Mobile Internet Growth and Services Trade *

Aerfate Haimiti[†], William R. Hauk, Jr.[‡], Mohammad Jakaria[§]

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Abstract

This paper studies how internet connectivity, encompassing both overall internet use and mobile broadband access, influences international trade with a particular focus on services. Using data for over 100 countries from 2004 to 2019, a two-stage structural gravity model shows that a 10 percent increase in internet users in the importing country raises bilateral services trade by about 7 percent, with comparable exporter-side effects. The strongest responses occur in telecommunications, information technology, finance, and intellectual property services, while the effects on goods trade are modest. Mobile broadband coverage has similar but somewhat smaller impacts, with 2G-and-higher (2G+) and 3G-and-higher (3G+) networks showing positive and significant elasticities, particularly in bandwidth-intensive sectors. Overall, the findings demonstrate that expanding internet access, both fixed and mobile, lowers trade costs and enhances participation in global markets.

Keywords: Internet connectivity, Mobile broadband, Services trade, Structural gravity.
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*All errors are the authors'.

[†]Darla Moore School of Business, University of South Carolina, Columbia, SC USA, haerfate@email.sc.edu

[‡]Darla Moore School of Business, hauk@moore.sc.edu

[§]Darla Moore School of Business, University of South Carolina, Columbia, SC USA, mohammad.jakaria@grad.moore.sc.edu

1 Introduction

Starting in the early 2000s, the growth of mobile broadband Internet has successfully brought high-speed connectivity to many locations that previously lacked reliable fixed-line service. Even in areas where fixed broadband was already available, the expansion of mobile devices brought unprecedented levels of convenience. Smartphones changed how consumers discover, purchase, and consume services, and how firms coordinate and deliver them across borders. In particular, mobile broadband has provided a cost-effective way to deliver high-speed Internet access in many developing countries, including through household devices such as mobile routers, dongles, or SIM-enabled home modems that use mobile networks as their primary source of connectivity where fixed lines are unavailable. As a result, an increasing share of trade, especially in services, is mediated by digital communication tools available on mobile devices.

Not surprisingly, the growth in trade in services has outpaced trade in goods and accounts for an increasing share of global value added and employment. According to the United Nations Conference on Trade and Development, service exports have grown at a rate of 9% year-over-year, approximately three times the rate of growth for trade in goods (Trade and Development 2025). However, much like trade in goods, there are still considerable frictions in cross-border services. Hence, anything that reduces these frictions (such as mobile broadband) will presumptively increase trade volumes.

There is a limited existing literature on the role of the Internet in facilitating services trade. However, many classic papers in this area, such as Freund and Weinhold (2002, 2004) and Choi (2010), while noting a positive effect of internet connectivity on services trade, focus primarily on web hosts or fixed-line internet users. More recent literature focuses on broadband growth (Nath and Liu 2017) and mobile phones (Rodriguez-Crespo, Marco, and Billon 2021) specifically. However, these studies do not distinguish between different generations of mobile telephony (2G vs. 3G vs. 4G, etc.) nor incorporate the latest in structural gravity techniques from the international trade literature.

This study aims to contribute to that literature along two dimensions. The core questions of this article are: Does deeper mobile broadband coverage increase bilateral trade in services? Do higher-capacity generations (e.g., 3G or 4G) matter more than earlier generations? Are these effects stronger on the importer side or the exporter side? Do the impacts vary across service industries with different levels of digital intensity?

The data that we bring to bear on these questions include a dataset from the International Telecommunication Union that provides the share of individuals using the Internet and population coverage for 2G-through-5G mobile networks. We also use the Dynamic Gravity Dataset from the U.S. International Trade Commission to examine bilateral trade flows, including both goods and services disaggregated across sectors. The granularity of these data allows us to observe both the extensive (network rollout) and intensive (network upgrading) margins of mobile broadband in international trade.

Our analysis shows that improvements in digital connectivity significantly increase bilateral trade in services. A 10 percent rise in the share of internet users in the importing country is associated with about a 6.9 percent increase in services imports, while an equivalent rise in exporter connectivity raises services exports by roughly 6.8 percent. The effects are strongest for information-intensive industries such as Telecommunications, Computer, and Information Services and Financial Services, where estimated elasticities approach 0.85 to 0.90, and remain positive though smaller for Intellectual Property services at around 0.40. Importer elasticities are also large in Education and Travel, highlighting the role of consumer-side access in expanding cross-border service consumption. By contrast, the estimated effects for agriculture, manufacturing, and mining are more modest, typically between 0.1 and 0.5, indicating that internet use has a limited influence where production and delivery depend on physical goods or inputs. Results using mobile broadband coverage yield consistent patterns: 2G-plus coverage increases trade by approximately 3.0 percent on the exporter side and 5.1 percent on the importer side, while 3G-plus networks generate smaller but statistically significant coefficients around 0.3 to 0.35 in digitally intensive sectors such as finance, telecommunications, and education. These results confirm that mobile connectivity reinforces the same pattern as overall internet access, with stronger effects in service industries where information transmission and coordination are central to trade.

This study therefore contributes to the literature by bringing in novel data that track mobile network generations across countries and over time. We also embed these data into a structural gravity design that links digital connectivity to bilateral trade costs in a theoretically consistent framework. This approach allows us to distinguish between the extensive margin of connectivity—how far networks reach—and the intensive margin—how much greater capacity or bandwidth enhances trade once basic access is available. It provides sector-specific evidence on where mobile bandwidth is most trade-enhancing, deepens our understanding of how digital infrastructure shapes the tradability of services, and highlights important policy implications for the design of digital infrastructure provisions in trade agreements and international development assistance.

The remainder of the paper is organized as follows. Section 2 reviews related work on internet connectivity, mobile broadband, and services trade. Section 3 describes the data sources and construction of key variables, including internet usage, mobile coverage, and bilateral trade flows. Section 4 presents the structural gravity framework that motivates the empirical specification, and Section 5 outlines the estimation strategy. Section 6 reports the empirical results by baseline specification, sectoral heterogeneity, and mobile network generations. Section 7 provides interpretation and broader implications. Section 8 concludes.

2 Literature Review

2.1 Internet and Trade

Two of the first papers to look at the effect of the role of ICT infrastructure, especially Internet penetration, in reducing trade costs in services are Freund and Weinhold (2002, 2004). Both find that the growth of the Internet has had a significant positive effect on trade in services. The 2004 paper uses time-series and cross-sectional data to estimate that a 10% increase in web hosts in a country is associated with a 0.2% - 0.4% increase in services trade volume. Vemuri and Siddiqi (2009), analyzing panel data for 64 countries (1985–2005), likewise concluded that ICT infrastructure and internet availability have a positive, significant impact on trade volumes. Notably, they found this effect for total trade in goods and services, highlighting ICT as a facilitator of globalization broadly. Similarly, Choi (2010) uses a gravity model with a fixed-effects GMM estimator to find that a doubling of Internet usage in a country leads to an increase in the trade of services of 2% - 4%. Liu and Nath (2013) focus on 40 emerging countries from 1995-2010 across multiple measures of ICT and find that greater ICT use – particularly with respect to internet subscriptions and hosts – is correlated with higher export and import shares in those economies. Nath and Liu 2017 look specifically at broadband penetration in developing countries and find that it is correlated with increased trade in several service categories. Furthermore, this effect seems to be more pronounced in developing economies than in developed ones. Finally, Kang (2020) looks at the expansion of mobile broadband specifically in South Korea and finds that the effect of mobile Internet penetration may have had an even greater impact on the trade in services than fixed line broadband.

While the literature on the relationship between ICT infrastructure and services trade is still developing, there is also an extensive literature looking at the relationship between ICT and goods trade. Fink, Mattoo, and Neagu (2005) look at the elasticity between communications costs and trade, finding that a 10% reduction in communications costs leads to an 8% increase in trade. Tang (2006) applies the same analysis to the variety of goods traded and finds that the post 1970s reduction in communication costs from improvements in ICT in the United States led to a significant increase in the variety of goods imported into the U.S.. For instance, Clarke and Wallsten (2006) demonstrated that internet access improvements in low-income countries translate into increased exports to rich markets. This implies ICT helps developing-country firms overcome traditional barriers (like poor information or high communication costs) that previously limited their export reach. At the firm level, Kneller and Timmis (2016) provided micro-level evidence from the UK, showing that the availability of high-speed broadband internet can increase the **extensive margin** of service exports – i.e. more firms start exporting services. Switching to Europe and the impact of ICT on exports, Mattes, Meinen, and Pavel (2012) find that the countries in the European Union with higher levels of ICT adoption have greater export intensity.

