries is positively correlated with exports to developed countries. In other words, our analysis suggests that internet use may, in fact, help stimulate exports from poor countries to rich. As a result, our analysis suggests that when countries block competition in telecommunications, something that is crucial to internet development, the country suffers not just in reduced internet penetration, but also in lower exports to rich countries.

The cross-country results in this paper suggest that the recent growth of the internet might explain some of the recent growth in trade and are consistent with the dynamic results in Freund and Weinhold (2004). Results from the cross-country correlations in this paper, however, are also consistent with an alternative explanation; rather than creating new trade, internet growth in a single country might simply redirect trade towards that country. That is, when internet access improves in one developing country, trade with high income economies might be redirected away from other developing countries that have not improved access. From the perspective of a single country, the policy recommendations for a country that wished to increase exports would remain the same. If a country improves access to the internet, exports will increase. Moreover, under the second hypothesis, if a country fails to improve access, it will slowly lose exports to other countries that do. From a global perspective, however, the implications are less clear. If

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(http://faculty.haas.berkeley.edu/arose/).

trade is merely redirected rather than created on a global scale, total trade would not increase as internet access improves globally.

V. TABLES

Table 1: % of Manufacturing Enterprises with Internet Access

Country	Year	ALL	Exporters	Non-Exporters	Difference between exporters and non-exporters
Albania	2002	38.2%	65.3%	26.9%	38.4%
Algeria	2002	41.5%	78.9%	39.6%	39.3%
Armenia	2002	43.3%	84.6%	31.1%	53.6%
Azerbaijan	2002	34.1%	63.0%	28.2%	34.8%
Bangladesh	2002	70.6%	86.0%	58.9%	27.1%
Belarus	2002	56.0%	79.2%	46.6%	32.5%
Bosnia and Herzegovina	2002	60.4%	75.4%	52.6%	22.8%
Bolivia	2001	56.3%	86.0%	50.8%	35.2%
Bulgaria	2002	63.2%	95.9%	49.1%	46.8%
China	2001	71.2%	81.8%	64.7%	17.0%
Croatia	2002	79.7%	89.0%	72.1%	16.9%
Czech	2002	77.2%	90.5%	69.6%	20.9%
Estonia	2002	91.8%	98.6%	86.0%	12.5%
Ethiopia	2001	39.2%	93.8%	35.1%	58.7%
FYR of Macedonia	2002	50.0%	70.6%	41.0%	29.6%
Georgia	2002	41.4%	72.7%	30.8%	42.0%
Hungary	2002	75.2%	92.8%	66.3%	26.5%
Kazakhstan	2002	45.6%	75.6%	38.7%	36.8%
Kyrgyz Republic	2002	34.1%	58.1%	27.6%	30.5%
Latvia	2002	63.1%	93.0%	53.8%	39.2%
Lithuania	2002	72.0%	98.4%	60.1%	38.2%
Moldova	2002	38.5%	65.5%	25.0%	40.5%
Morocco	1999	49.3%	59.0%	35.9%	23.1%
Mozambique	2002	73.8%	95.0%	70.6%	24.4%
Pakistan	2002	33.8%	74.9%	23.7%	51.2%
Peru	2002	57.5%	77.0%	40.4%	36.6%
Poland	2002	69.0%	88.5%	60.3%	28.2%
Romania	2002	59.2%	84.4%	50.8%	33.6%
Russia	2002	57.3%	88.2%	49.1%	39.1%
Slovakia	2002	84.7%	91.5%	78.4%	13.1%
Slovenia	2002	92.6%	97.1%	87.2%	9.8%
Tajikistan	2002	13.1%	25.7%	10.1%	15.6%
Turkey	2002	54.3%	77.8%	45.1%	32.6%
Ukraine	2002	60.0%	85.2%	51.0%	34.2%
Uzbekistan	2002	23.1%	60.6%	17.6%	43.0%
Yugoslavia	2002	71.2%	88.4%	62.2%	26.2%

Source: Investment Climate Surveys, The World Bank.

