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Internet Adoption and Firm Exports in Developing Economies

by

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Abstract

This paper investigates the effect of Internet technology on how firms access export markets - directly or via intermediaries. Empirical evidence suggests that technology diffusion is geographically localised, with spillover effects from neighbouring firms decaying quickly over short distances. To address the endogeneity of Internet adoption, I construct an instrument that captures these local network effects, by matching IP addresses to firm locations. Using a cross-section of firms in 18 developing countries I find that Internet access magnifies direct trade with no discernible effect on intermediated trade. Adopting the Internet because of local networks increases direct exports as a proportion of firm sales by 32-36%. The analysis is robust to consideration of a wide-range of potentially omitted variables.

JEL classification: F12; F14; D22; L22; O33

Keywords: Internet, Technology, Intermediation, International Trade, Heterogeneous Firms

Outline

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Non-Technical Summary

In this paper I investigate how Internet technology affects exports. The existing literature predominantly focuses at the country-level; here I describe the effects on the firm. I provide the first evidence of the effect of the Internet on how firms access foreign markets – directly or via intermediaries.

In developing economies it is particularly prevalent for firms to export via intermediaries such as agents, wholesalers and retailers. Exporting indirectly can involve substantial mark-ups that may be an obstacle for the export participation of smaller firms. For firms that do export there may be substantial efficiency gains from doing so, for example, through scale economies and upgrading production technologies.

This analysis contrasts the distinct effects of Internet adoption on direct and indirect exports. The firm-level dataset I employ is unique in that it captures both direct and indirect exports of the firm. Alternative data sources, such as customs data, do not contain information on the firms that export indirectly.

The potential for two-way causality can make causal inference a thorny issue. Empirical evidence suggests that technology diffusion is geographically localised, with spillover effects from neighbouring firms decaying quickly over short distances. I construct an instrument that captures these local network effects at the level of cities and suburbs, by matching IP addresses to firm locations.

Using a cross-section of firms in 18 developing countries I find that Internet technology is positively and significantly correlated with both direct trade and intermediated trade. The instrument is a strong predictor of the Internet adoption of firms in that locality and passes all conventional tests. Under instrumental variable (IV) estimation I find Internet technology magnifies direct trade with no significant effect on intermediated trade. Adopting the Internet because of local networks increases direct exports as a proportion of firm sales by 32-36%. The results are robust to the inclusion of a range of potentially omitted factors.

1. Introduction

"A manufacturing start-up in Boston can connect with a previously impossible-to-reach supplier in China; a marketing agency in New York can instantaneously collaborate with a client in London; a services firm in France can augment its team by having software developed in India." BBC News, 2012

This paper investigates how Internet technology affects exports. The existing literature predominantly focuses at the country-level; here I describe the effects on the firm. I provide the first evidence of the effect of the Internet on how firms access foreign markets – directly or via intermediaries. The potential for two-way causality can make causal inference a thorny issue. Empirical evidence suggests that technology diffusion is geographically localised, with spillover effects from neighbouring firms decaying quickly over short distances[1]. I construct an instrument that captures these local network effects at the level of cities and suburbs, by matching IP addresses to firm locations. Using a cross-section of firms in 18 developing countries I find that Internet technology magnifies direct trade with no discernible effect on intermediated trade.

In developing economies it is particularly prevalent for firms to export via intermediaries such as agents, wholesalers and retailers[2]. Exporting indirectly can involve substantial mark-ups that may be an obstacle for the export participation of smaller firms. For firms that do export there may be substantial efficiency gains from doing so, for example, through scale economies and upgrading production technologies (Lileeva and Trefler, 2010, Bustos, 2011).

Growing evidence suggests that the Internet can facilitate direct exchange between buyers and sellers within national borders. For example, through diminished matching frictions and reduced costs of communicating information over long distances[3]. These channels are likely to equally apply to international markets.

[1] See for example, Baptista (2000), Conley and Udry (2010), Foster and Rosenweig (1995), Haller and Siedshlag (2011), Keller (2002).
[2] Intermediaries account for account for 23% of Chinese exports, 17% of Turkish exports and 41% of Chilean imports (Ahn et al, 2011, Abel-Koch, 2013, Blum et al, 2010).
[3] See for example, Lieber and Syverson (2012) and Agrawal et al (2011).

This analysis contrasts the distinct effects of Internet adoption on direct and indirect exports[4]. The firm-level dataset I employ is unique in that it captures both direct and indirect exports of the firm. Alternative data sources, such as customs data, do not contain information on the firms that export indirectly.

A significant challenge is how to address the endogeneity of Internet adoption, particularly, in a data-scarce environment. Empirical evidence suggests that spillovers from neighbouring firms are an important determinant of technology diffusion[5]. However, these network effects are particularly localised, decaying quickly with distance. I construct an instrumental variable to capture local spillovers, using the real-world locations of IP addresses to measure the Internet connections in the firm's locality. A key advantage of this instrument is that it measures local Internet connections at a remarkably disaggregated level (a lower bound of 10 square miles). The disaggregated geography also rules out aggregate factors that could be driving the analysis, and allows identification based on local Internet connectivity. I exploit this within-country geographic variation to identify the effect of Internet adoption.

I find that under OLS, Internet adoption is positively and highly significantly correlated with both direct and indirect exports. The instrument is a strong predictor of the Internet adoption of firms in that locality and passes all conventional tests. Under instrumental variable (IV) estimation I find Internet technology magnifies direct trade with no significant effect on intermediated trade. Adopting the Internet because of local networks increases direct exports as a proportion of firm sales by 32-36%. The results are robust to the inclusion of a range of potentially omitted factors, such as measures of local infrastructure and agglomeration. The analysis is also robust to consideration of alternative firm responses to the instrument, including productivity, skilled labour employment and the use of trade credit.

This paper contributes to the literature on trade and technology. A large number consider the effect of trade on technology[6]. I look at technology as a determinant of trade. The existing literature is predominantly at an aggregate level and finds a positive correlation between the Internet connections and country-level trade flows[7]. I distinguish by looking at

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[4] Indirect exports capture sales to third parties that then export the good abroad. Direct exports refer to direct sales to foreign customers.
[5] See for example, Baptista (2000), Conley and Udry (2010), Foster and Rosenweig (1995), Haller and Siedshlag (2011), Keller (2002).
[6] For example,Yeaple (2005), Bustos, (2005, 2011), Atkeson and Burstein, (2010), Bloom et al, (2011).
[7] See Freund and Weinhold (2002, 2004), Clarke and Wallsten (2006).

firm behaviour and in particular, the channel through which firms access export markets. Using firm-level data from the same source as this paper, Ricci and Trionfetti (2012) find that being an exporter correlates with having email or a website. Abramovsky and Griffith (2006) use a similar identification strategy to this paper, instrumenting a firm's technology investment with the proportion of household Internet connections in their locality. UK firms with greater technology investments tend to purchase more offshore services.

This paper also contributes to the emerging literature on intermediaries and international trade. A number of studies have examined the characteristics of firms that use intermediaries and the features of their destination markets. The largest, most productive firms tend to export directly with smaller firms exporting via intermediaries (Ahn et al, 2011, Abel-Koch, 2013). Intermediaries tend to export a wider range of products than other exporters and account for a larger share of exports to more remote markets (Blum et al, 2010, Ahn et al, 2011). This paper extends such characteristics, considering the relationship between a firm's communication and export technologies.

The remainder of the paper is structured as follows. Section 2 discusses the firm-level data and the instrumental variable, details of the instrument construction are included in Appendix. In Section 3 I present the econometric specification. I present the results in Section 4, with instrument validity tests in Section 5. In Section 6 I conclude.

2. Data

a. Export Data

Data on firm exports is taken from the World Bank Enterprise Surveys. The Enterprise Surveys provide unique access to both the direct and indirect exports of the firm[8][9]. Existing research often uses transaction level data from customs authorities (e.g. Akerman, 2010, Crozet et al, 2013), however this provides no information on the firms that use intermediaries. The World Bank data contains a representative sample of mainly manufacturing firms from developing economies. The focus on developing countries is advantageous because of the relative importance of intermediaries and partial diffusion of Internet access in the developing world.