A more recent literature focuses more specifically on mobile broadband and trade. An early paper in this literature, Chung, Fleming, and Fleming (2013), who studied APEC countries' agricultural trade: they found internet use helped trade, but the largest effect was from fixed-line phones, with no significant effect from mobile phones. They speculate that either data limitations or the timeframe (1997–2006, when mobile internet was nascent) might explain why mobile effects were not yet evident. However, in later literature the consensus is that mobile broadband connectivity has become a critical factor for trade, especially in regions where cellular networks are the main conduit for business and consumer internet access. Ahmad, Ismail, and Hook (2011) who study Malaysia specifically, find that mobile and fixed telephone subscriptions have the biggest impact on trade flows, more than just internet users. Xing (2018) analyzes ICT and e-commerce adoption's impact on bilateral trade flows across 51 countries. It finds that ICT significantly increases exports, particularly for developing countries integrating into global value chains. Rodriguez-Crespo, Marco, and Billon (2021) look at the relative impacts of the Internet, mobile phones, and broadband penetration on trade flows and come to the conclusion that that mobile phones have a greater short-run impact on trade than fixed location Internet, including broadband. Abeliansky, Barbero, and Rodriguez-Crespo (2021), using data on both number of subscribers and quality of connections find that more ICT subscribers and higher bandwidth influence the extensive and intensive margins of trade, respectively. Mulenga and Mayondi (2022) look more at the impact of growth in digital services trade on GDP and find that it has a positive impact, especially in developing countries. However, in the process, the paper observes that ICT infrastructure is an important determinant of growth in that trade.

Hence, the literature points to there being an important impact of the growth in ICT infrastructure on growth in services trade. Indeed, the impact of mobile broadband may have the greatest impact of all. Our study contributes to this literature by creating a unique, cross-county database of the spread of mobile broadband and embedding that data into a gravity model of trade.

2.2 Trade in Services

Compared with goods, there is relatively limited empirical research on international trade in services, largely because of persistent data and measurement challenges. Services are less standardized, often require direct interaction between producers and consumers, and are subject to a wide range of domestic regulations that restrict cross-border supply. As a result, official trade statistics understate the true scale of services trade. Nevertheless, existing studies highlight that services account for most global value added and employment, and that openness in services markets can significantly enhance productivity in both services and manufacturing. Producer services such as telecommunications, finance, and logistics are central to enabling transactions and coordination across borders, reinforcing their role as a foundation for modern trade and global value chains.

Conceptual and quantitative work has shown that barriers in services trade are structurally different from those in goods markets. Francois and Hoekman (2010) emphasize that services are exchanged through multiple modes of supply, including cross-border delivery, consumption abroad, commercial presence, and movement of natural persons. Since explicit tariffs are rare, the main constraints are regulatory—licensing, ownership limits, and administrative discretion—which vary widely across sectors and countries (see also Hoekman and Braga 1997). Computable general equilibrium analyses, such as those by Christen, Francois, and Hoekman (2013), show that liberalizing service sectors can generate large indirect gains through productivity spillovers, as more efficient intermediate services improve competitiveness in downstream industries. These studies also stress that the scarcity and inconsistency of data remain key barriers to empirical analysis.

Recent empirical work has begun to map the scale and consequences of services trade using improved data and methods. Anderson et al. (2018) document that despite falling policy barriers, services face higher trade costs than goods, driven by information frictions and regulation (see also Miroudot, Sauvage, and Shepherd 2013). Fenske et al. (2021) show that the growing expenditure share of services—rising from roughly 60 percent in 1970 to nearly 80 percent in 2015—has moderated the aggregate growth of global trade, since many services remain less tradable even as demand for them expands. Firm-level evidence from Breinlich, Soderbery, and Wright (2018) and Lassmann (2020) shows that firms engaging in services exports tend to be more productive, pay higher wages, and rely more on skilled labor. Together, these findings underscore that services are both a growing source of comparative advantage and a critical input to other traded activities.

Building on this literature, our study introduces new evidence on how digital infrastructure reduces the distinctive frictions that limit cross-border services exchange. By linking multi-generation mobile coverage and internet usage to bilateral trade flows, we identify how connectivity improves tradability in information-intensive and consumer-facing services, extending prior work that could not observe or quantify these effects directly.

2.3 The Gravity Model and Trade

The "Gravity Model" of international trade developed from an observation by Tinbergen (1962) that the volume of trade between two countries could be predicted by the product of the two countries' GDPs divided by the distance between them. The name of the model came from the similarity between his formula and that of the Newtonian gravitational pull between two objects. The gravity equation quickly became a workhorse of empirical international trade.

However, for a while, the theoretical foundations of this empirical tool remained unexplored. Starting with James E Anderson and van Wincoop (2003), the literature tried to reconcile the theoretical literature on trade and trade costs with the empirical, creating a "structural" gravity model. Key to this insight was the what they referred to as the "gold medal" mistake in the existing empirical trade literature, a lack of a link between partial equilibrium impacts of changes in trade costs with general equilibrium effects such as trade diversion.

This work received some elaboration in subsequent studies, such as Head and Mayer (2014), Yotov et al. (2016), and Yotov (2022). However, many of the papers cited above (with the exception of Choi (2010) and Lin (2015)), do not seem to fully engage with this literature. Hence, estimates of the effects of ICT on bilateral trade may not be consistent in these studies. This study contributes to the literature by fully engaging with the literature on structural gravity modeling and the impact of ICT on the trade in services.

2.4 Summary of Contributions

In summary, this paper advances the literature on ICT and services trade along five fronts:

1. **New cross-country, multi-generation mobile coverage panel.** We assemble and harmonize annual country-level measures of Internet access from the ITU (share of users; 2G–5G population coverage) and, as a robustness source, raster-based 3G availability aggregated to population-weighted national coverage from Collins Bartholomew. We link these to the USITC Dynamic Gravity Dataset (v2) to study bilateral trade flows by broad sector and detailed services industries. This dataset allows us to distinguish *network rollout* (extensive margin) from *network upgrades* (intensive margin).

2. **Structural gravity with two-step identification.** We embed the Internet variables in a modern structural gravity framework, estimating a first-stage with bilateral trade frictions and high-dimensional fixed effects via PPML, and a second-stage that replaces exporter–time and importer–time effects with Internet coverage and country characteristics. This design addresses multilateral resistance, zeros, and heteroskedasticity in a transparent, replicable way.

3. **Documented elasticities, asymmetries, and sectoral heterogeneity.** We provide *quantified* headline effects and show they are not uniform: importer-side Internet access is consistently more trade-enhancing for services than exporter-side access; digitally deliverable services (telecom/IT, finance, and IP-related) exhibit the largest elasticities; and effects for goods are smaller, serving as a falsification benchmark. We also compare coverage *levels* vs. *logs* and report results for 2G vs. 3G to separate bandwidth from mere connectivity.

4. **Policy-relevant implications for digital trade and development.** By pinpointing where mobile bandwidth matters most (and on which side of the border), we inform priorities for digital chapters in trade agreements, universal service obligations, and development assistance aimed at services export capacity and market access.

5. **Deeper understanding of the service sector.** Existing empirical work on international services trade remains limited relative to goods, largely because services are less standardized, often require regulatory approval or physical presence, and are harder to measure consistently across countries. The available evidence emphasizes that services differ from goods not only in their production and delivery modes but also in their sensitivity to information, coordination, and policy barriers. This study adds new quantitative evidence on how digital infrastructure, particularly mobile broadband, reduces these frictions and reshapes the geography of trade in information-intensive and consumer-facing services. In doing so, it clarifies the mechanisms through which technology enables the growing cross-border tradability of services.