Table 2: Countries in the sample

High Income Countries	Developing Countries		
Australia	Albania	Grenada	Poland
Bahrain	Argentina	Guatemala	Romania
Belgium	Azerbaijan	Guinea	Russian Federation
Canada	Barbados	Honduras	Rwanda
Cyprus	Belarus	Hungary	Saudi Arabia
Denmark	Benin	Indonesia	Senegal
Finland	Bolivia	Iran, Islamic Rep.	South Africa
France	Botswana	Jordan	Sri Lanka
Germany	Brazil	Latvia	St Lucia
Greece	Burkina Faso	Lebanon	Swaziland
Iceland	Burundi	Lithuania	Tanzania
Ireland	Cameroon	Macedonia, FYR	Thailand
Italy	Cape Verde	Malawi	Togo
Korea, Rep.	Chile	Malaysia	Trinidad and Tobago
Malta	China	Mauritius	Tunisia
Netherlands	Colombia	Mexico	Turkey
New Zealand	Costa Rica	Moldova	Uganda
Norway	Croatia	Mongolia	Uruguay
Portugal	Czech Republic	Morocco	Venezuela, RB
Singapore	Dominica	Mozambique	Zambia
Slovenia	Ecuador	Namibia	
Spain	Egypt, Arab Rep.	Niger	
Sweden	El Salvador	Pakistan	
Switzerland	Estonia	Panama	
United Kingdom	Fiji	Peru	
United States	Georgia	Philippines	

Table 3: Means and Standard Deviations of Variables Included In Model

Variable	Source	High-Income Countries			Low-Income Countries		
		Obs.	Mean	Std. Dev.	Obs.	Mean	Std. Dev.
Exports (% of GDP)	COMTRADE	31	37.0%	27.0%	76	26.2%	20.8%
Exports to high-income countries (% of GDP)	COMTRADE	31	27.9%	18.9%	76	16.1%	16.7%
Exports to low-income countries (% of GDP)	COMTRADE	31	9.1%	14.2%	76	10.0%	10.0%
Internet Users (% of population)	ITU (2003)	31	35.4%	13.3%	68	4.7%	6.1%
Internet Hosts (Per 100 population)	ITU (2003)	30	66.4%	77.9%	76	3.1%	6.3%
Entry Restrictions for ISPs (Dummy)	Wallsten and others (2004)	---	---	---	30	56.7%	50.4%
Monopoly for Data Lines (Dummy)	ITU (2002).	26	7.7%	27.2%	74	24.3%	43.2%
Monopoly for ISPs (Dummy)	ITU (2002).	28	3.6%	18.9%	59	10.2%	30.5%
Monopoly for Leased Lines (Dummy)	ITU (2002).	27	11.1%	32.0%	70	54.3%	50.2%
Population (Natural Log)	World Bank (2003a)	31	15.8	1.8	76	15.9	1.9
Area (Natural Log)	World Bank (2003a)	27	11.5	2.6	75	11.8	2.4
GDP per Capita (000s of US$, PPP adjusted)	World Bank (2003a)	30	24.8	7.5	75	5.6	3.7
Oil Exporter [a] (Dummy)	COMTRADE	31	6.5%	25.0%	76	9.2%	29.1%
Member of WTO (Dummy)	WTO website [b]	31	96.8%	18.0%	76	85.5%	35.4%
Member of WTO Agreement on Telecommunications	WTO website [c]	31	87.1%	34.1%	76	56.6%	49.9%
Average Tariff	COMTRADE [d]	25	3.4	1.9	73	10.7	5.7
Political Openness	Kraay and others (2003)	30	1.2	0.4	69	-0.1	0.8
Remoteness from rest of world (inverse of the mean of log GDP for trading partners divided by log distance)	Rose (2004a)	31	0.5	0.0	75	0.5	0.0

Notes: COMTRADE is United Nations Statistical Division (UNSD) Commodity Trade (COMTRADE) database.
[a] Oil Exporters are countries for whom oil makes up more that 30% of exports. High-income countries are countries with per capita income over US$10,000. [b] Data is available on http://www.wto.org/english/thewto_e/whatis_e/tif_e/org6_e.htm [c] Includes countries that were signatories of the original basic telecommunication services and those that had subsequently reached agreement on telecommunications services by the end of 2000 (including those that reached agreement based upon the accession agreements). [d] Data was supplemented with data from Heritage Foundation (2003) for most recent year available.

Table 4: First Stage Regressions of Internet Use on Regulatory Variables (OLS).