The identification strategy relies on within-country variation in firm location, comprehensive location data is therefore important. The detail of location information within the Enterprise Surveys varies substantially across countries. Some countries report only administrative region, whereas others note the district within a city. I include countries which report firm location at the city or district level. I further restrict the sample to countries which have firms located in at least five different locations. Table 1 shows my country sample and years of data.

Table 1: Sample of Countries and Years Available

Afghanistan	2009	Mexico	2006, 2010
Albania	2005, 2007	Moldova	2005, 2009
Argentina	2006, 2010	Nicaragua	2006
Brazil	2009	Pakistan	2007
Chile	2006, 2010	Panama	2006, 2010
Ecuador	2006, 2010	Paraguay	2006, 2010
El Salvador	2006	Peru	2006, 2010
Guatemala	2006, 2010	Turkey	2008
Honduras	2006	Uruguay	2006, 2010

Source: World Bank Enterprise Surveys

[8] Indirect exports capture sales to third parties that then export the good abroad.
[9] Unfortunately the data contains no information on the destination of exports.

Unfortunately, the panel aspect of the World Bank data is limited and is further constrained by the instrument being available only from 2005. I perform consistency checks on the data (for example that the ownership categories of the firm sum to 100%) and drop firms that report missing or inconsistent data. This leaves me with 9,964 observations in my baseline specification.

The World Bank collects data on whether a firm has a website or uses email to communicate with suppliers or customers. I categorise a firm as having Internet access if they either have a website or use email, or both[10]. 81% of firms have Internet access, with nearly all of those having email and 52% of firms having a website, as noted in Table 2.

As one would expect, a minority of firms trade (28%) and even amongst exporters, exports only account for a reasonable proportion of overall sales (40%). This compares closely to Ricci and Trionfetti (2012) who find 31% of firms export using a broadly similar sample of developing countries. The majority of trading firms are direct exporters: 22% of all firms export directly whereas only 9% engage in intermediated trade (and 3% engage in both). Direct exporters export a greater proportion of sales than indirect exporters. This is what one would expect given that direct exporters are on average larger and more productive (Ahn et al, 2011). There are also substantial differences in the proportion of firms who export across countries, both in terms of direct and indirect exporters (see Appendix Table 6). However, for almost every country the number of direct exporters dominates indirect. Manufacturing firms are more likely to export than those in the service sector (36% and 13% respectively) and this is true across both direct and indirect channels (Appendix Table 7).

[10] The effects of these individually are remarkably similar. Results are available on request.

Table 2: Summary Statistics of Key Variables

Variable	Mean	Std. Dev.	Obs.
Internet	0.811	0.391	9,964
Website	0.520	0.500	9,964
Email	0.805	0.396	9,964
Proportion of Exporting Firms	0.282	0.450	9,964
Exports / Sales for Exporters	0.401	0.355	2,805
Proportion of Direct Exporting Firms	0.224	0.417	9,964
Direct Exports / Sales for Direct Exporters	0.381	0.313	2,230
Proportion of Indirect Exporting Firms	0.088	0.284	9,964
Indirect Exports / Sales for Indirect Exporters	0.313	0.312	879
Firm Age (Years)	23.073	18.571	9,964
Lagged Labour Employment[a] (Logs)	3.264	1.424	9,964
Lagged Labour Productivity[a] (Log US Dollars)	9.093	3.088	9,964
Foreign Ownership[b]	0.075	0.248	9,964
State Ownership[c]	0.004	0.060	9,964
Manufacturing Sector Firms	0.663		
Service Sector Firms	0.337		

Notes: [a] Firms also report sales and employment 3 years prior to the survey; [b] Percentage of firm owned by foreign private sector; [c] Percentage of firm owned by the state;

Source: World Bank Enterprise Surveys

b. Instrumental Variable

A growing literature demonstrates that geography can play a significant role in determining technology diffusion[11]. Information costs can form a substantial barrier to technology adoption. This information is often obtained through interactions with neighbours (Comin et al, 2012). The presence of neighbouring adopters influences diffusion through localised spillover effects, such as reductions in information costs.

I capture neighbouring adopters by the number of IP addresses per capita in the firm's locality (IP_{ct}). The existing literature typically uses Internet connections at an aggregate level as a measure of infrastructure (e.g. Freund and Weinhold, 2002, 2004). Here I employ connections at a local level as a predictor of a firm's adoption. The identification strategy relies on cross-sectional within-country variation in local connectivity.

Every computer or device connected to the Internet has a unique IP address allocated by the Internet service provider. To construct the instrument I employ "geo-location" data, which maps IP addresses to physical locations, and is available from 2005 onwards. The instrument is accessible at a fine level of geography, often at the level of towns or city boroughs. The construction of the instrument and the mapping to firm data is discussed in the Appendix.

The distribution of the instrumental variable is skewed to the left (Figure 1). Over a quarter of locations have no IP addresses and two-thirds of locations have fewer than 5 per 100 people. These locations typically correspond to towns and city suburbs. However, there is a long-tail with 0.5% of locations (typically the centres of large cities) with more than one IP address per person. Firms are not uniformly distributed over these locations. Fewer (more) firms are located in areas with a relative scarcity (abundance) of IP addresses (Figure 2).

I construct a second instrument in order to employ over-identification tests for the joint validity of my instruments. I expect the instrument to be a poorer predictor of Internet access for the very largest firms, so I interact the instrument with a lagged size dummy[12]. In mapping firm locations to Internet infrastructure I assume a single plant location, whereas the largest firms are likely to have multiple sites. Information barriers are also less likely to be an

[11] See for example, Baptista (2000), Conley and Udry (2010), Foster and Rosenweig (1995), Haller and Siedshlag (2011), Keller (2002).

[12] The size dummy is defined as firms above the 90th percentile within their country in terms of lagged employment.

issue for the very largest firms, suggesting they may be less reliant on local networks to determine the timing of Internet adoption.

For later robustness checks, I compose another measure of Internet infrastructure using geo-location data kindly provided free-of-charge by Geobyte. The data represents a more aggregated geography than the baseline instrument, available at the city level only.

Figure 1: Distribution of Instrumental Variable over Locations

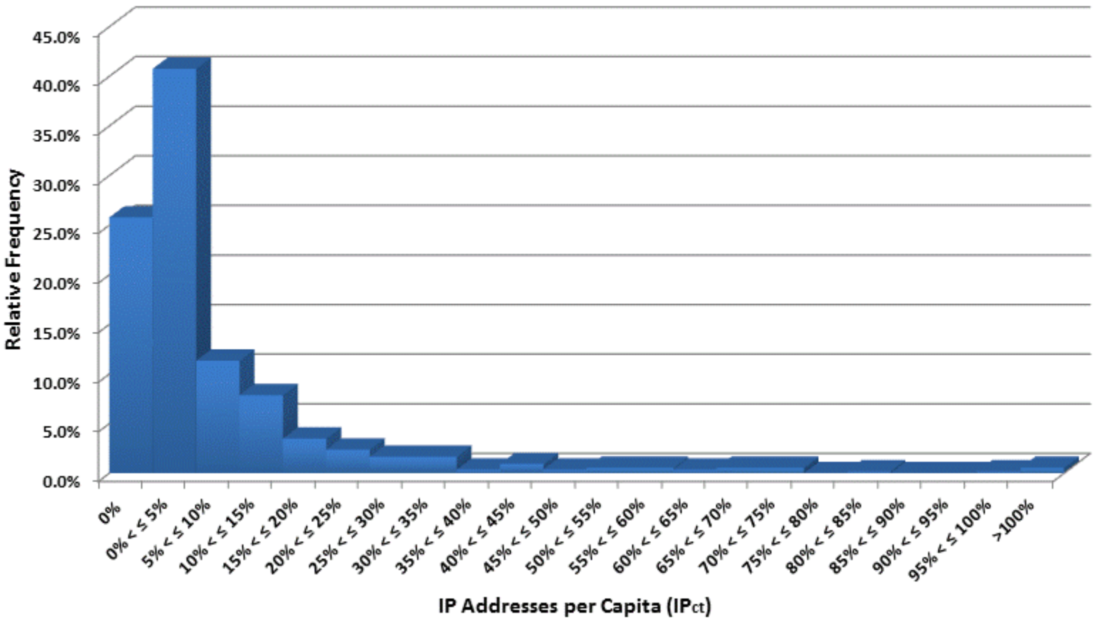
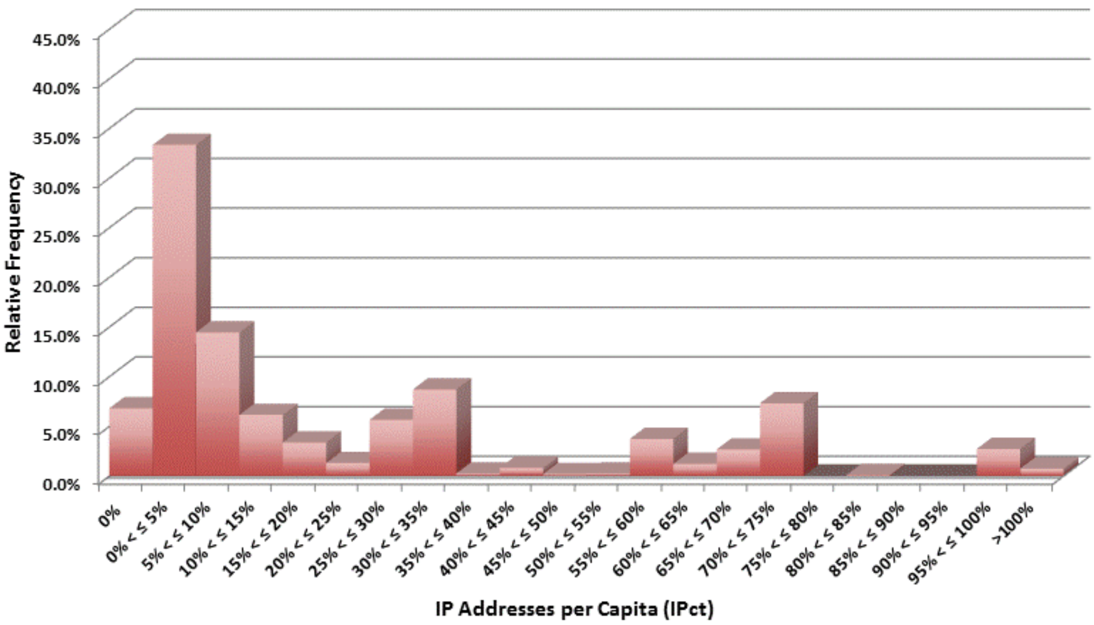


