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Digital Trade and Development

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Abstract

In this paper, we investigate the role of digital trade, especially exports of ICT services, in supporting economic development. Using a country-level panel dataset covering 150 countries for the period 2005 to 2020, we find that specialization on ICT service exports has a developmental effect, with countries that graduate to middle- or high-income status accounting for a larger share of global ICT service exports. Our results suggest that a percentage point increase in the share of ICT service exports in GDP is associated with a 0.53 percentage point increases the share of non-ICT service exports in GDP. A similar increase in magnitude of ICT service exports would increase TFP growth by 0.079 percentage point and the number of adults who use digital financial services by 3.4 percentage point. However, our analysis documents a rising concentration of ICT service exports in fewer countries, outpacing the trends for ICT goods exports and non-ICT services and goods exports. We identify both international and domestic digital connectivity as key drivers of trade in ICT service exports, with domestic digital connectivity crucial in determining top ICT service exporters.

Keywords: Digital, Trade, Development

JEL Codes: L96, L14, O14

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1 Introduction

The digital economy and more specifically trade in services has in the recent past become the focal point of research interest (see Guillin (2013); Nayyar *et al.* (2021); Wu *et al.* (2023)). Advancement in the digital economy and the continued development of global value chains (GVCs) have increased opportunities for international specialization, not only in final goods and their parts but also in services and service tasks (Wu *et al.*, 2023). Nayyar *et al.* (2021) documents the growing role of the service sector on development and growth.

Technological progress, especially the diffusion of digital technologies has enabled the service sector to gain attributes such as scale, innovation and spillovers previously associated with the manufacturing sector and that are essential for economy-wide productivity improvement and large-scale job creation. The sector has not only contributed to creation of value chains in competing sectors but also to the development of its own distinct value chains.

Digitally delivered services, especially those traded internationally, have become the fastest growing sub-sector across many economies, including low- or middle-income-countries. And in particular, global trade in information and communication technologies services (ICT services) is growing faster than international trade in digitally delivered services.[1] There is an extensive body of literature that explores the drivers and benefits of international trade (see Amador & Cabral (2016); Sousa *et al.* (2019)), but the body of literature on drivers of trade in ICT services, their impact on global value chains and economic development is limited.

In this paper, we investigate the relationship between ICT service exports and economic development with a focus on three channels: (i) ***scale*** as ICT service exports can strengthen

[1]For instance, in 2020, ICT services saw an increase from 10% in 2019 to nearly 14%, a marked acceleration of the long-term trend and grew to 14.42% of total service exports in 2022 (see https://unctad.org/news/trade-data-2020-confirm-growing-importance-digital-technologies-during-covid-19 & https://tradingeconomics.com/world/ict-service-exports-percent-of-service-exports-bop-wb-data.html)

integration of local economies within global value chains, thereby boosting the growth of non-ICT service exports; (ii) ***innovation*** as they can enhance productivity growth through increased usage of ICT by businesses; and (iii) ***spillovers*** as they can accelerate the development of the broader digital economy through the mobility of talents and knowledge spillovers. We also examine the patterns of ICT service exports and its key drivers to derive policy implications for countries seeking to leverage international trade in ICT services as a path toward economic development.

We build a country-level panel dataset that covers 150 countries over 16 years, from 2005 to 2020. This dataset was built using data from various sources, including (i) the United Nations Conference on Trade and Development (UNCTAD) and the International Monetary Fund (IMF) databases on exports and imports of goods and services, including digitally deliverable services and ICT goods and services; (ii) the GSM Association (GSMA) and Telegeography's databases on international and domestic digital infrastructure and connectivity; as well as (iii) the World Bank's World Development Indicators database on socioeconomic development indicators like GDP per capita, gross secondary enrollment rate, and access to electricity. Our estimation strategy primarily derives from two-fixed effects models, including dynamic panel models, controlling for key confounders from the literature. This estimation strategy comes in addition to descriptive statistics.