	OLS						
Dependent Variables	**Internet hosts per capita in 2001**						
Observations	25	26	25	72	57	68	29
Monopoly for Data Lines	3.4349			-0.400***			
(Dummy)	(0.89)			(2.73)			
Monopoly for ISPs		1.5938			-0.3631*		
(Dummy)		(0.48)			(1.74)		
Monopoly for Leased Lines			-6.1999			-0.4187**	
(Dummy)			(1.38)			(2.42)	
Entry Restrictions for ISPs							-0.6051
(Dummy)							(1.58)
Population	-2.1616*	-2.1962**	-2.679***	-0.0774	-0.0391	-0.1670	-0.2136
(Natural Log)	(2.09)	(2.17)	(3.10)	(1.04)	(0.57)	(1.59)	(0.92)
Area	1.0876**	1.0481*	0.8454*	0.0559	0.0215	0.1196*	0.1435
(Natural Log)	(2.14)	(2.09)	(1.78)	(1.13)	(0.45)	(1.78)	(1.52)
GDP per Capita	2.2501	1.5841	1.6140	0.0859	0.0447	0.0705	0.1777
(000s of US$, PPP adjusted)	(0.88)	(0.65)	(0.83)	(1.45)	(0.83)	(1.23)	(1.19)
GDP per Capita Squared	-0.0378	-0.0250	-0.0294	0.0014	0.0071	0.0016	-0.0037
(000s of US$, PPP adjusted)	(0.67)	(0.45)	(0.67)	(0.27)	(1.61)	(0.32)	(0.37)
Oil Exporter	-4.618***	-4.1428*	-2.0412	-0.2376*	-0.5074	-0.2584*	-0.0176
(Dummy)	(3.29)	(1.80)	(0.89)	(1.76)	(1.43)	(1.76)	(0.10)
Constant	-2.9198	6.3450	18.8003	0.4694	0.2440	1.3500	1.6495
	(0.12)	(0.34)	(0.90)	(0.65)	(0.35)	(1.29)	(0.54)
R-Squared	0.50	0.47	0.52	0.42	0.49	0.45	0.51
Joint sig. level for per capita GDP variables	0.11	0.09	0.40	0.00	0.00	0.00	0.00

Note: T-statistics are in parentheses. Standard errors are Huber-White robust standard errors. Entry restrictions for ISP were only available for developing countries

Table 5: Effect of Internet on exports (OLS).

	OLS					
Sample	**High Income Countries**			**Developing Countries**		
Dependent Variables	**Exports (% of GDP)**	**Exports to high-income countries (% of GDP)**	**Exports to low- and middle-income countries (% of GDP)**	**Exports (% of GDP)**	**Exports to high-income countries (% of GDP)**	**Exports to low- and middle-income countries (% of GDP))**
Observations	27	27	27	74	74	74
Internet hosts	-0.0006	-0.0074	0.0068	0.0445	0.0447	-0.0002
(Per 100 people)	(0.07)	(1.27)	(1.36)	(0.76)	(0.97)	(0.01)
Population	0.0411	0.0059	0.0352*	-0.0248	-0.0005	-0.0243**
(Natural Log)	(0.97)	(0.21)	(1.78)	(0.76)	(0.01)	(2.58)
Area	-0.1030*	-0.0494*	-0.0535*	0.0304	0.0089	0.0215***
(Natural Log)	(2.06)	(1.85)	(2.00)	(1.13)	(0.32)	(2.83)
GDP per Capita	0.0601	0.0024	0.0577	0.0372*	0.0314*	0.0058
(000s of US$, PPP adjusted)	(0.66)	(0.04)	(1.12)	(1.87)	(1.91)	(0.60)
GDP per Capita Squared	-0.0009	0.0004	-0.0013	-0.0015	-0.0014	-0.0001
(000s of US$, PPP adjusted)	(0.43)	(0.38)	(1.19)	(1.18)	(1.38)	(0.12)
Oil Exporter [a]	0.0503	-0.1680	0.2183	0.0039	-0.0315	0.0354
(Dummy)	(0.51)	(1.40)	(1.65)	(0.06)	(0.44)	(1.07)
Constant	-0.0019	0.4957	-0.4976	0.1393	-0.0600	0.1994*
	(0.00)	(0.81)	(0.77)	(0.53)	(0.27)	(1.82)
R-Squared	0.47	0.42	0.55	0.20	0.17	0.12

*** Sig. at 1% level ** Sig. at 5% level * Sig. at 10% level.
Note: T-statistics are in parentheses. Standard errors are Huber-White robust standard errors.

Table 6: Effect of Internet on exports (2SLS).