3 Data

3.1 Data on Broadband Internet Coverage and Subscription

Our data on internet access come from the International Telecommunication Union (ITU).[1] We use annual country-level measures of the share of individuals using the internet and the population coverage of 2G-and-higher (2G+) and 3G-and-higher (3G+) mobile networks. Our main analysis focuses on 3G+ coverage, which supports web browsing and social media and expanded broadly across countries during our study period. For completeness, we also report results using 2G+ coverage, which includes basic 2G connectivity and all higher generations and better captures the extensive margin of basic connectivity. To our knowledge, this is the most comprehensive source that jointly spans a long time horizon and broad country coverage, making it well suited for panel analysis of trade flows.

Ideally, we would also incorporate 4G-and-higher and 5G-and-higher coverage as additional bandwidth measures that should, in principle, capture greater reductions in service-sector trade costs. In practice, those series exhibit substantial missingness across countries and years, and even a conservative two-year interpolation leaves large gaps. We therefore focus on 2G+ and 3G+ coverage, which provide the best balance between temporal continuity and global coverage.

Figure 1 plots the share of internet users by country and year. Figures 2 and 3 plot 2G+ and 3G+ mobile coverage, respectively. Each panel is a heat map where the printed numbers represent percentages. These figures document the diffusion of connectivity over time: widespread 2G+ availability arrives earlier and saturates at high levels, while 3G+ expands later and displays richer within-country dynamics during our study window.[2]

3.2 Data on International Trade

All trade analysis in this paper is based on the Dynamic Gravity Dataset (version 2) from the U.S. International Trade Commission, covering the period 2004–2019.[3] This dataset provides annual bilateral trade flows between countries, measured in U.S. dollars and disaggregated by industry. It includes harmonized data across sources, with consistent country codes, product classifications, and sector definitions, making it well-suited for panel analysis. Trade values reflect total exports from the origin country to the destination country.

We focus on aggregate trade as well as trade in different sectors and industries, using the sectoral and industry identifiers provided in the dataset. For most of the analysis, we use total trade as the outcome, but we also examine patterns by broad industry group—agriculture, manufacturing, mining, and services—based on the dataset's classification. All trade flows are measured in current U.S. dollars and matched by country-pair and year to other data sources used in the analysis.

1. https://datahub.itu.int/data/

2. Appendix A reproduces these panels after applying a simple two-year interpolation to fill short gaps in the raw ITU series. The interpolated visuals clarify regional diffusion patterns where annual data are sparse. Importantly, no interpolation is used in any estimation or quantitative result.

3. https://www.usitc.gov/data/gravity/dgd.htm

4 Theoretical foundations

This section briefly presents a standard structural gravity model. For simplicity in notation, we do not include product-level indicators. However, as demonstrated by Yotov et al. (2016), the inclusion of product-level indicators does not substantially change the structure of the model.

4.1 Structural Gravity

Consumer preferences are identical across countries, and consumers' utility U function for country j follows a CES structure:

$$U(c_j) = \left\{ \sum_i \alpha_i^{\frac{1-\sigma}{\sigma}} c_{ij}^{\frac{\sigma-1}{\sigma}} \right\}^{\frac{\sigma}{\sigma-1}} \tag{1}$$

where c_{ij} is consumption of varieties from country i in country j, $\sigma > 1$ is the elasticity of substitution between varieties of goods from different countries, and $\alpha_i > 0$ is the CES preference weight parameter, which can be interpreted as product quality or appeal.

Consumers maximize their utility function subject to the following budget constraint:

$$\sum_i p_{ij} c_{ij} = E_j, \tag{2}$$

where E_j is the total spending on varieties from all countries. The delivery price of the good is country j $p_{ij} = p_i t_{ij}$ is determined by the f.o.b. export price of the good p_i from country i and the bilateral "iceberg" trade costs t_{ij}.

Following James E Anderson and van Wincoop (2003, 2004) we can use the CES utility function and a general equilibrium setting to solve for a general equilibrium model of trade flows between countries. The gravity equation that governs bilateral trade between any two countries i and j, X_{ij}, is as follows:

$$X_{ij} = \frac{Y_i E_j}{Y} \left(\frac{t_{ij}}{\Pi_i P_j} \right)^{1-\sigma}, \tag{3}$$

where Y_i denotes the total expenditure on a good from country i, and Y is defined as the total expenditure on the good in question from all from countries: $Y = \sum_i Y_i$. The key insights from this literature are the "multilateral resistance terms" $\Pi_i^{1-\sigma}$ and $P_j^{1-\sigma}$. These terms substantively link the partial equilibrium and the general equilibrium impacts of trade costs. Mathematically, the are the CES prices indexes. The "outward" multilateral resistance term $\Pi_i^{1-\sigma}$ captures the CES price index of exports from country i and is equal to:

$$\Pi_i^{1-\sigma} = \sum_j \left(\frac{t_{ij}}{P_j} \right)^{1-\sigma} \frac{E_j}{Y}. \tag{4}$$

The "inward" multilateral resistance term $P_j^{1-\sigma}$ is the CES price index of imports to country j and is equal:

$$P_j^{1-\sigma} = \sum_i \left(\frac{t_{ij}}{\Pi_i} \right)^{1-\sigma} \frac{Y_i}{Y}, \tag{5}$$

From here, we can estimate the predicted trade flows between countries i and j with a log-link generalized linear model of the form

$$E\left[X_{i,j}\right] = e^{\mu_i + \chi_j + \beta t_{i,j}} \tag{6}$$

where μ_i and χ_j are exporter and importer fixed-effects,[4] respectively, and $t_{i,j}$ are various determinants of trade costs between the two countries. As noted by Silva and Tenreyro (2006), a log-linear OLS specification is generally inappropriate for two reasons. The first is that many bilateral trade flows will have zero observations and will therefore be dropped from a log-linear sample in a way that is unlikely to be random. The second is that log-linear OLS may be biased if there is considerable heteroskedasticity in the sample. Consequently, the authors suggest that a Poisson pseudo-maximum likelihood (PPML) estimator will best address the econometric issues arising in a gravity specification.

4.2 Trade Effects of Internet

We define the trade cost of a good $t_{ij}^{1-\sigma}$ from country i to j in the following functional form:

$$t_{ijt}^{1-\sigma} = e^{\beta_1 \text{Internet}_{it} + \beta_2 \text{Internet}_{jt} + \beta_3 \chi_{ijt} + \delta_{it} + \gamma_{jt}}. \tag{7}$$

The variables Internet$_{it}$ and Internet$_{it}$ represent the internet coverage of country i and j, respectively. χ_{ijt} indicate a vector of bilateral trade variables including distance between country i and j and the presence of bilateral free trade agreement, contiguous borders, common language and colonial ties. $\delta_{it}$and γ_{jt} represent the exporter-time and importer-time fixed effects capturing other country specific unobserved characteristics. In the next section, we discuss the econometric specifications.

Internet also have two indirect effects on bilateral trade flows. Indirectly, Internet may affect outward multilateral resistance Π_i and inward multilateral resistance $P_j^{1-\sigma}$ can be estimated by equation (4) and (5), respectively. Moreover, the Internet can also affect the production of a country as a cultural good and by affecting the technology. In this paper, we focus on identifying the effect of internet's effect on trade through the direct trade cost channel.

5 Empirical Analysis

To estimate the direct impact of internet on trade, we incorporate (7) into (3), and we get the following econometric model:

$$X_{ij,t} = \exp\left[\beta_0 + \beta_1 \text{Internet}_{it} + \beta_2 \text{Internet}_{jt} + \beta_3 \chi_{ijt} + \delta_{it} + \gamma_{jt} + \epsilon_{ij,t}\right]. \tag{8}$$

The variable X_{ijt}^s is bilateral trade (in levels) between partners i and j at time t for sector s. The error term is denoted by $\epsilon_{ij,t}$. The other variables follow the same definition. We estimate the equation using the PPML estimator.

Since internet variables varies at country-year level like the exporter-time and importer-time fixed effects, we estimate the equation using a twp-step approach like Anderson and Yotov (2016). In the first step, we regress observed bilateral trade on bilateral trade variables, sector-time fixed effects, and exporter-time and importer-time fixed effects following the standard structural gravity model literature. In the second step,

4. James E Anderson and van Wincoop (2003) call the lack of these fixed-effects terms in traditional gravity models the "gold medal" mistake in earlier estimations.

we incorporate the parameter estimates of the constant term, bilateral trade variables, and sector-time fixed effects from the first stage into equation (3), we then replace the exporter-time and importer-time fixed effects with the Internet variables, and exporter, importer and time fixed effects.