Figure 2: Distribution of Firms over Locations



3. Econometric Specification

I estimate two models, a pooled OLS and an instrumental variables regression. I regress the export intensity of firm i, at location c and time t (X_{ict}) on Internet access ($Internet_{ict}$), other controls (Y_{ict}) and country-sector-time fixed effects (FE_{kt}) for country k. Export intensity is measured by exports as a percentage of firm sales.

$$X_{ict} = \beta_0 + \beta_1 Internet_{ict} + \beta_2 Y_{ict} + FE_{kt} + \varepsilon_{ict}$$

In the first stage, I instrument Internet access with Internet infrastructure in the firm's locality (IP_{ct}) and its interaction with a size dummy.

$$Internet_{ict} = \gamma_0 + \gamma_1 IP_{ct} + \gamma_2 IP_{ct} * Size\ Dummy_{ict-1} + \gamma_3 Y_{ict} + FE_{kt} + \upsilon_{ict}$$

Inclusion of country-sector-time fixed effects controls for any country or sector-level factors that might influence firm exports or Internet adoption. These would include variables such as WTO membership, GDP and country or sector-level regulations. I use within-country-industry-time variation in the availability of Internet infrastructure to identify the effect of the Internet on exports.

The instrumental variable approach quantifies the causal effect of Internet adoption on firm exports for those firms that employ Internet technology because of local networks. Clearly there are numerous alternative factors behind the technology adoption, such as productivity shocks, government subsidies and foreign takeovers. OLS estimates an average effect across the population as a whole and are therefore not directly comparable with the IV coefficients (Angrist and Imbens, 1995).

4. Baseline Results

Table 3 presents the baseline results. Under OLS estimation, firms with Internet access export significantly more of their sales both directly and indirectly than those without (see columns 1, 4 and 7). Firm exports are also significantly correlated with being younger, larger and foreign-owned, which is consistent with Ricci and Trionfetti (2012). More productive firms export more directly and state-owned firms have lower indirect exports.

Columns 2-3, 4-5 and 8-9 present the results of instrumental variable estimation, the key results of this paper. Turning to the first stage regressions, the instrument is positively and significantly correlated with Internet adoption. Whilst the effect is highly significant, the magnitude is small. Firms are 1% more likely adopt the Internet in locations with 10% higher IP address per capita. Introducing the second instrument suggests, as expected, IP infrastructure is a poorer predictor of adoption for the very largest firms. The F-statistics remain high in all cases confirming the strength of the instruments. Stock-Yogo (2005) provide a formal test of weak instruments using the finite sample bias of IV estimation. They suggest strong instruments have a bias of less than 10%, which cannot be rejected here. The Hansen-J statistic over-identification test cannot reject the null of jointly valid instruments. The other control variables suggest that younger, more productive, larger and foreign-owned firms are more likely to adopt the Internet, which is consistent with the technology adoption literature (such as Haller and Siedschlag, 2011).

The second stage results indicate Internet adoption has no discernible effect on indirect exports. Conversely, Internet adoption leads to 32-36% higher direct exports as a proportion of sales, with a corresponding effect of 27-30% higher total exports. IV estimates suggest the effect of Internet adoption on total trade is stronger for those who adopt because of local networks, than the average effect estimated by OLS. This is consistent with findings for the UK (see Abromovsky and Griffith, 2006). The contrast across export modes is perhaps unsurprising. Intermediaries provide an export technology that matches firms with foreign customers. Through reductions in matching and communication costs, the Internet provides a similar technology that facilitates direct exchange.

Table 3: Baseline Results

Second Stage	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Dependent Variable:	Indirect Exports / Sales			Direct Exports / Sales			Total Exports / Sales		
	OLS	IV		OLS	IV		OLS	IV	
Internet	0.008**	-0.053	-0.043	0.059***	0.358***	0.322***	0.067***	0.304***	0.274***
	(0.004)	(0.050)	(0.004)	(0.005)	(0.096)	(0.079)	(0.006)	(0.104)	(0.088)
Firm Age	-0.006***	-0.006***	-0.006***	-0.017***	-0.013***	-0.013***	-0.023***	-0.020***	-0.020***
	(0.002)	(0.002)	(0.002)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Lagged Labour	0.002**	0.007*	0.006	0.034***	0.010	0.003	0.036***	0.017**	0.009
	(0.001)	(0.002)	(0.004)	(0.002)	(0.008)	(0.007)	(0.002)	(0.009)	(0.008)
Lagged Productivity	-0.001	0.001	0.001	0.003**	-0.006*	-0.004	0.002	-0.005	-0.004
	(0.001)	(0.002)	(0.002)	(0.001)	(0.003)	(0.003)	(0.002)	(0.004)	(0.003)
Foreign Ownership	0.019***	0.022***	0.021***	0.128***	0.116***	0.111***	0.147***	0.137***	0.133***
	(0.006)	(0.007)	(0.007)	(0.014)	(0.015)	(0.014)	(0.014)	(0.015)	(0.015)
State Ownership	-0.015***	-0.021***	-0.021***	-0.022	0.007	0.004	-0.036	-0.015	-0.017
	(0.005)	(0.008)	(0.007)	(0.043)	(0.048)	(0.047)	(0.044)	(0.047)	(0.046)
Size Dummy			0.002			0.082***			0.084***
			(0.007)			(0.014)			(0.015)
First Stage									
Endogenous Variable:	Internet			Internet			Internet		
Internet Infrastructure		0.112***	0.126***		0.112***	0.126***		0.112***	0.126***
		(0.016)	(0.017)		(0.016)	(0.017)		(0.016)	(0.017)
Internet Infrastructure * Size Dummy			-0.194***			-0.194***			-0.194***
			(0.017)			(0.017)			(0.017)
Firm Age		-0.014***	-0.013***		-0.014***	-0.013***		-0.014***	-0.013***
		(0.006)	(0.005)		(0.006)	(0.005)		(0.006)	(0.005)
Lagged Labour		0.080***	0.090***		0.080***	0.090***		0.080***	0.090***
		(0.026)	(0.003)		(0.026)	(0.003)		(0.026)	(0.003)
Lagged Productivity		0.031***	0.030***		0.031***	0.030***		0.031***	0.030***
		(0.002)	(0.002)		(0.002)	(0.002)		(0.002)	(0.002)
Foreign Ownership		0.042***	0.046***		0.042***	0.046***		0.042***	0.046***
		(0.010)	(0.011)		(0.010)	(0.011)		(0.010)	(0.011)
State Ownership		-0.097	-0.102		-0.097	-0.102		-0.097	-0.102
		(0.076)	(0.076)		(0.076)	(0.076)		(0.076)	(0.076)
Size Dummy			-0.038***			-0.038***			-0.038***
			(0.014)			(0.014)			(0.014)
Country-Sector-Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Cragg-Donald F statistic		50.202	35.541		50.202	35.541		50.202	35.541
Stock-Yogo 10% Bias (critical value)		16.38	19.93		16.38	19.93		16.38	19.93
Hansen-J statistic (*p*-value)			0.697			0.603			0.714
Observations	9,964	9,964	9,964	9,964	9,964	9,964	9,964	9,964	9,964