	2SLS					
Sample	**High Income Countries**			**Developing Countries**		
Dependent Variables	**Exports (as share of GDP)**	**Exports to high-income countries (as share of GDP)**	**Exports to low-and middle-income countries (% of GDP)**	**Exports (as share of GDP)**	**Exports to high-income countries (as share of GDP)**	**Exports to low-and middle-income countries (% of GDP)**
Instruments	**Monopoly for data lines (Dummy)**					
Observations	26	26	26	72	72	72
Internet hosts	-0.0182	-0.0216	0.0035	0.2522**	0.2210**	0.0312
(Per 100 people)	(0.36)	(0.67)	(0.10)	(2.04)	(2.20)	(0.39)
Population	0.0274	-0.0052	0.0326	-0.0193	0.0059	-0.0252**
(Natural Log)	(0.56)	(0.14)	(1.25)	(0.52)	(0.17)	(2.10)
Area	-0.0849*	-0.0350	-0.0500	0.0170	-0.0022	0.0193*
(Natural Log)	(1.89)	(1.02)	(1.29)	(0.60)	(0.08)	(1.95)
GDP per Capita	0.0032	-0.0431	0.0463	0.0208	0.0175	0.0034
(000s of US$, PPP adjusted)	(0.02)	(0.41)	(0.43)	(1.20)	(1.25)	(0.32)
GDP per Capita Squared	0.0006	0.0017	-0.0010	-0.0018	-0.0017*	-0.0001
(000s of US$, PPP adjusted)	(0.15)	(0.61)	(0.36)	(1.49)	(1.72)	(0.13)
Oil Exporter [a]	-0.0278	-0.2318	0.2041	0.0811	0.0330	0.0481
(Dummy)	(0.10)	(1.34)	(1.11)	(1.30)	(0.59)	(1.20)
Constant	0.6052	0.9820	-0.3768	0.2469	0.0005	0.2464**
	(0.33)	(0.77)	(0.35)	(0.80)	(0.00)	(2.44)

*** Sig. at 1% level ** Sig. at 5% level * Sig. at 10% level.
Note: Instrument is a dummy variable indicating that data lines are (legally) a monopoly in that country. T-statistics are in parentheses. Standard errors are Huber-White robust standard errors.

Table 7: Effect of Internet use on exports from developing countries to high-income countries--robustness checks (2SLS)

	Levels										Changes
Sample	**Developing Countries**										
Estimation Method	2SLS										
Dependent Variables	**Exports to high-income countries**										
Instruments	Monopoly for Data Lines								Additional Instruments	Entry restrictions for ISPs	Monopoly for Data Lines
Observations	72	70	72	72	72	59	68	73	52	29	39
Internet hosts	0.2285**	0.2570*	0.2369**	0.2302**	0.2792**	0.2490**	0.1941**	0.2321**	0.1771**	0.1436	0.3635**
(per 100 people)	(2.08)	(1.93)	(2.15)	(2.05)	(2.16)	(2.11)	(2.13)	(1.98)	(2.03)	(1.37)	(2.15)
GDP per Capita	0.0212	0.0184	0.0121	0.0202	0.0523**	0.0363	0.0132		0.0067	0.0057	0.0441
(000s of US$, PPP adjusted)	(1.03)	(1.36)	(0.88)	(1.35)	(2.34)	(1.20)	(1.01)		(0.39)	(0.39)	(0.52)
GDP per Capita Squared	-0.0020	-0.0020*	-0.0014	-0.0018*	-0.0036**	-0.0026	-0.0014*		-0.0008	-0.0006	-0.0044
(000s of US$, PPP adjusted)	(1.35)	(1.86)	(1.58)	(1.68)	(2.29)	(1.41)	(1.73)		(0.55)	(0.46)	(0.46)
Population	0.0101	0.0146	0.0083	0.0010	-0.0020	-0.0009	-0.0077	0.0065	0.0517*	0.0263	0.5824*
(Natural Log)	(0.35)	(0.35)	(0.24)	(0.02)	(0.05)	(0.02)	(0.18)	(0.18)	(1.86)	(0.78)	(1.65)
Area	-0.0053	-0.0092	-0.0072	-0.0010	0.0077	-0.0001	0.0098	-0.0014	-0.0361	-0.0261	
(Natural Log)	(0.24)	(0.29)	(0.27)	(0.04)	(0.27)	(0.00)	(0.31)	(0.05)	(1.58)	(0.89)	
Oil Exporter [a]	0.0503	0.0499	0.0449	0.0224	0.1118	0.0455	0.0195	0.0328	-0.0024	0.0447*	
(Dummy)	(1.07)	(0.85)	(0.77)	(0.40)	(1.63)	(0.72)	(0.36)	(0.55)	(0.04)	(1.70)	
Member of WTO	0.0430										
(Dummy)	(0.64)										
Member of WTO Telecom Agreement	-0.0176										
(Dummy)	(0.24)										
Average Tariff Rate		0.0031									
		(0.70)									
Remoteness			1.5484								
(Dummy)			(1.06)								
Political Openness				-0.0221							
(higher values mean more open)				(0.55)							
Rural Population					0.0047**						
(% of total population)					(2.31)						
Gross Secondary Enrollment Rate						-0.0017					
(% of total)						(1.06)					
Paved Roads							0.0009				
(% of total roads)							(1.01)				
Constant	-0.0705	-0.0979	-0.6885	0.0522	-0.3504	0.1216	0.0523	-0.0001	-0.3021	-0.0088	-8.2201*
	(0.28)	(0.30)	(0.98)	(0.16)	(1.52)	(0.35)	(0.17)	(0.00)	(1.23)	(0.03)	(1.65)