6 Empirical Results

This section presents the empirical results from our two-stage estimation strategy. We begin by validating the gravity framework with a first-stage regression that establishes expected effects of distance, contiguity, language, and trade agreements. We then turn to the second-stage results, which quantify the role of overall internet usage on bilateral trade flows, with particular attention the service sectors. Next, we examine heterogeneity across service industries to assess which sectors are the most responsive to internet connectivity. We then distinguish between the effects of different generations of mobile internet (2G versus 3G) to capture the importance of bandwidth upgrades. Finally, we interpret these findings in light of mechanisms emphasized in the literature and draw broader implications for digital trade and development policy.

6.1 First-Stage: Gravity Estimates

Panel A of Table 1 reports the first-stage results from the structural gravity estimation. The coefficients are highly consistent with theoretical expectations and provide strong validation of the model's structure. Distance enters negatively and significantly across all sectors, ranging from -0.346 in services to -1.058 in mining, implying that a 1% increase in bilateral distance reduces trade in services by approximately 0.35% and in mining by roughly 1.06%. These magnitudes align closely with standard trade elasticities reported in the gravity literature, suggesting that the data construction and estimation design are sound.

The standard trade-facilitating covariates behave as expected. Contiguity and common language significantly increase trade volumes, capturing the importance of shared borders and linguistic proximity for information flows and contract enforcement. Colonial ties are also positively associated with bilateral trade, particularly in mining and services, which likely reflects persistent institutional linkages and lower informational asymmetries across historically connected economies. The presence of a free trade agreement strongly and significantly raises trade across all sectors, consistent with the structural interpretation that policy-driven reductions in trade barriers directly lower bilateral trade costs t_{ij}. These patterns confirm that the first-stage regression effectively recovers the underlying geography and policy determinants of trade costs.

The first-stage coefficients for the alternative samples used in the 2G+ and 3G+ specifications are nearly identical in both sign and magnitude, confirming that the baseline gravity relationships are stable across subsamples and specifications. To conserve space, these results are not shown here but are available in the Appendix A. Collectively, the first-stage estimates provide a solid foundation for the second-stage analysis, where we replace the exporter–time and importer–time fixed effects with measures of digital infrastructure and country-level characteristics to identify how internet connectivity affects bilateral trade flows.

6.2 Second-Stage: Effects of Internet Infrastructure

Panel B of Table 1 presents the second-stage estimates linking internet access to bilateral trade. Using the log of internet users (combining both fixed and mobile access), we find robust positive effects on trade volumes, with particularly strong results for services. For services, the elasticity with respect to ln(Internet users) is

0.713 on the exporter side and 0.726 on the importer side, both highly significant. In manufacturing, the elasticities are 0.504 (exporter) and 0.488 (importer); in agriculture, 0.111 (exporter) and 0.320 (importer). For mining, the importer elasticity is large and significant at 0.718, while the exporter elasticity (0.104) is small and statistically insignificant. At the aggregate level, the exporter and importer elasticities of 0.305 and 0.453, respectively, suggest that both sides' connectivity increases trade volumes, though the demand side plays a somewhat larger role.

These results fit naturally within the structural gravity framework, where the bilateral trade-cost function t_{ijt} depends multiplicatively on exporter and importer factors. Internet access reduces trade costs by lowering both fixed and variable costs of coordination, enhancing search and matching, and enabling the transmission of complex, information-intensive products and services. The stronger importer-side elasticities indicate that demand-side frictions are critical: when buyers and consumers in destination markets are more connected, it becomes easier to search for, contract with, and consume foreign services. The exporter effects remain meaningful, particularly for producer services that rely on coordination and remote delivery, but they are typically smaller in magnitude, reflecting the importance of absorptive capacity on the importer side.

Comparing Internet Users, 2G+, and 3G+. Tables 2 and 3 extend the analysis to mobile broadband coverage, distinguishing between the extensive margin of basic connectivity and the intensive margin of bandwidth. For 2G+ mobile broadband access, the overall elasticities are 0.314 (exporter) and 0.535 (importer), with both being statistically significant. At the sectoral level, the manufacturing sector shows sizable elasticities of 0.522 and 0.617, while mining records a very large importer elasticity of 1.117. The services sector displays extremely large coefficients—about 3.78 on both sides with wide standard errors, which likely reflect the saturation of 2G coverage by the late sample period. These results underscore that early mobile connectivity, even at low bandwidth, significantly facilitated cross-border transactions by enabling communication and market access in countries with limited fixed-line infrastructure.

In contrast, the 3G+ effects are more moderate and better aligned with theoretical predictions. The aggregate elasticities are smaller and generally not statistically significant, but the sectoral-level variation remains instructive. Mining again exhibits a significant importer elasticity of 0.179, while services show positive elasticities of 0.318 (exporter) and 0.324 (importer), each marginally significant. These patterns suggest that 3G+ networks—representing higher bandwidth and more data-intensive connectivity—contribute to trade in sectors where digital transmission and real-time interaction are key, such as services and mining supply chains. Relative to the broader internet-users measure, which combines fixed and mobile access, mobile-only indicators capture a narrower channel, so it is unsurprising that their estimated effects are less stable but still economically meaningful.

From a theoretical standpoint, the combination of exporter and importer connectivity corresponds to a bilateral trade-cost structure of the form $t_{ijt} = e^{-\beta_1 \text{Internet}_{it} - \beta_2 \text{Internet}_{jt}}$. Improvements in digital infrastructure on either side reduce effective trade costs, but their joint interaction lowers the multilateral resistance terms Π_i and P_j as well. The stronger importer-side coefficients reflect greater sensitivity of trade to the demand-side reduction in informational barriers. The progression from 2G+ to 3G+ supports a bandwidth interpretation: as mobile networks expand and transmission speeds improve, services that depend on richer data exchange—finance, IT-enabled services, and professional consulting—become more tradable. These findings highlight that the internet's contribution to trade operates through both extensive-margin participation (driven by access) and intensive-margin efficiency (driven by capacity).

6.3 Heterogeneity by Service Industry

Table 4 reports substantial heterogeneity across service industries. The effects of internet usage are strongest for digitally deliverable and information-intensive services, where transmission, coordination, and data handling are central. In Telecommunications, Computer, and Information Services (industry 162), the exporter and importer elasticities are 0.856 and 0.824, both highly significant. Financial Services (industry 160) display elasticities of 0.802 (exporter) and 0.865 (importer), and Intellectual Property (industry 161) records 0.420 and 0.414, respectively. These large and precisely estimated coefficients align with the theoretical mechanism in which the internet reduces variable trade costs by enabling seamless digital delivery, synchronized communication, and real-time verification between trading partners.

Consumer-oriented sectors show stronger importer-side elasticities, emphasizing the demand-side role of connectivity. For Travel (industry 157), elasticities are 0.424 (exporter) and 0.762 (importer), indicating that digitally connected consumers are better able to search, compare, and purchase foreign services. In Education Services (industry 166), the elasticities are 0.809 (exporter) and 0.959 (importer), both significant, highlighting the growing global market for online and hybrid learning where student-side access is essential. These importer-dominant patterns are consistent with a gravity interpretation where digital access enhances absorptive capacity and raises the elasticity of substitution between domestic and foreign providers.

By contrast, sectors with inherently local delivery or administrative orientation show weaker or statistically insignificant effects. Government services (industry 167) display minimal exporter responsiveness (-0.020) and a moderate importer elasticity of 0.572, reflecting institutional or programmatic cross-border transfers rather than market-driven trade. Heritage and Recreational Services (industry 164) exhibit small and insignificant coefficients (0.170 exporter, 0.046 importer), consistent with physical presence requirements and local consumption. Such results reinforce the idea that digital infrastructure primarily facilitates tradable services whose delivery can be decoupled from geography.