Our analysis yields a number of findings. First, we find several evidence that support the hypothesis that ICT services exports support economic development. In fact, our descriptive analysis suggests that countries that graduate from low- to middle- or high-income groups during 2005-2020 are the ones that have increased their global market shares in ICT service exports. Furthermore, the econometric estimation suggests a positive impact of ICT services exports on non-ICT services exports, total factor productivity, and the development of the digital economy, proxied by the usage intensity of digital financial services.

Using a framework proposed by Nayyar *et al.* (2021) to explain the impact of trade in

services on economic development, we find that a percentage increase in the share of ICT service export in GDP is associated with 0.89 percentage point increase in non-ICT service exports in GDP. However, the magnitude drops to 0.67 and 0.53 after controlling for common regional shocks and skills respectively. On the other hand, a percentage point increase in ICT service exports is associated with 0.079 percentage point increase in TFP growth. Furthermore, we find that ICT service exports are associated with higher usage of ICT services. Lastly, a percentage point increase in ICT service exports in GDP is associated with 3.4 percentage point increase in the percentage of adults using digital financial services.

Our descriptive analysis documents a rising concentration of ICT service exports in a few countries, especially since 2015, outpacing the trends for ICT goods exports and non-ICT services and goods exports. Finally, our econometric analysis identifies both domestic and international digital connectivity as key drivers of ICT service exports, with domestic digital connectivity playing a crucial role in determining top ICT service exporters. These results fit into the broader literature on drivers of ICT enabled service exports. For instance, Sinha Roy *et al.* (2024a) find that mobile and broadband connectivity are key drivers trade in net ICT enabled services exports.

Our study contributes to the broader literature on the role of trade in supporting economic development by providing novel evidence of the potential of international trade in digital/ICT services to support development. It also contributes to the literature on the drivers of international trade by focusing specifically on the drivers of ICT services exports to identify new policy recommendations for countries seeking to leverage digital trade for development. Moreover, the study adds new evidence to the literature on the industrial organization of trade by highlighting the growing concentration of ICT services exports in a few countries, driven by the specific features of these services such as the strong role of skills and the global nature of the labor market for digital talents.

The remainder of the paper is organized as follows. Section 2 provides some back-

ground on global trends in digital trade, its definition and a benchmarking with international trade more broadly. Section 3 provides an overview of the related literature on trade and development, barriers to and drivers of trade, and recent work on the link between digitalization and international trade. Section 4 presents the conceptual framework, especially the channels through which digital trade can affect development, and specific attributes, especially skills, that drive the structure of ICT services exports. Section 5 presents the data with descriptive statistics. Section 6 presents the econometric models, the estimation strategies and reports the results. Section 7 concludes.

2 Background on digital trade

Digitalization is transforming international trade in goods and services (hereafter 'trade'). The role of trade in supporting development is well recognized (WBG, 2020). In the meantime, the rapid diffusion of information and communication technologies (ICT) comes with a growing trade in ICT products and an increasing volume of goods and services traded by leveraging ICT. According to the World Trade Organization statistics (WTO), global exports in ICT services[2] grew at an annual rate of 11.2 percent on average between 2005 and 2023, while exports in digitally delivered non-ICT services[3] grew an annual rate of 7.5 percent over the same period, compared to 4.6 percent for exports of services not digitally delivered over that period.[4] A similar trend can be observed for global goods exports.

The rapid increase in adoption and utilization of digital technologies has substantially reduced barriers to internationalization. These technologies have improved the productive efficiency of firms by enhancing communication between firms and consumers across the globe, reducing search costs and easy access to price information. They have also improved the management of supplies and reduced transportation costs (see Aker (2010); González

[2]Include computer services, telecommunications services and information services.

[3]Include charges for the use of intellectual property; financial services; insurance and pension services; personal, cultural and recreational services; as well as other business services.

[4]Sources: WTO, *https://stats.wto.org/* for service exports data, and *https://www.wto.org/english/res_e/statis_e/gstdh_digital_services_e.htm* for digitally delivered exports data

& Jouanjean (2017); Mothobi & Kebotsamang (2024)). In addition, they have revolutionized business activities by allowing faster and smoother value exchange and simplifying transactions through new exchange ecosystems (González & Ferencz, 2018).