***** Sig. at 1% level ** Sig. at 5% level * Sig. at 10% level. Note: T-statistics are in parentheses. Standard errors are Huber-White robust standard errors. [a] Oil Exporters are countries for whom oil makes up more that 30% of exports. High income countries are countries with per capita income over US$10,000. Instrument is dummy variable indicating monopoly over fixed lines for all regressions except for columns with additional instruments (dummies for data lines, leased lines, and ISPs) and column with entry restrictions (dummy for entry restrictions for ISPs).

Table 8: Results from cross-sectional gravity model for developing and high income countries

Exporters	Industrial			Developing		
Partners	All	Developing	High Income	All	Developing	High Income
Observations	3733	2984	749	9163	6489	2674
Internet Variables						
Internet Hosts - Exporter	1.7313	1.4976	2.1692	0.2690***	0.2775***	0.2555***
(natural log)	(0.41)	(0.42)	(0.36)	(7.56)	(6.76)	(3.43)
Internet Hosts - Importer	-0.0240	-0.0047	0.6065	-0.0634	-0.0276	1.1968*
(natural log)	(0.41)	(0.09)	(0.34)	(1.24)	(0.63)	(1.71)
Controls						
GDP - Exporter	1.0314***	1.0621***	0.9231***	1.1308***	1.1046***	1.2302***
(natural log)	(3.76)	(4.24)	(3.15)	(71.92)	(56.83)	(42.86)
GDP - Importer	0.9208***	0.9228***	0.8819***	0.8163***	0.7121***	1.1113***
(natural log)	(21.14)	(23.56)	(5.14)	(54.27)	(40.59)	(31.94)
Per Capita GDP - Exporter	-2.9240	-2.4259	-4.0883	-0.4973***	-0.5480***	-0.4046***
(natural log)	(0.36)	(0.36)	(0.32)	(6.22)	(5.80)	(2.60)
Per Capita GDP - Importer	0.1824	0.1340	-1.6085	0.2251**	0.1359	-2.7248**
(natural log)	(1.10)	(1.12)	(0.51)	(2.36)	(1.47)	(2.05)
Distance	-1.5929	-1.6597	-1.4047	-1.4772***	-1.5450***	-1.5165***
(natural log)	(1.16)	(1.32)	(1.15)	(45.19)	(39.88)	(6.64)
Common Border	-0.3908	-0.5188	0.5860	1.1907***	1.1260***	-0.0733
(dummy)	(0.39)	(0.25)	(1.22)	(9.30)	(8.26)	(0.16)
European Union	-0.5536		0.0196			
(dummy)	(0.61)		(0.03)			
ASEAN	3.3686*	3.2888*		1.7362***	1.5591***	3.2525***
(dummy)	(1.94)	(1.99)		(7.26)	(5.98)	(8.35)
NAFTA	-2.1194	-2.4837	-3.1678	-0.2307		-2.5009**
(dummy)	(0.37)	(0.53)	(0.48)	(0.73)		(2.52)
Constant	5.2107	3.4614	16.7533	-5.6585***	-2.6854***	-2.0911
	(0.13)	(0.10)	(0.39)	(10.19)	(4.70)	(0.31)
R-squared	0.56	0.53	0.34	0.55	0.50	0.54

*** Sig. at 1% level ** Sig. at 5% level * Sig. at 10% level.

Note: T-statistics are in parentheses. Standard errors are Huber-White robust standard errors. High income countries are countries with per capita income over US$10,000

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Endnotes:

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Abbreviations

2SLS: Two-Stage Least Squares

COMTRADE: Commodity Trade

GDP: Gross Domestic Product

ICT: Information and Communication Technology

ISP: Internet Service Provider

ITU: International Telecommunication Union

OECD: Organization for Economic Co-operation and Development

OLS: Ordinary Least Squares

UNSD: United Nations Statistical Division

WTO: World Trade Organization