Tables 6 and 5 further clarify the roles of basic connectivity and bandwidth. Under 2G+, the pattern is uniformly positive, though magnitudes are often large and imprecise. In industry 162, exporter and importer elasticities reach 3.823 and 3.553, while Financial Services (160) record 3.709 and 2.753. These high values likely reflect both limited within-country variation at high coverage levels and the composite nature of 2G+, which aggregates multiple generations. Nevertheless, the direction of the effects supports the view that even low-bandwidth connectivity expanded the extensive margin of participation in international service markets, especially for countries lacking robust fixed-line infrastructure.

Under 3G+, the elasticities are more moderate and tightly linked to sectors where bandwidth intensity is crucial. In industry 162, exporter and importer elasticities are 0.356 and 0.395, both significant, and Financial Services (160) shows 0.342 for each side, marginally significant. Intellectual Property (161) exhibits a significant importer elasticity of 0.103, while Education Services (166) registers 0.385 (exporter) and 0.282 (importer). These results provide compelling evidence that higher-bandwidth mobile networks enhance intensive-margin trade in services that rely on real-time data transmission, interaction, and authentication—key features of digital globalization.

In contrast, industries with proximity constraints or limited digitizability — such as Heritage/Recreation (164) or Government (167) — remain unresponsive to bandwidth upgrades, consistent with the model's implication that digital infrastructure reduces trade costs primarily where delivery can be virtualized. The combined evidence across internet users, 2G+, and 3G+ confirms that connectivity affects both margins of trade: extensive participation through network reach and intensive efficiency through bandwidth. These findings underscore the central role of digital infrastructure in shaping the modern geography of services trade and highlight that the largest gains accrue where technology most directly substitutes for physical proximity.

7 Interpretation and Broader Implications

The estimates are best interpreted within a structural gravity framework in which connectivity variables alter bilateral trade costs and, through general equilibrium, shift multilateral resistance on both exporter and importer sides. Mobile internet affects several margins simultaneously. Rollout increases the number of connected agents, reducing fixed costs of search, contracting, authentication, and coordination. Bandwidth upgrades improve reliability and speed, lowering variable costs for data-intensive and synchronous exchanges. The two-step estimation design, which first absorbs country–time fundamentals and then replaces them with measurable connectivity and country characteristics, aligns these mechanisms with the standard gravity structure described by James E Anderson and van Wincoop (2003) and extended by Yotov et al. (2016).

Industry patterns align with established distinctions in services tradability and regulation. Information-intensive services such as telecommunications, computer and information, finance, and intellectual property are either digitally delivered or rely on dense remote coordination. Reductions in information and coordination costs therefore yield larger elasticities in these sectors. By contrast, proximity-bound or publicly administered sectors respond weakly, consistent with their limited scope for technology-based substitution. Structural gravity work on services by Anderson et al. (2018) documents large but uneven declines in border barriers and ties these differences to geography, income, infrastructure, and institutions. Similarly, Francois and Hoekman (2010) emphasize that cross-border services are strongly conditioned by behind-the-border rules governing entry, data, and professional licensing. These results are consistent with the heterogeneity observed across service categories in the estimated elasticities.

Importer connectivity typically matters at least as much as exporter connectivity. Buyer-side access reduces search and verification frictions, expands the potential customer base, and improves the matching efficiency for international transactions. Hjort and Tian (2021) highlight precisely these demand-side channels in addition to supply-side productivity gains. When consumers and firms in destination markets are connected, they can discover and transact with foreign providers more easily, which raises trade flows even if exporter-side infrastructure remains constant. This interpretation is consistent with the larger importer elasticities estimated for consumer-facing and digitally deliverable services.

The distinction between extensive and intensive margins is also central. Early mobile networks primarily expanded coverage and enabled participation, while later generations enhanced data throughput and reduced latency. The review evidence indicates that bandwidth upgrades magnify productivity and trade gains when activities are information-intensive or require real-time interaction. The larger elasticities observed for 3G+ networks in digitally intensive services are consistent with this channel.

Firm-level evidence from micro studies supports complementary supply-side adjustments. Breinlich, Soderbery, and Wright (2018) show that UK firms shifted from selling goods to selling services as tariffs on manufacturing inputs declined, with greater responses among firms with higher R&D intensity. This pattern of servicification demonstrates how improved connectivity and lower trade barriers induce firms to expand into services exports, particularly in producer and knowledge-based activities. The same logic helps explain why exporter-side elasticities are strongest for finance, information technology, and intellectual property services.

At the macro level, structural change provides context for interpreting magnitudes. Services now account for about two thirds of global value added and roughly half of employment. The share of services in final expenditures rose from about 58 percent in 1970 to nearly 80 percent in 2015, while the ratio of services trade to services expenditure increased from roughly 8 to 18 percent (Fenske et al. 2021). Counterfactual exercises suggest that if global expenditure shares had remained at 1970 levels, openness in 2015 would have been about one third higher despite falling trade costs. These patterns imply that strong service-sector elasticities can coexist with a slower aggregate trade-to-GDP ratio because demand has shifted toward sectors with inherently lower tradability.

Policy and regulatory context determine how much connectivity translates into actual cross-border flows. Quantitative decompositions of services trade costs reveal that despite widespread declines, barriers remain large and vary widely across sectors and partners (Anderson et al. 2018). Computable general equilibrium analyses of market access, such as Christen, Francois, and Hoekman (2013), show that relaxing regulatory constraints, enhancing transparency, and improving competition can deliver large welfare and trade gains, especially when paired with infrastructure improvements. The literature consistently finds that similar physical networks yield different outcomes depending on the regulatory quality and the efficiency of domestic services markets (Francois and Hoekman 2010).

Taken together, the evidence implies four main conclusions. First, mobile internet reduces bilateral trade costs in a manner consistent with structural gravity and with observed declines in sector-specific barriers. Second, importer-side connectivity often produces larger effects because most frictions in services trade originate on the demand side. Third, bandwidth upgrades strengthen the intensive margin, particularly in data- and information-intensive industries. Fourth, digital infrastructure alone is not sufficient: complementary reforms in regulation, competition, and services market access determine how effectively connectivity increases cross-border trade. These results align with established evidence on the multiple modes of service delivery, the importance of information and coordination costs, and the persistent heterogeneity in border barriers across sectors and partners.

8 Conclusion

This study provides new evidence on how internet connectivity, encompassing both overall and mobile broadband access, shapes international trade patterns with particular emphasis on services. Using a comprehensive dataset that links multi-generation mobile coverage and internet usage to bilateral trade flows within a structural gravity framework, the analysis shows that improvements in digital infrastructure significantly reduce trade costs and expand cross-border exchange. The estimated elasticities indicate that both exporter and importer connectivity enhance services trade, but importer-side access generally has the larger effect. A 10 percent rise in the share of internet users in the importing country increases bilateral services trade by roughly 7 percent, with a similar effect on the exporter side. These magnitudes underscore that digital access meaningfully lowers informational and coordination frictions, especially on the demand side of international service markets. By contrast, the effects are notably smaller for agriculture, manufacturing, and mining, suggesting that connectivity primarily facilitates trade in sectors where delivery and coordination can be digitized.

The results further show that the impact of internet access varies substantially across sectors. The largest effects appear in digitally intensive industries. Telecommunications, Computer, and Information Services exhibit exporter and importer elasticities near 0.85, while Financial Services show effects around 0.80 to 0.90. Intellectual Property services record smaller but still positive coefficients near 0.40, and importer elasticities in Education and Travel services reach between 0.70 and 0.95. By contrast, sectors with limited scope for digital delivery, such as Government and Recreational services, display coefficients close to zero and are statistically insignificant. These cross-industry differences confirm that the benefits of digital infrastructure are concentrated in sectors where service provision and consumption can occur remotely.

Mobile broadband coverage produces similar, though more nuanced, effects. Broader 2G-plus coverage raises overall trade flows, with exporter and importer elasticities of about 0.31 and 0.54, respectively. For higher-speed 3G-plus networks, elasticities average around 0.30 to 0.35 in the services sector and remain statistically significant for telecommunications, finance, and education. The effects for agriculture, manufacturing, and mining are weaker and generally smaller in magnitude, consistent with their limited reliance on data-intensive coordination. These findings indicate that both access and bandwidth are relevant: basic mobile networks expanded market participation, while higher-speed connections supported more complex and information-rich service exchanges across borders.