(Robust standard errors in parentheses)

5. Instrument Validity

The instrumental variable analysis hinges on satisfaction of the exclusion restriction. This requires that the only effect of local Internet connectivity on trade is through Internet adoption. The restriction therefore rules out any factor that is correlated with both infrastructure and the trade. Unfortunately this is not directly testable. Over-identification tests (reported in the previous section) require at least one instrument to be valid, so provide only tentative evidence.

To provide further support for the instrument, I consider a number of plausible alternative variables that could be correlated with both local networks and trade. I include these as control variables and check the identification remains strong. Finally, I also explore alternative firm-level responses to show they are unaffected by the instrument. All results are included in the Appendix.

Clearly it is not possible to rule out all alternative candidates, however, the task is made slightly easier by the results of the IV regressions. Any omitted variable would need to be correlated with both infrastructure and direct exports, but not indirect exports. It is more difficult to think of candidates that impact direct exports alone. The identification is also weakest for the largest firms. These are precisely the firms (if any) that one would expect to be able influence the instrumental variable, suggesting the instrument is exogenous from the individual firm's perspective.

a. Agglomeration

Firms do not locate uniformly throughout a country. More productive firms tend to be located in larger, denser urban environments (Combes et al, 2012). Internet infrastructure is also likely to be rolled out first to areas with higher demand, where more productive, larger firms are located. It seems plausible that these agglomeration effects may be correlated with both exports and the instrumental variable.

To measure urban scale I follow the agglomeration literature and use population density per square kilometre (Combes et al, 2011). If agglomeration economies are driving the identification, one would expect the instrument to be a stronger predictor of Internet adoption in locations of high population density. However, I find the reverse is true. Identification is strongest in areas where agglomeration forces are likely to be weakest.

I split the sample based population density and report the first stage IV estimation in Appendix Table 8. The instrument is a poor predictor of Internet adoption for firms located in areas of high population density (columns 4 and 5). IP infrastructure has a negative sign and is insignificant at any conventional level, confirmed by the small F statistics. Conversely, the instrument is a much stronger predictor of adoption for firms in areas of lower density (columns 2 and 3). These results are consistent with findings in the urban economics literature, where Internet adoption tends to be highest in smaller, more remote cities (Forman et al, 2005, Sinai and Waldfogel, 2004).

In addition, I include country-density fixed effects[13] as control variables to capture country-specific agglomeration effects (see Table 8). Identification now relies on variation in Internet connectivity within comparably dense locations in the same country, for example, comparing "city centres". On the whole, the instrument remains strong and the null of jointly valid instruments is not rejected. The second stage results for direct exports are largely unchanged; however, Internet adoption now has a significantly negative effect on indirect exports.

b. Alternative Local Infrastructure

Another concern is that the instrument could be capturing some other measure of the local environment that also correlates with trade flows. Two obvious candidates are electricity provision and distance from the border.

In developing countries constant supply of electricity may be an issue, with adverse effects on the cost of production (Steinbuks and Foster, 2010). Clearly without reliable electricity, Internet access is also problematic. It is well-established that distance forms a significant barrier to trade; more remote firms face greater transportation costs. However, distance also increases the cost of providing Internet infrastructure. I include the duration of power cuts and distance from the nearest border as measures of electricity infrastructure and transport costs respectively[14]. I also encompass local measures of water infrastructure and corruption. I calculate location averages using firms in the same vicinity, ensuring there are at least five firms to reduce the influence of an individual firm. Summary statistics for these variables are included in Appendix Table 5.

The main conclusion is that the instrument remains a strong predictor of Internet access even when all the additional infrastructure measures are included (Table 10). The second

[13] Locations are divided into quartiles with each quartile assigned a country-specific dummy variable. Quartile categories correspond to 0-1087, 1087-4348, 4348-5339, 5339+ inhabitants per square km.

[14] Distance to the nearest container port or international airport have been considered as alternative measures of transport costs, however it is not known how the goods are exported. Inclusion of these additional measures does not affect the conclusions. Results are available on request.

stage results are also largely unchanged relative to the baseline. Transport costs and corruption significantly reduces both exports and Internet adoption, and water infrastructure restricts exports alone. Surprisingly, electricity infrastructure does not seem to impact Internet adoption or exports. However, this likely reflects the use of generators that limit the impact of power disruption.

c. Alternative Firm-Level Responses

In order to satisfy the exclusion restriction, the instrument cannot affect any other endogenous variable that correlates with exports. In the previous analyses Internet adoption has been the only firm response to the instrument. Here I consider alternative channels through which the instrument could operate. In essence, whether the instrument is a strong predictor of another firm response and whether that variable is significant in the second stage.

I include a range of possible channels that are commonly found to be correlated with exports, namely firm size, productivity, skilled labour, product quality and access to credit. Table 10 presents the IV results. The instrument does not strongly predict any of the alternative responses in the first stage at any conventional level of significance.

d. Endogenous Firm Location

The identification strategy assumes that the firm location is pre-determined. However, one concern might be that firms move location to gain access to the Internet. The Internet is diffusing rapidly throughout the developing world, so the benefit is likely to be short-term. Given the significant costs of moving location it seems unlikely many firms would relocate.

However, to address this concern more formally, I restrict the sample to firms for which the costs of moving are likely to be large. Table 11 presents the results for a sample of manufacturing firms that are at least 10 years old. Identification remains strong, despite the smaller sample size. The positive effect of the Internet on direct exports is significant only in column 5; however, the effect on indirect exports is negative and marginally significant. The overall message from the second stage results is unchanged.

e. Clustering, Sample Size, Alternative IP Data

Table 12 reports the results using standard errors clustered at location of the firm, i.e. the city / district level. In the baseline results I do not cluster standard errors since the size of the clusters is quite unequal, which impacts the efficiency of the standard errors. Clustering renders the effect of the Internet on total exports marginally significant. However, conclusions regarding the composition of direct and indirect exports are unchanged.

The baseline sample contains countries with firms in at least 5 different locations. Now I restrict the sample to the 10 countries with at least 15 different locations, see Table 13. Identification remains strong, however, the second stage effect of the Internet on total exports is now insignificant. This seems to be driven by the Internet now having a marginally significant negative effect on indirect exports; the effect on direct exports remains positive and significant.

The instrumental variable has been constructed using data from MaxMind. I use similar data provided by Geobyte to construct an alternative instrument. The results are presented in Table 15. The Geobyte data represents a far more aggregated geography and contains fewer locations, which limits the sample size. The instrument is therefore far weaker as suggested by the F statistics. However, the sign and size of the instrument coefficients are comparable to the baseline instrument. In the second stage the Internet variables have the same sign as the baseline and a marginally significant positive effect on direct exports is observed. In the main, the Geobyte data reinforces the messages of the first instrument.

6. Conclusion

I provide the first evidence of the effect of the Internet on how firms access foreign markets – directly or via intermediaries. To address the endogeneity of Internet adoption, I construct a measure of local networks, by matching IP addresses to firm locations. Using a cross-section of firms in developing economies, I find Internet adoption because of local networks magnifies direct exports, with no discernible effect on indirect trade.

This paper implies the rapid diffusion of Internet access throughout the developing world has important implications for how firms access international markets. The Internet presents new possibilities for matching with foreign customers, supplementing existing channels such as intermediaries. The ability to export directly, and so avoiding intermediary mark-ups, is also suggestive of potential welfare benefits to Internet diffusion.