Arguably, the most significant impact that digitalization has had on trade has been the rapid rise of services that are traded at a distance. In particular, digital platforms allowed services that traditionally require proximity between producers and consumers to be traded remotely. The use of digital platforms allows service providers to segment and relocate, in the form of microwork, to a series of online workers with the skills needed to deliver high-quality services (Morgan *et al.*, 2023). At the same time, the world has also seen a surge in cross-border trading of smartphone applications, online banking services, and gaming applications via digital platforms (Ahmed, 2019).

An increased access, deployment and advancement in digital infrastructure coupled with falling prices for voice and data communications as well as computerization of tasks have allowed service providers to segment and relocate work to take advantage of large, remote pools of lower cost labor with the language and technical skills needed to deliver quality services.[5] Advancement in ICT has not only allowed trade in ICT services to evolve from basic call centers, simple software coding, and generation of digital content to more complex business processes such as system design and R&D but has also led to the growth of trade in services.

Moreover, the digitalization of international trade has also affected the multilateral trading system by shifting international trade regime and negotiations from focusing on traditional border-related matters to a more holistic approach that encompasses issues such as investments, services, and property rights in global trade governance processes (Orefice & Rocha, 2014; Azmeh *et al.*, 2020).

The rise of digital trade has triggered a long-standing debate about its definition and

[5] A growing number of countries and industries are embracing these opportunities, both as importers and exporters.

measurement. The second edition of the Handbook on Digital Trade (Quill *et al.*, 2023) defines digital trade as all international trade that is digitally ordered and/or digitally delivered. Digitally ordered trade involves the international sale or purchase of a good or service, conducted over computer networks by methods specifically designed for the purpose of receiving or placing orders. Digitally delivered trade only covers services and is defined as all international trade transactions that are delivered remotely over computer networks. This definition goes beyond trade on e-commerce or digital platforms.

An alternative definition used by the UN Conference on Trade and Development (UNCTAD), focused on services and considered trade in digitally deliverable services. Such a definition is much broader than digitally delivered services and encompasses trade in services such as insurance and pension services; financial services; charges for the use of intellectual property; telecommunications, computer and information services; research and development services; professional and management consulting services; architectural, engineering, scientific and other technical services; trade-related services; other business services not included elsewhere; audio-visual and related services; health services and education services (excluding those consumed during international travel); as well as heritage and recreational services. That definition could be further broadened by considering all international trade enabled by digital technologies, including those that were not ordered or delivered through computers networks (González & Jouanjean, 2017).

Further, the expansion of the digital economy has enabled novel combinations of goods and services and their delivery forms (Kere & Zongo, 2023). For example, an item can cross a border as a service but becomes a good when it is consumed, as it happens with 3D printing service.

3 Related Literature

The literature on the drivers and development impact of digital trade remains nascent. Existing studies focused on domestic factors that could affect trade in ICT products, and the impact of digitization on trade. For instance, Sinha Roy *et al.* (2024b) investigated the determinants of ICT service exports by 45 top service exporters countries and found that mobile connectivity, foreign investment, world demand, growing manufacturing sector, and more favorable business environment are key drivers of net ICT service exports. Vogiatzoglou (2009) investigated the determinants of ICT goods exports specialization across 28 countries and found research and development expenditures as well as human capital as key determinants.

Likewise, several studies have examined the impact of digitalization on trade. Notable examples include Malgouyres *et al.* (2021) who found that the staggered roll-out of broadband internet in France resulted in an increased firm-level imports by around 25%, driven by a larger diversification of products and sourcing countries per firm, especially for capital goods. Using data from Sub-Saharan Africa, Kere & Zongo (2023) found that internet use, especially mobile payment services, has positive and significant effects on exports and negative effects on imports of primary products and total goods between African countries. Carballo *et al.* (2022) also found that access to online business platforms, in particular, results in increased firms' total exports, particularly of those that are small or had no digital presence, of differentiated products, and to less familiar destinations. Further, Cariolle & da Piedade (2023) found that digital connectedness, defined based on international connectivity through telecommunications submarine cables, is associated with increased export basket complexity.