In sum, the evidence demonstrates that digital connectivity has become a central determinant of international services trade. Internet usage and mobile broadband coverage both substantially reduce service-specific trade costs, with the strongest effects arising in information-intensive, tradable service industries. The magnitudes observed imply that improvements in connectivity can deliver sizable trade gains, particularly in economies where digital infrastructure and regulatory quality evolve together. Policies that promote affordable internet access, expand high-speed mobile coverage, and ensure open and competitive service markets will be critical for realizing the full potential of digital globalization.

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Figures and Tables

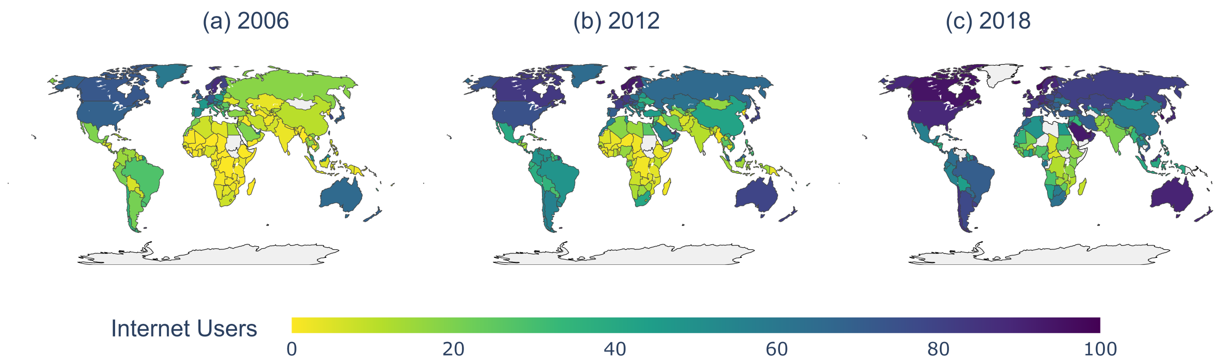

Figure 1: Internet User Percentage, 2006–2018

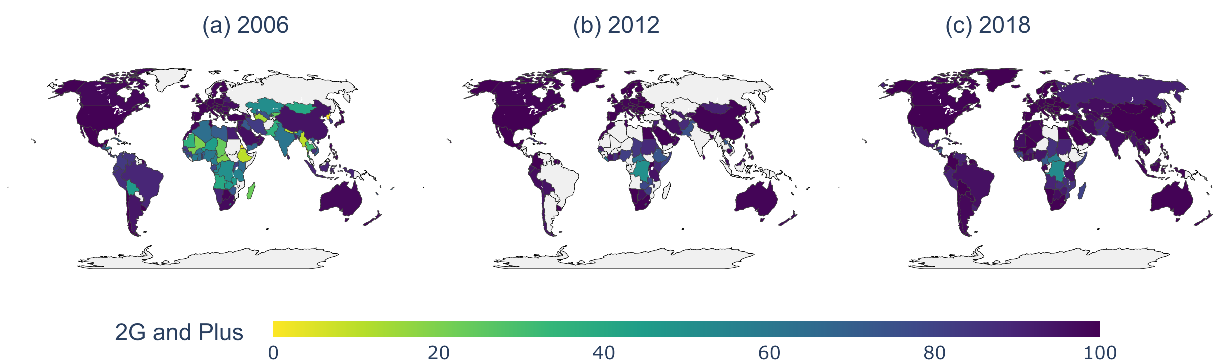

Figure 2: Mobile 2G+ Coverage Percentage, 2006–2018

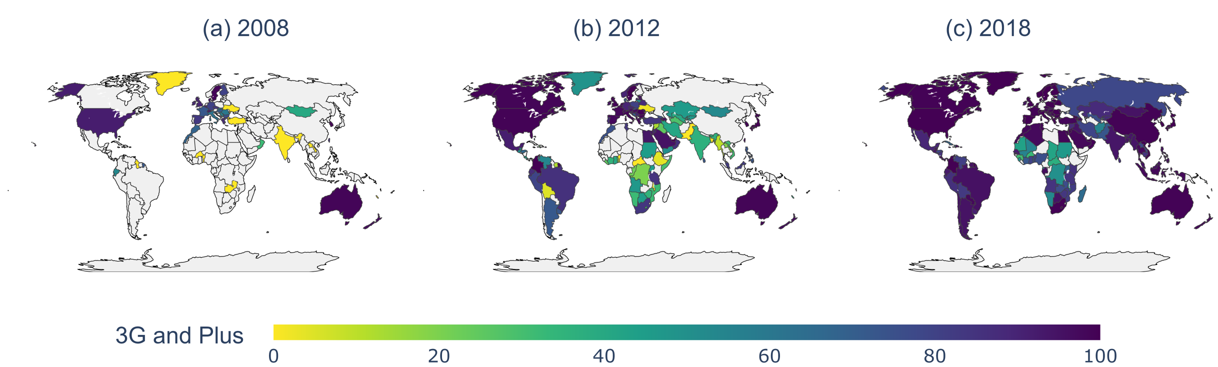

Figure 3: Mobile 3G+ Coverage Percentage, 2008–2018

Table 1: Effects of Internet Users

Panel A: First Stage	(1) Overall		(2) Agri	(3) Manuf	(4) Mining	(5) Services
FTA	0.443***		0.964***	0.569***	0.458***	0.329***
	(0.066)		(0.097)	(0.078)	(0.118)	(0.113)
ln(Distance)	−0.402***		−0.861***	−0.486***	−1.058***	−0.346***
	(0.043)		(0.074)	(0.054)	(0.089)	(0.052)
Contiguity	0.639***		0.548***	0.497***	0.419**	0.532***
	(0.087)		(0.161)	(0.097)	(0.206)	(0.118)
Common language	0.283***		0.198*	0.301***	0.454***	0.326***
	(0.056)		(0.109)	(0.069)	(0.131)	(0.091)
Colony ever	0.336***		0.022	0.209*	0.520**	0.666***
	(0.091)		(0.188)	(0.116)	(0.240)	(0.150)
Observations	1,497,078		444,685	633,334	332,095	86,651
R-squared	0.956		0.968	0.970	0.954	0.993
Panel B: Second Stage	**(1a) Overall**	**(1b) Overall**	**(2) Agri**	**(3) Manuf**	**(4) Mining**	**(5) Services**
Internet users$_o$	0.008**					
	(0.004)					
Internet users$_d$	0.013***					
	(0.004)					
ln(Internet users)$_o$		0.305***	0.111***	0.504***	0.104	0.713***
		(0.061)	(0.042)	(0.066)	(0.076)	(0.270)
ln(Internet users)$_d$		0.453***	0.320***	0.488***	0.718***	0.726***
		(0.052)	(0.053)	(0.068)	(0.059)	(0.266)
Observations	1,497,078	1,497,078	444,685	633,334	332,182	86,877
R-squared	0.671	0.673	0.787	0.875	0.807	0.677

Notes: Panel A presents the first-stage regressions. Panel B shows the second-stage results. Standard errors are clustered at the exporter–importer pair level and shown in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 2: Effects of 2G+ Mobile Internet Coverage, Second Stage

	(1a) Overall	(1b) Overall	(2) Agri	(3) Manuf	(4) Mining	(5) Services
2G+ coverage$_o$	0.006***					
	(0.002)					
2G+ coverage$_d$	0.010***					
	(0.003)					
ln(2G+ coverage)$_o$		0.314**	−0.089	0.522***	−0.032	3.777**
		(0.125)	(0.093)	(0.159)	(0.231)	(1.495)
ln(2G+ coverage)$_d$		0.535***	0.136	0.617***	1.117***	3.770**
		(0.150)	(0.147)	(0.163)	(0.312)	(1.487)
Observations	884,858	884,858	266,880	345,032	208,481	64,455
R-squared	0.681	0.680	0.804	0.873	0.811	0.686

Notes: Standard errors are clustered at the exporter–importer pair level and shown in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 3: Effects of 3G+ Mobile Internet Coverage, Second Stage