7. Appendix

a. Instrument Construction

I employ "geo-location" data, which maps IP addresses to physical locations, kindly provided at a discounted rate by MaxMind Inc. The database covers virtually all IP addresses in the world on a monthly basis from January 2005 onwards. The data are consequently particularly large, for example, containing 3.8 billion IP addresses in December 2010.

For each IP address the database provides the city name and longitude and latitude coordinates associated with it. MaxMind provide an additional geographic database containing city locations, whether or not they have an IP address associated with them. I use the two files to calculate the total number of IP addresses at each location.

The data is available at a very fine level of geographical detail. The term "city" is used generously in the MaxMind data, with the location corresponding to far more granular locations such as towns and districts of a city. For example, within my sample of countries there are around 26,000 "city" locations.

The "city" locations are not all symmetric in size either geographically or in terms of population. In order to control for size differences, I scale the number of IP addresses by the population of that town, city or city district. Population data is obtained from the closest year of census data. The population data can be less granular than the IP data; where necessary I aggregate IP address locations to be consistent.

I match the IP infrastructure variable to each firm using the firm's location information in the World Bank Enterprise Surveys. The quality of this information is mixed. Argentinian firms provide details of their district within Buenos Aires. Conversely, Polish firms do not provide any city information, only their regional location within Poland. I restrict the sample to countries that have firms in at least five different city locations. Therefore countries like Poland are omitted from the sample.

Typically the mapping is reasonably straightforward. Where the firm location information is less granular than the IP data, I aggregate IP data (and population) to be consistent.

Figure 3 illustrates the construction of the instrument for the municipality of Cerrillos within Santiago, Chile. The World Bank data records the location of Chilean firms at the municipality level. Census data also records population at the municipality level. Within Cerrillos there are two "city" locations in the IP data, Errazuriz and Los Cerrillos, these are marked on the map in blue. The instrumental variable for firms in Cerrillos is calculated as the total number of IP addresses at Errazuriz plus the number at Los Cerrillos, divided by the population of the municipality of Cerrillos.

Figure 3: Instrument Construction for Cerrillos - Santiago

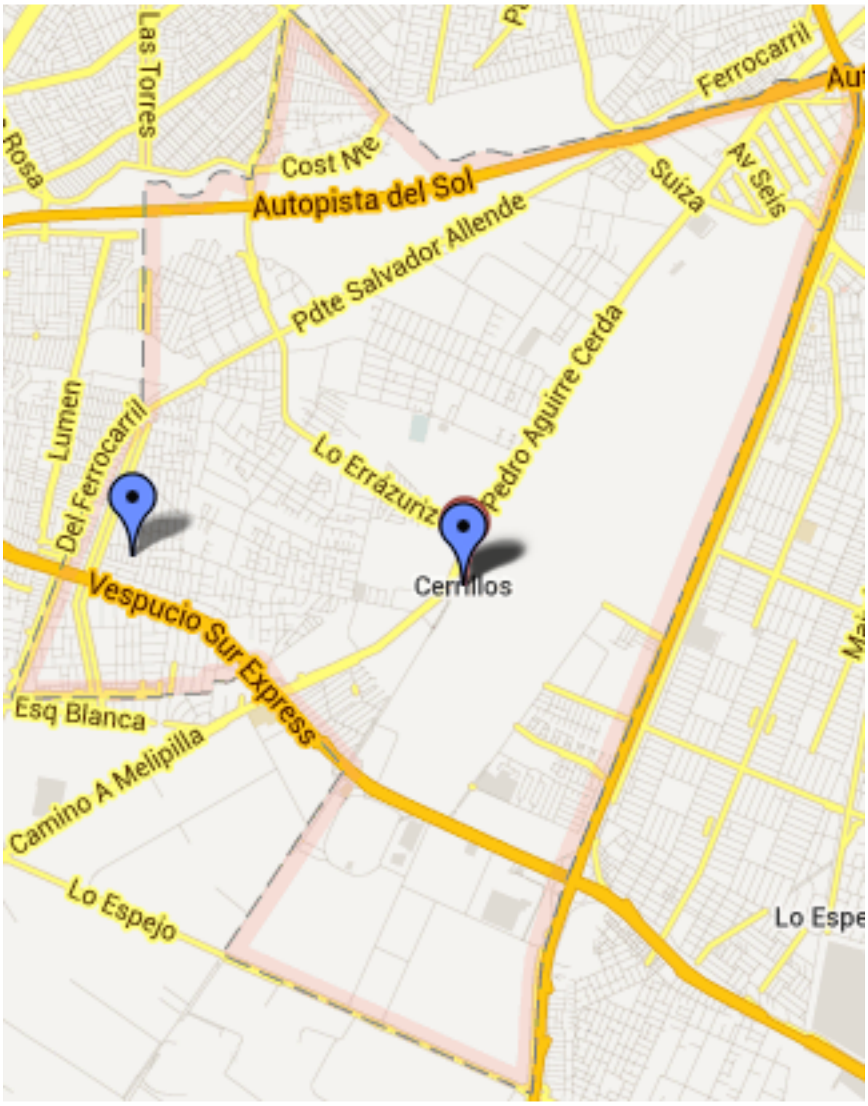


Table 4 shows the number of different "city" locations for each country in my sample.

Table 4: Number of Different Matched Firm Locations

Afghanistan	5	Mexico	45
Albania	8	Moldova	14
Argentina	85	Nicaragua	33
Brazil	117	Pakistan	12
Chile	67	Panama	13
Ecuador	11	Paraguay	18
El Salvador	32	Peru	8
Guatemala	31	Turkey	13
Honduras	15	Uruguay	19

Figure 4 shows the dispersion of Guatemalan firm locations and Figure 5 the locations of Internet infrastructure. The infrastructure data maps closely to the actual firm location. In general, the IP data is more geographically disaggregated than firm location information.

Figure 6 and Figure 7 show the locations of Chilean firms and Internet infrastructure respectively. Unlike Guatemala, Chilean firms are concentrated within a handful of regions of Chile. As noted earlier, Chilean firms record both the city and neighbourhood within which they reside. For example, within Santiago this enables me to map firms of each neighbourhood to a separate Internet infrastructure measure (Figure 8 and Figure 9). In general, the instrument is available at a remarkably disaggregated level; within Santiago I am able to map firms to an area of less than 10 square miles.

As one would expect, the mapping to locations is not error-free. For the countries in my sample, the location is correctly assigned to within 25 miles for between 64% and 90% of IP addresses (Maxmind, 2013). The locations are corrected and updated on a monthly basis, which generates some noise in the monthly data. I use the average of the monthly data over the year to minimise this noise.

Figure 4: Map of Guatemalan Firm Locations (31 different locations)

Figure 5: Map of Guatemalan IP Infrastructure Locations (364 different locations)

Map data ©2013 Google

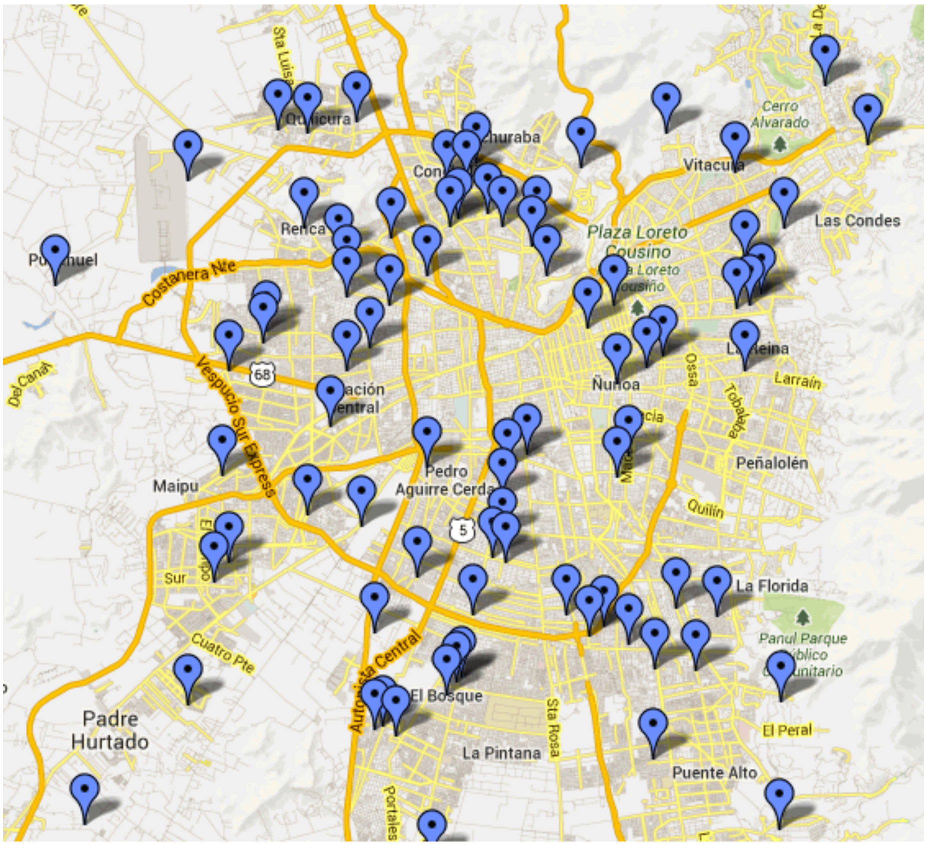
Figure 6: Map of Chilean Firm Locations (67 different locations)