Given the role of ICT in supporting trade in services, it is important to anchor research on digital trade to the broader literature on trade in services, especially its impact on development (Nayyar *et al.*, 2021). Historically, many services have been defined by the si-

multaneity of their production and consumption, which necessitates the concurrent presence of both producer and consumer, possibly in the same location (Hill, 1977; Breinlich & Criscuolo, 2011). Such a feature is now becoming obsolete with the diffusion of ICT, enabling the storage of services and their trade across locations as wide as the Internet permits. Services are also recognized as heterogeneous, encompassing a broad range of economic activities Hoekman & Mattoo (2008).

Evidence from the empirical literature suggests that countries performance in trade in service depends on human capital, the quality of the telecommunication network, and the quality of institutions Francois & Hoekman (2010). Using a gravity framework Lennon (2009); Lennon *et al.* (2009) show that human capital skills and electronic infrastructure are important determinants of trade in services. The literature also indicates that the quality of institutions, as measured by the degree of corruption, complexity of export procedures, and rigidity in employment law (Lennon, 2009), or the economic freedom index (Kimura & Lee, 2006; Fukunari & Hyun-Hoon, 2006) also positively influence trade in services.

Further, Walsh (2008) found that a common language is important for trade in services. (Copeland & Mattoo, 2008) found that countries that are well endowed with skilled labor are more likely to export certain skill-intensive professions and those that are endowed with capital are more likely to export capital-intensive services. Van der Marel (2012) found that services trade is particularly influenced by a country's availability of high-skilled and mid-skilled labor, as well as the robustness of regulatory governance structures.

Technological changes are clearly reducing the need for proximity between the producer and the consumer. These changes are also allowing the fragmentation of production into tasks that may be performed in different locations (Feenstra, 2010). Fragmentation, which affects the production of both goods and services, means that a vertically connected production process that takes place in one location can now be undertaken in different regions or countries (Jones, 2000).

4 Conceptual Framework

This research focuses on trade in services, given the rising importance of services in development. Further, because of the importance of the heterogeneous nature of services (Hoekman & Mattoo, 2008), this paper further focuses on ICT services, as opposed to digitally deliverables or delivered services. Trade in ICT goods is primarily used for comparison purposes.

Against that background, the paper seeks to investigate three related questions on digital trade: (i) Is there any empirical evidence that ICT services exports contribute to economic development? (ii) Are developing economies taking advantage of ICT service exports to catch up with developed economies? and (iii) Given that digitalization and trade are global trends, why do some countries grow their ICT services exports faster than others?

On the first question, the existing literature offers limited evidence on the impact of ICT services exports on economic development as it focuses on the impact of ICT diffusion on trade, recognizing the ambiguous relationship between trade and development due to potential adverse distributional effects (Rodrik, 2024). In this paper, we define economic development as growth in income per capita and considered two approaches to investigate the question. First, we consider a discrete approach which involves assessing the correlation between a country's graduation from a baseline income group and a gain in market share of global ICT service exports. A positive correlation would provide an initial indication of some association between ICT services exports and economic development. A negative or no correlation would mean no association between ICT services exports and economic development.

This is complemented by a more continuous approach whereby we assessed any causal impact of ICT service exports on drivers of income per capita through a regression analysis. In particular, we build on Nayyar *et al.* (2021) by investigating three channels through which ICT service exports could affect income per capita. First, we considered the ***scale channel*** whereby ICT service exports can strengthen the integration of domestic economies

into global value chains, thereby inducing a faster growth in non-ICT service exports. Second, we considered the ***innovation channel*** whereby some ICT services exported are also provided to domestic businesses, thereby accelerating their productivity growth. Finally, the ***spillover channel*** as ICT services exports require skill development which could spillover to local firms and enables the development of a broader domestic digital ecosystem through the mobility of talents.