	(1a) Overall	(1b) Overall	(2) Agri	(3) Manuf	(4) Mining	(5) Services
3G+ coverage$_o$	−0.002					
	(0.002)					
3G+ coverage$_d$	−0.002					
	(0.002)					
ln(3G+ coverage)$_o$		0.008	−0.083	−0.049	0.016	0.318*
		(0.063)	(0.069)	(0.080)	(0.057)	(0.192)
ln(3G+ coverage)$_d$		0.023	−0.018	−0.081	0.179***	0.324*
		(0.062)	(0.052)	(0.078)	(0.064)	(0.193)
Observations	600,399	600,399	180,017	239,349	138,691	42,336
R-squared	0.661	0.661	0.800	0.859	0.809	0.696

Notes: Standard errors are clustered at the exporter–importer pair level and shown in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 4: Effects of Internet Users by Service Industry, Second Stage

Panel A	(1) 154	(2) 155	(3) 156	(4) 157	(5) 158
$\ln(\text{internet users})_o$	0.504	1.057***	0.738***	0.424***	1.016***
	(0.761)	(0.279)	(0.261)	(0.138)	(0.329)
$\ln(\text{internet users})_d$	0.971	0.164	0.760***	0.762***	1.016***
	(0.767)	(0.151)	(0.256)	(0.167)	(0.328)
Observations	19,432	29,422	75,331	54,258	47,106
R-squared	0.672	0.857	0.565	0.814	0.521

Panel B	(1) 159	(2) 160	(3) 161	(4) 162	(5) 163
$\ln(\text{internet users})_o$	0.814***	0.802***	0.420**	0.856***	0.729***
	(0.273)	(0.239)	(0.203)	(0.241)	(0.222)
$\ln(\text{internet users})_d$	0.809***	0.865***	0.414***	0.824***	0.666***
	(0.268)	(0.211)	(0.104)	(0.255)	(0.221)
Observations	54,244	56,911	51,032	68,077	70,523
R-squared	0.748	0.712	0.906	0.750	0.707

Panel C	(1) 164	(2) 165	(3) 166	(4) 167	(5) 168
$\ln(\text{internet users})_o$	0.170	0.617***	0.809***	−0.020	−0.142
	(0.110)	(0.231)	(0.231)	(0.149)	(0.127)
$\ln(\text{internet users})_d$	0.046	0.518**	0.959***	0.572**	0.029
	(0.175)	(0.240)	(0.174)	(0.243)	(0.131)
Observations	13,292	31,206	40,321	47,620	31,984
R-squared	0.798	0.755	0.873	0.840	0.846

Panel D	(1) 169	(2) 170	(3)	(4)	(5)
$\ln(\text{internet users})_o$	0.774***	0.016			
	(0.290)	(0.104)			
$\ln(\text{internet users})_d$	0.759***	0.113			
	(0.292)	(0.130)			
Observations	45,056	13,152			
R-squared	0.498	0.687			

Notes: Industry IDs refer to the following service categories: 154 is manufacturing services on physical inputs owned by others; 155 is maintenance and repair services not included elsewhere (n.i.e.); 156 is transport; 157 is travel; 158 is construction; 159 is insurance and pension services; 160 is financial services; 161 is charges for the use of intellectual property n.i.e.; 162 is telecommunications, computer, and information services; 163 is other business services; 164 is heritage and recreational services; 165 is health services; 166 is education services; 167 is government goods and services n.i.e.; 168 is services not allocated; 169 is trade-related services; and 170 is other personal services. Standard errors are clustered at the exporter–importer pair level and shown in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 5: Effects of 2G+ Coverage by Service Industry, Second Stage

	(1)	(2)	(3)	(4)	(5)
Panel A	154	155	156	157	158
$\ln(\text{2G+ coverage})_o$	−1.661	0.717	0.390	1.044*	5.797***
	(1.466)	(0.749)	(0.714)	(0.585)	(1.951)
$\ln(\text{2G+ coverage})_d$	1.860	0.336	1.353	2.390**	5.651***
	(1.690)	(0.607)	(1.598)	(1.061)	(1.928)
Observations	16,763	24,385	56,534	43,432	36,511
R-squared	0.690	0.864	0.571	0.817	0.519
	(1)	(2)	(3)	(4)	(5)
Panel B	159	160	161	162	163
$\ln(\text{2G+ coverage})_o$	5.048**	3.709**	−0.207	3.823***	3.969**
	(2.005)	(1.829)	(0.438)	(1.289)	(1.619)
$\ln(\text{2G+ coverage})_d$	3.494	2.753	0.492	3.553**	3.333**
	(2.170)	(1.841)	(0.311)	(1.555)	(1.533)
Observations	41,598	43,949	39,275	52,737	54,236
R-squared	0.752	0.711	0.905	0.750	0.711
	(1)	(2)	(3)	(4)	(5)
Panel C	164	165	166	167	168
$\ln(\text{2G+ coverage})_o$	−1.247	5.419***	5.778***	0.521	0.098
	(0.000)	(1.841)	(1.964)	(0.493)	(0.186)
$\ln(\text{2G+ coverage})_d$	−0.255	5.478***	2.335**	−0.124	0.190
	(0.000)	(1.789)	(1.182)	(0.207)	(0.144)
Observations	11,482	25,800	33,027	37,035	24,370
R-squared	0.791	0.768	0.882	0.843	0.863
	(1)	(2)	(3)	(4)	(5)
Panel D	169	170			
$\ln(\text{2G+ coverage})_o$	3.779***	0.674			
	(1.370)	(0.000)			
$\ln(\text{2G+ coverage})_d$	3.610**	0.958			
	(1.462)	(0.000)			
Observations	36,514	11,497			
R-squared	0.514	0.682			

Notes: Industry IDs refer to the following service categories: 154 is manufacturing services on physical inputs owned by others; 155 is maintenance and repair services not included elsewhere (n.i.e.); 156 is transport; 157 is travel; 158 is construction; 159 is insurance and pension services; 160 is financial services; 161 is charges for the use of intellectual property n.i.e.; 162 is telecommunications, computer, and information services; 163 is other business services; 164 is heritage and recreational services; 165 is health services; 166 is education services; 167 is government goods and services n.i.e.; 168 is services not allocated; 169 is trade-related services; and 170 is other personal services. Standard errors are clustered at the exporter–importer pair level and shown in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 6: Effects of 3G+ Coverage by Service Industry, Second Stage

	(1)	(2)	(3)	(4)	(5)
Panel A	154	155	156	157	158
$\ln(\text{3G+ coverage})_o$	0.049	0.255	0.312*	0.168	0.458**
	(0.212)	(0.166)	(0.178)	(0.130)	(0.198)
$\ln(\text{3G+ coverage})_d$	−0.143	0.129***	0.311*	0.262**	0.460**
	(0.223)	(0.047)	(0.174)	(0.117)	(0.199)
Observations	12,944	18,480	36,589	28,046	23,583
R-squared	0.722	0.873	0.577	0.836	0.533
	(1)	(2)	(3)	(4)	(5)
Panel B	159	160	161	162	163
$\ln(\text{3G+ coverage})_o$	0.364*	0.342*	0.205	0.356**	0.312**
	(0.207)	(0.199)	(0.152)	(0.158)	(0.153)
$\ln(\text{3G+ coverage})_d$	0.366*	0.342*	0.103***	0.395**	0.301*
	(0.206)	(0.189)	(0.035)	(0.188)	(0.170)
Observations	27,082	28,247	25,326	34,298	35,221
R-squared	0.766	0.726	0.909	0.779	0.729
	(1)	(2)	(3)	(4)	(5)
Panel C	164	165	166	167	168
$\ln(\text{3G+ coverage})_o$	−0.287	0.298	0.385**	0.158***	−0.642
	(0.326)	(0.182)	(0.189)	(0.059)	(0.610)
$\ln(\text{3G+ coverage})_d$	−0.332	0.300*	0.282***	0.039	0.081
	(0.357)	(0.180)	(0.086)	(0.075)	(0.208)
Observations	7,971	17,131	21,138	24,077	8,298
R-squared	0.800	0.804	0.892	0.854	0.795
	(1)	(2)	(3)	(4)	(5)
Panel D	169	170			
$\ln(\text{3G+ coverage})_o$	0.300	−0.065			
	(0.193)	(0.130)			
$\ln(\text{3G+ coverage})_d$	0.300	−0.033			
	(0.193)	(0.120)			
Observations	23,432	7,720			
R-squared	0.589	0.715			