Figure 7: Map of Chilean IP Infrastructure Locations (606 different locations)

Map data ©2013 Google

Figure 8: Map of Chilean Firm Locations – Santiago City

Figure 9: Map of Chilean IP Infrastructure Locations – Santiago City



Map data ©2013 Google

b. Tables

Table 5: Summary Statistics of Additional Variables

Variable	Mean	Std. Dev.	Obs.
Sales (Log US Dollars)	12.861	3.492	9,606
Proportion of Skilled Labour Employment[a]	0.471	0.273	6,490
Product Quality Certification[b]	0.205	0.403	9,684
Credit Availability[c]	0.727	0.446	9,390
Population Density[d] (Inhabitants Per Square Km)	4,744	4,313	8,357
Distance to Border (Miles)	47.354	61.483	9,963
Power Cuts (Days Per Month)	0.494	1.030	9,384
Water Cuts (Days Per Month)	0.387	0.723	9,342
Corruption[e]	0.012	0.014	9,326

Notes: [a] Skilled labour employment as a proportion of total employment of the firm; [b] Firm has internationally-recognized quality certification; [c] Firm has overdraft facility, credit line or loan. [d] Population density obtained from census data; [e] Informal payments or gifts to public officials as a percentage of firm sales.

Table 6: Direct and Indirect Exporting Across Countries

	Proportion of Exporting Firms	Proportion of Direct Exporting Firms	Proportion of Indirect Exporting Firms
Afghanistan	0.076	0.025	0.051
Albania	0.309	0.266	0.060
Argentina	0.421	0.377	0.082
Brazil	0.203	0.149	0.074
Chile	0.251	0.203	0.069
Ecuador	0.233	0.182	0.065
El Salvador	0.393	0.334	0.083
Guatemala	0.366	0.280	0.122
Honduras	0.196	0.146	0.061
Mexico	0.216	0.171	0.069
Moldova	0.218	0.210	0.028
Nicaragua	0.164	0.114	0.072
Pakistan	0.460	0.357	0.125
Panama	0.189	0.138	0.071
Paraguay	0.200	0.143	0.072
Peru	0.168	0.111	0.068
Turkey	0.686	0.561	0.328
Uruguay	0.355	0.273	0.131
Overall	0.282	0.224	0.088

Table 7: Direct and Indirect Exporting Across Sectors

	Proportion of Exporting Firms	Proportion of Direct Exporting Firms	Proportion of Indirect Exporting Firms
Manufacturing	0.356	0.287	0.110
Services	0.134	0.100	0.045
Overall	0.282	0.224	0.088

Table 8: First Stage Regression across Samples of Population Densities

	Density Available	Density < 3000	Density < 4000	Density > 4000	Density > 5000
First Stage	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
Endogenous Variable:			**Internet**		
Internet Infrastructure	**0.104*** (0.017)**	**0.122*** (0.034)**	**0.146*** (0.024)**	**-0.003 (0.027)**	**-0.034 (0.023)**
Other Controls	**Y**	**Y**	**Y**	**Y**	**Y**
Country-Sector-Year FE	**Y**	**Y**	**Y**	**Y**	**Y**
Cragg-Donald F statistic	**32.668**	**6.503**	**28.787**	**0.001**	**0.788**
Observations	**8,208**	**2,894**	**3,628**	**4,580**	**3,308**

(Robust standard errors in parentheses)

Table 9: Inclusion of Country-Density Fixed Effects

	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
Dependent Variable:		**Indirect Exports / Sales**			**Direct Exports / Sales**			**Total Exports / Sales**	
Second Stage	**OLS**	**IV**		**OLS**	**IV**		**OLS**	**IV**	
Internet	**0.009** (0.004)**	**-0.173** (0.080)**	**-0.119* (0.063)**	**0.038*** (0.005)**	**0.383*** (0.146)**	**0.272** (0.108)**	**0.047*** (0.006)**	**0.210 (0.150)**	**0.136 (0.119)**
Other Controls	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
Endogenous Variable: First Stage		**Internet**			**Internet**			**Internet**	
Internet Infrastructure		**0.095*** (0.019)**	**0.112*** (0.020)**		**0.095*** (0.019)**	**0.112*** (0.020)**		**0.095*** (0.019)**	**0.112*** (0.020)**
Internet Infrastructure * Size Dummy			**-0.144*** (0.028)**			**-0.144*** (0.028)**			**-0.144*** (0.028)**
Other Controls	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
Country-Density FE	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
Country-Sector-Year FE	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
Cragg-Donald F statistic		**19.745**	**15.827**		**19.745**	**15.827**		**19.745**	**15.827**
Stock-Yogo 10% Bias		**16.38**	**19.93**		**16.38**	**19.93**		**16.38**	**19.93**
Stock-Yogo 15% Bias (critical value)		**8.96**	**11.59**		**8.96**	**11.59**		**8.96**	**11.59**
Hansen-J statistic (*p*-value)			**0.172**			**0.264**			**0.562**
Observations	**8,208**	**8,208**	**8,208**	**8,208**	**8,208**	**8,208**	**8,208**	**8,208**	**8,208**

(Robust standard errors in parentheses)

Table 10: Inclusion of Alternative Local Infrastructure Controls

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Dependent Variable: Second Stage	**Indirect Exports / Sales**					**Direct Exports / Sales**				
Internet	**-0.053**	**-0.027**	**-0.040**	**-0.036**	**-0.030**	**0.361*** **	**0.410*** **	**0.425*** **	**0.415*** **	**0.454*** **
	(0.050)	**(0.055)**	**(0.058)**	**(0.054)**	**(0.057)**	**(0.096)**	**(0.112)**	**(0.117)**	**(0.108)**	**(0.120)**
Transport Costs	**-0.001**				**0.000**	**-0.005*** **				**-0.005** **
	(0.001)				**(0.001)**	**(0.002)**				**(0.002)**
Power Cuts		**-0.005**			**-0.004**		**-0.004**			**-0.004**
		(0.004)			**(0.004)**		**(0.007)**			**(0.007)**
Water Cuts			**-0.013*** **		**-0.012** **			**-0.037*** **		**-0.036*** **
			(0.005)		**(0.005)**			**(0.008)**		**(0.009)**
Corruption				**0.206**	**0.209**				**-0.586** **	**-0.492**
				(0.182)	**(0.189)**				**(0.286)**	**(0.314)**
Other Controls	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
Endogenous Variable: First Stage	**Internet**									
Internet Infrastructure	**0.113*** **	**0.101*** **	**0.098*** **	**0.105*** **	**0.098*** **	**0.113*** **	**0.101*** **	**0.098*** **	**0.105*** **	**0.098*** **
	(0.016)	**(0.017)**	**(0.017)**	**(0.017)**	**(0.017)**	**(0.016)**	**(0.017)**	**(0.017)**	**(0.017)**	**(0.017)**
Transport Costs	**-0.005** **				**-0.005** **	**-0.005** **				**-0.005** **
	(0.002)				**(0.003)**	**(0.002)**				**(0.003)**
Power Cuts		**-0.010**			**-0.007**		**-0.010**			**-0.007**
		(0.012)			**(0.012)**		**(0.012)**			**(0.012)**
Water Cuts			**0.007**		**0.009**			**0.007**		**0.009**
			(0.010)		**(0.010)**			**(0.010)**		**(0.010)**
Corruption				**-0.952** **	**-1.073** **				**-0.952** **	**-1.073** **
				(0.433)	**(0.439)**				**(0.433)**	**(0.439)**
Other Controls	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
Country-Sector-Year FE	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
Cragg-Donald F statistic	**43.337**	**38.393**	**35.789**	**34.353**	**35.667**	**43.337**	**38.393**	**35.789**	**34.353**	**35.667**
Stock-Yogo 10% Bias (critical value)	**16.38**	**16.38**	**16.38**	**16.38**	**16.38**	**16.38**	**16.38**	**16.38**	**16.38**	**16.38**
Observations	**9,963**	**9,384**	**9,342**	**9,326**	**9,188**	**9,963**	**9,384**	**9,342**	**9,326**	**9,188**