Notes: Industry IDs refer to the following service categories: 154 is manufacturing services on physical inputs owned by others; 155 is maintenance and repair services not included elsewhere (n.i.e.); 156 is transport; 157 is travel; 158 is construction; 159 is insurance and pension services; 160 is financial services; 161 is charges for the use of intellectual property n.i.e.; 162 is telecommunications, computer, and information services; 163 is other business services; 164 is heritage and recreational services; 165 is health services; 166 is education services; 167 is government goods and services n.i.e.; 168 is services not allocated; 169 is trade-related services; and 170 is other personal services. Standard errors are clustered at the exporter–importer pair level and shown in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

A Appendix: Additional Figures and Tables

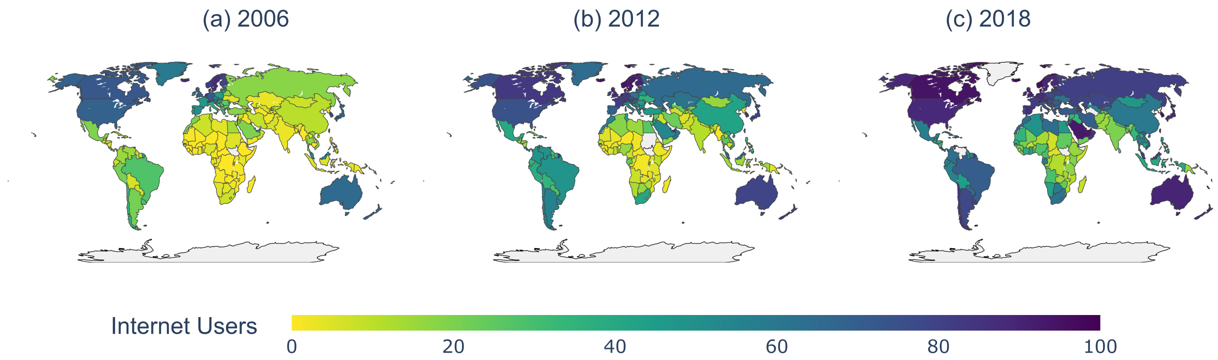

Figure A.1: Internet User Percentage (2-year Interpolation), 2006–2018

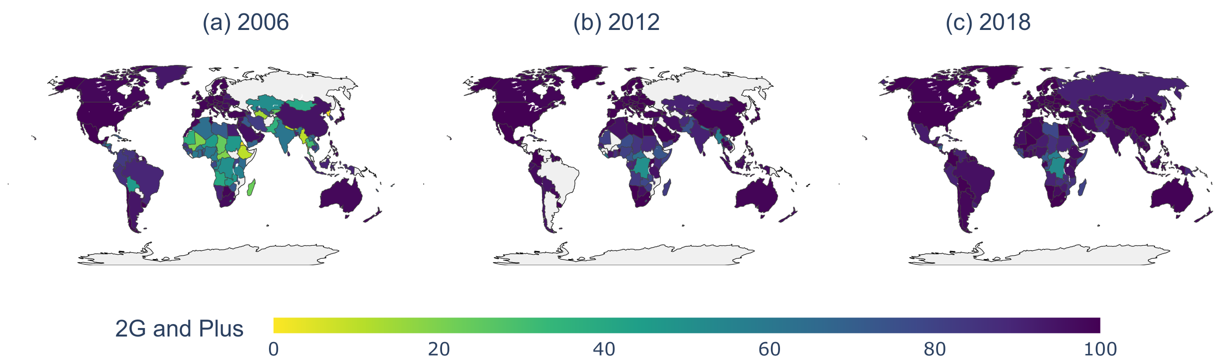

Figure A.2: Mobile 2G 2G+ Coverage Percentage (2-year Interpolation), 2006–2018

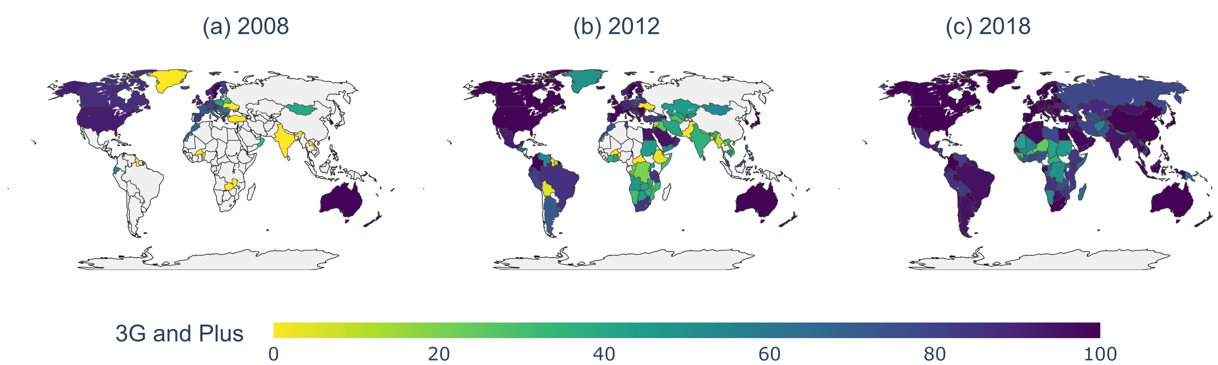

Figure A.3: Mobile 3G+ Coverage Percentage (2-year Interpolation), 2008–2018

Table A.1: Effects of 2G+ Mobile Internet Coverage, First Stage

	(1a) Overall	(1b) Overall	(2) Agri	(3) Manuf	(4) Mining	(5) Services
FTA	0.370***	0.370***	0.996***	0.481***	0.547***	0.262**
	(0.069)	(0.069)	(0.094)	(0.076)	(0.115)	(0.126)
ln(Distance)	−0.387***	−0.387***	−0.867***	−0.485***	−1.032***	−0.350***
	(0.044)	(0.044)	(0.079)	(0.055)	(0.093)	(0.055)
Contiguity	0.716***	0.716***	0.678***	0.560***	0.617***	0.594***
	(0.086)	(0.086)	(0.162)	(0.090)	(0.184)	(0.124)
Common language	0.250***	0.250***	0.190*	0.269***	0.460***	0.317***
	(0.057)	(0.057)	(0.105)	(0.068)	(0.129)	(0.094)
Colony ever	0.334***	0.334***	0.080	0.167	0.548**	0.692***
	(0.095)	(0.095)	(0.195)	(0.124)	(0.255)	(0.156)
Observations	938,063	938,063	280,731	372,826	218,398	65,112
R-squared	0.959	0.959	0.971	0.972	0.964	0.993

Notes: Standard errors are clustered at the exporter–importer pair level and shown in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table A.2: Effects of 3G+ Mobile Internet Coverage, First Stage

	(1a) Overall	(1b) Overall	(2) Agri	(3) Manuf	(4) Mining	(5) Services
FTA	0.427***	0.427***	0.874***	0.542***	0.538***	0.360***
	(0.064)	(0.064)	(0.095)	(0.076)	(0.100)	(0.100)
ln(Distance)	−0.343***	−0.343***	−0.866***	−0.455***	−1.009***	−0.335***
	(0.044)	(0.044)	(0.073)	(0.057)	(0.097)	(0.050)
Contiguity	0.757***	0.757***	0.559***	0.615***	0.542***	0.528***
	(0.088)	(0.088)	(0.148)	(0.094)	(0.183)	(0.117)
Common language	0.299***	0.299***	0.203**	0.247***	0.472***	0.441***
	(0.056)	(0.056)	(0.100)	(0.070)	(0.122)	(0.091)
Colony ever	0.338***	0.338***	0.069	0.272**	0.391	0.708***
	(0.097)	(0.097)	(0.198)	(0.116)	(0.250)	(0.157)
Observations	641,644	641,644	189,215	263,829	145,614	42,644
R-squared	0.957	0.957	0.968	0.963	0.956	0.994

Notes: Standard errors are clustered at the exporter–importer pair level and shown in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.