(Robust standard errors in parentheses)

Table 11: Alternative Firm-Level Responses

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Dependent Variable: Second Stage	Indirect Exports / Sales					Direct Exports / Sales				
Sales	**-0.108** (0.256)					**1.419** (2.423)				
Productivity		**-0.173** (0.547)					**2.270** (6.285)			
Skilled Labour			**-25.337** (742.952)					**51.355** (1501.85)		
Product Quality				**-25.337** (742.952)					**-6.093** (15.276)	
Credit Availability					**-0.182** (0.242)					**1.376** (1.026)
Other Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Endogenous Variable: First Stage	Sales	Productivity	Skilled Labour	Product Quality	Credit Availability	Sales	Productivity	Skilled Labour	Product Quality	Credit Availability
Internet Infrastructure	**0.030** (0.053)	**0.019** (0.053)	**0.001** (0.016)	**-0.007** (0.017)	**0.029** (0.021)	**0.030** (0.053)	**0.019** (0.053)	**0.001** (0.016)	**-0.007** (0.017)	**0.029** (0.021)
Other Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Country-Sector-Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Cragg-Donald F statistic	0.286	0.123	0.001	0.152	2.356	0.286	0.123	0.001	0.152	2.356
Stock-Yogo 10% Bias	16.38	16.38	16.38	16.38	16.38	16.38	16.38	16.38	16.38	16.38
Stock-Yogo 25% Bias (critical values)	5.53	5.53	5.53	5.53	5.53	5.53	5.53	5.53	5.53	5.53
Observations	9,606	9,600	6,452	9,684	9,390	9,606	9,600	6,452	9,684	9,390

(Robust standard errors in parentheses)

Table 12: Manufacturing Firms at least 10Years Old

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Dependent Variable:	**Indirect Exports / Sales**			**Direct Exports / Sales**			**Total Exports / Sales**		
Second Stage	**OLS**	**IV**		**OLS**	**IV**		**OLS**	**IV**	
Internet	0.010	-0.121*	-0.091*	0.070***	0.192*	0.106	0.079***	0.071	0.004
	(0.006)	(0.068)	(0.054)	(0.005)	(0.115)	(0.087)	(0.010)	(0.127)	(0.099)
Other Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y
Endogenous Variable: First Stage	**Internet**			**Internet**			**Internet**		
Internet Infrastructure		0.120***	0.144***		0.120***	0.144***		0.120***	0.144***
		(0.020)	(0.021)		(0.020)	(0.021)		(0.020)	(0.021)
Internet Infrastructure * Size Dummy			-0.219***			-0.219***			-0.219***
			(0.031)			(0.031)			(0.031)
Other Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y
Country-Sector-Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Cragg-Donald F statistic		28,245	22.934		28,245	22.934		28,245	22.934
Stock-Yogo 10% Bias (critical value)		16.38	19.93		16.38	19.93		16.38	19.93
Hansen-J statistic (*p*-value)			0.430			0.256			0.430
Observations	5,169	5,169	5,169	5,169	5,169	5,169	5,169	5,169	5,169

(Robust standard errors in parentheses)

Table 13: Clustered Standard Errors

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Dependent Variable:	**Indirect Exports / Sales**			**Direct Exports / Sales**			**Total Exports / Sales**		
Second Stage	**OLS**	**IV**		**OLS**	**IV**		**OLS**	**IV**	
Internet	0.008**	-0.053	-0.048	0.059***	0.358***	0.312**	0.067***	0.304	0.258*
	(0.004)	(0.046)	(0.041)	(0.013)	(0.170)	(0.128)	(0.014)	(0.196)	(0.139)
Other Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y
Endogenous Variable: First Stage	**Internet**			**Internet**			**Internet**		
Internet Infrastructure		0.112***	0.126***		0.112***	0.126***		0.112***	0.126***
		(0.021)	(0.025)		(0.021)	(0.025)		(0.021)	(0.025)
Internet Infrastructure * Size Dummy			-0.194***			-0.194***			-0.194***
			(0.052)			(0.052)			(0.052)
Other Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y
Country-Sector-Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Cragg-Donald F statistic		50.202	35.561		50.202	35.561		50.202	35.541
Stock-Yogo 10% Bias (critical value)		16.38	19.93		16.38	19.93		16.38	19.93
Hansen-J statistic (*p*-value)			0.741			0.755			0.799
Observations	9,964	9,964	9,964	9,964	9,964	9,964	9,964	9,964	9,964

(Robust standard errors clustered at the city / district level in parentheses)

Table 14: Restricted Sample of 10 Countries

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Dependent Variable:	**Indirect Exports / Sales**			**Direct Exports / Sales**			**Total Exports / Sales**		
Second Stage	**OLS**	**IV**		**OLS**	**IV**		**OLS**	**IV**	
Internet	**0.009****	**-0.119***	**-0.086***	**0.035*****	**0.236****	**0.133***	**0.044*****	**0.117**	**0.033**
	(0.004)	**(0.064)**	**(0.050)**	**(0.005)**	**(0.108)**	**(0.078)**	**(0.006)**	**(0.117)**	**(0.090)**
Other Controls	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
Endogenous Variable: First Stage	**Internet**			**Internet**			**Internet**		
Internet Infrastructure		**0.111*****	**0.134*****		**0.111*****	**0.134*****		**0.111*****	**0.134*****
		(0.018)	**(0.019)**		**(0.018)**	**(0.019)**		**(0.018)**	**(0.019)**
Internet Infrastructure * Size Dummy			**-0.210*****			**-0.210*****			**-0.210*****
			(0.028)			**(0.028)**			**(0.028)**
Other Controls	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
Country-Sector-Year FE	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
Cragg-Donald F statistic		**30.874**	**25.710**		**30.874**	**25.710**		**30.874**	**25.710**
Stock-Yogo 10% Bias (critical value)		**16.38**	**19.93**		**16.38**	**19.93**		**16.38**	**19.93**
Hansen-J statistic (*p*-value)			**0.827**			**0.193**			**0.349**
Observations	**6,774**	**6,774**	**6,774**	**6,774**	**6,774**	**6,774**	**6,774**	**6,774**	**6,774**

(Robust standard errors in parentheses)

Table 15: Alternative IP Data

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Dependent Variable:	**Indirect Exports / Sales**			**Direct Exports / Sales**			**Total Exports / Sales**		
Second Stage	**OLS**	**IV**		**OLS**	**IV**		**OLS**	**IV**	
Internet	**0.008**	**-0.048**	**-0.068**	**0.072*** **	**0.144**	**0.243***	**0.079*** **	**0.096**	**0.158**
	(0.005)	**(0.054)**	**(0.053)**	**(0.006)**	**(0.152)**	**(0.136)**	**(0.007)**	**(0.159)**	**(0.140)**
Other Controls	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
Endogenous Variable: First Stage	**Internet**			**Internet**			**Internet**		
Internet Infrastructure		**0.147*** **	**0.160*** **		**0.147*** **	**0.160*** **		**0.147*** **	**0.160*** **
		(0.031)	**(0.031)**		**(0.031)**	**(0.031)**		**(0.031)**	**(0.031)**
Internet Infrastructure * Size Dummy			**-0.209*** **			**-0.209*** **			**-0.209*** **
			(0.079)			**(0.079)**			**(0.079)**
Other Controls	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
Country-Sector-Year FE	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
Cragg-Donald F statistic		**15.570**	**10.577**		**15.570**	**10.577**		**15.570**	**10.577**
Stock-Yogo 10% Bias		**16.38**	**19.93**		**16.38**	**19.93**		**16.38**	**19.93**
Stock-Yogo 15% Bias (critical values)		**8.96**	**11.59**		**8.96**	**11.59**		**8.96**	**11.59**
Hansen-J statistic (*p*-value)			**0.289**			**0.187**			**0.403**
Observations	**7,744**	**7,744**	**7,744**	**7,744**	**7,744**	**7,744**	**7,744**	**7,744**	**7,744**

(Robust standard errors in parentheses)

8. References

Abel-Koch, J., (2013). Who uses intermediaries in international trade? Evidence from firm-level survey data. *The World Economy* (forthcoming).

Abramovsky, L., Griffith, R., (2006). Outsourcing and offshoring of business services: How important is ICT? *Journal of European Economic Association* 4(2-3), pp594-601.

Ahn, J., Khandelwal, A. K., S-J. Wei (2011). The role of intermediaries in facilitating trade. *Journal of International Economics* 84(1), pp73-85.

Agrawal, A., Catalini, C., A. Goldfrab (2011). Offline relationships, distance and the Internet: The geography of crowdfunding. NYU Stern School of Business, Working Paper available from: http://pages.stern.nyu.edu/~atakos/ResearchCamp/agoldfarbpaper.pdf

Akerman, A. (2010). A theory of wholesalers in international trade based on European scope. Stockholm University, Research Papers in Economics 2010:1

Angrist, J., Imbens, G., (1995). Two-stage least squares estimation of average causal effects in models with variable treatment intensity. *Journal of the American Statistics Association* 90, pp431-442.

Baptista, R., (2000). Do innovations diffuse faster within geographical clusters? *International Journal of Industrial Organisation* 18, pp515-535.

BBC News, (2012). No borders mean flatter world will get us anywhere.

[Accessed 10 February 2013]. Available from: http://www.bbc.co.uk/news/business-18594623

Bernard, A. B., Eaton, J., Jensen, J. B., P. K. Schott (2007). Firms in international trade. *Journal of Economic Perspectives* 21(3), pp 105-130.

Bernard, A. B., Jensen, J. B., P. Schott (2009). Importers, exporters and multinationals: a portrait of firms in the U.S. that trade goods. T. Dunne, J.B. Jensen, M.J. Roberts (eds), Producer Dynamics: New Evidence from Micro Data. Yale University Press.

Bernard, A. B., Jensen, J. B., Redding, S., P. K. Schott (2010). Wholesalers and retailers in US trade. *American Economic Review* 100(2), pp408-413.

Blum, B., Claro, S., I. Horstmann, (2010). Facts and figures on intermediated trade. *American Economic Review* 100(2), pp419-423.

Bustos, P., (2011). Trade liberalization, exports and technology upgrading: Evidence on the impact of MERCOSUR on Argentinian Firms. *American Economic Review* 101(1), pp304-340.

Cecere, G., Corrocher, N., (2011). The intensity of VoIP usage in Great Britain: Users' characteristics and firms' strategies. *Telecommunications Policy* 35, pp522-531.

Cecere, G., Corrocher, N., (2012). The usage of VoIP services and other communication services: An empirical analysis of Italian consumers. *Technological Forecasting & Social Change* 79, pp570-578.

Clarke, G., Wallsten, S., (2006). Has the Internet increased trade? Developed and Developing Country evidence. *Economic Inquiry* 44(3), pp 465-484.

Clarke, G., (2008). Has the Internet increased exports for firms from low and middle-income countries? *Information Economics and Policy* 20, pp 16-37.

Combes, P-P., Duranton, G., L. Gobillon (2011). The identification of agglomeration economies. *Journal of Economic Geography* 11(2), pp253-266.

Combes, P-P., Duranton, G., Gobillon, L., Puga, G., S. Roux (2012). The productivity advantages of large cities: distinguishing agglomeration from firm selection. *Econometrica* 80(6), pp2543-2594.

Comin, D., Dmitriev, M., Rossi-Hansberg, E., (2012). The spatial diffusion of technology. NBER Working Paper 18534.

Conley, T., Udry, C., (2010). Learning about a new technology: Pineapple in Ghana. *American Economic Review* 100(1), pp35-69.

Crozet, M., Lulanne, G., S. Poncett (2013). Wholesalers in international trade. European Economic Review 58, pp 1-17.

Fink, C., Mattoo, A., I. C. Neagu (2005). Assessing the impact of communication costs on international trade. *Journal of International Economics* 67(2), pp428-445.

Forman, C., Goldfarb, A., S. Greenstein (2005). How did location affect adoption of the commercial Internet? Global village vs urban leadership. *Journal of Urban Economics* 58, pp389-420.

Foster, A., Rosenzweig, M., (1995). Learning by doing and learning from others: Human capital and technical change in agriculture. *Journal of Political Economy* 103(6), pp1176-1209.

Freund, C., Weinhold, D., (2002). The Internet and international trade in services. *American Economic Review* 92(2), pp 236-240.

Freund, C., Weinhold, D., (2004). The effect of the Internet on international trade. *Journal of International Economics*, 62(1), pp 171-189.

George, L. M., (2008). The Internet and the Market for Daily Newspapers. *B.E. Journal of Economic Analysis & Policy.*

Haller, S., Siedschlag, I., (2011). Determinants of ICT adoption: evidence from firm-level data. *Applied Economics* 43, pp 3775-3788.

Hansen, L., (1982). Large sample properties of generalised method of moments estimators. *Econometrica* 50, pp 1029-1054.

Hong, S-H., Wolak, F. A. (2008). Relative prices and electronic substitution: Changes in household-level demand for postal delivery services from 1986-2004. *Journal of Econometrics* 145(1-2), pp226-242.

Keller, W., (2002). Geographical localisation of international technology diffusion. *American Economic Review* 90, pp120-142.

Kolko, J., (1999). The death of cities? The death of distance? Evidence from the geography of commercial Internet usage. Harvard University, mimeo.

Levin, J., (2013). The Economics of Internet Markets. D. Acemoglu, M. Arellano, E. Dekel (eds), Advances in Economics and Econometrics. Cambridge University Press

Lieber, E., Syverson, C., (2012). Online versus offline competition. M. Peitz, J. Waldfogel (eds), The Oxford Handbook of the Digital Economy. Oxford University Press.

Liebowitz, S. J., Zentner, A., (2012). Clash of the titans: Does Internet use reduce television viewing? *The Review of Economics and Statistics* 94(1), pp234-245.

Lileeva, A., Trefler, D., (2010). Improved access to foreign markets raises plant-level productivity…for some plants. *Quarterly Journal of Economics* 125(3), pp1051-1099.

Maxmind, (2013). GeoIP City accuracy for selected countries. [Accessed 01 February 2013]. Available from http://www.maxmind.com/en/city_accuracy

O'Mahoney, M.P., Robinson, C., M. Vecchi (2008). The impact of ICT on the demand for skilled labour: A cross-country comparison. *Labour Economics* 15(6), pp1435-1450.

Ricci, L. A., Trionfetti, F., (2012). Productivity, networks, and export performance: Evidence from a cross-country firm dataset. *Review of International Economics* 20(3), pp 552-562.

Sinai, T., Waldfogel, J., (2004). Geography and the Internet: is the Internet a substitute or a complement for cities? *Journal of Urban Economics* 45, pp1-24.

Staiger, D., Stock, J., (1997). Instrumental variables regression with weak instruments. *Econometrica* 65, pp 557-586.

Steinbuks, J., Foster, V. (2010). When do firms generate? Evidence on in-house electricity supply in Africa. *Energy Economics* 32, pp 505-514.

Stock, J., Yogo, M. (2005). Testing for weak instruments in linear IV regression, identification and inference for econometric models. Essays in honour of Thomas Rothenberg. Ed. Andrews, D., Stock, J., pp 80-108.

Tang, L., (2006). Communication costs and trade of differentiated goods. *Review of International Economics,* 14(1), pp 54-68.

UNESCO, (2013). Broadband Commission. [Accessed 1 February 2013]. Available from: http://www.broadbandcommission.org/

Wagner, J. (2007). Exports and productivity: A survey of the evidence from firm-level Data. *The World Economy* 30(1), pp 60-82.