To investigate the second question, whether developing economies are taking advantage of ICT service exports to catch up with developed economies, we examined the evolution of the concentration of ICT services exports across countries over 2005-2020, a period of fast diffusion of ICT. Such an evolution would be contrasted with the same trend for ICT goods and non-ICT products. A rising concentration of ICT services exports would mean a negative answer, especially based on the income profile of gainers, a declining concentration would mean a positive answer, whereas a flat concentration would be inconclusive.

On the third question, why some countries grow their ICT services exports faster than others, we considered a regression analysis to explain the share of ICT service exports in GDP as a function of a number factors drawn from the literature (connectivity, skills, income). Those factors also reflects trade theories, especially the role of comparative advantages and distance.

5 Data and descriptive statistics

We build a country-level panel dataset covering 150 countries over 16 years, from 2005 to 2020. The dataset primarily includes data on digital trade, digital connectivity, as well as socio-demographic data on income, education, population and access to electricity. Treatment of missing values is presented in Section A-1 in the Appendix. More details on variables and data sources are presented in Table A-1 in the Appendix.

As discussed in Section 4, we took a narrow definition of digital trade by focusing

on the international trade in ICT goods and services, measured by the values of ICT services/goods exports/imports. Data on ICT services/goods exports/imports was retrieved from the UNCTAD database. A definition of these variables is provided in Appendix A-3. This ICT trade data was complemented by total trade data from the World Development Indicators database of the World Bank. Total trade data includes the values of exports/imports of goods, merchandises or services.

Digital connectivity data were obtained from databases maintained by the GSMA Intelligence and Telegeography, two major references on telecommunications statistics. For the purposes of this research, we considered four measures of mobile connectivity, namely the number of mobile telephony subscriptions, the number of high-speed mobile Internet (broadband) subscriptions, and the number of unique subscribers to mobile telephony/broadband, all four taken in percentage of population. They allow us to test the robustness of our results to the measurement of mobile connectivity. We measured fixed broadband connectivity through the households penetration of high-speed fixed Internet subscriptions. Further, we also considered the capacity of international connectivity, measured by the used bandwidth of Internet traffic across countries.

We also used data on total factor productivity growth as a proxy for innovation in the wider economy. Data on TFP growth come from the dataset maintained by the World Bank.[6] We also used data on the ICT usage, especially the percentage of adults making or receiving digital payments. That data comes from the Findex database and only available for two years (2014 and 2017) over the period of our analysis.

Finally, we extracted key socio-demographic variables such as Gross Domestic Product (GDP), population, gross enrollment in secondary education, and the percentage of population with access to electricity. We also retrieved the historical country income group classification of the World Bank.

[6] See $https://prosperitydata360.worldbank.org/en/dataset/WB+ASPD$

Table A-2 in the Appendix presents the summary statistics of the key variables.

A few descriptive statistics are provided in Table 1. Overall, growth in total and ICT trade is moderating. However, ICT trade is growing faster than total trade, consistent with the global trends reported in Section 2. Further, ICT services trade is growing faster than trade in ICT goods, recognizing that ICT service trade was 10-times smaller than trade in ICT goods in 2005, our baseline year, compared to a ratio of 4 to 1 for total trade.

Table 1: Trends in global digital trade

			CAGR		
year	**Obs.**	**2005 (billion USD)**	**2005-2010**	**2010-2015**	**2015-2020**
service_exports_bop_usd	150	2481.92	8.11%	5.62%	0.71%
service_imports_bop_usd	150	2363.47	7.61%	5.90%	0.54%
ict_service_exports	132	143.47	13.16%	9.99%	9.79%
ict_service_imports	132	96.98	10.75%	11.50%	6.63%
goods_exports_bop_usd	150	9068.67	7.71%	2.85%	1.39%
goods_imports_bop_usd	150	9258.30	7.47%	2.52%	1.36%
ict_goods_exports	143	1121.44	6.16%	3.34%	3.75%
ict_goods_imports	145	1192.65	6.79%	3.40%	3.84%

6 Empirical analysis

We employ specific empirical strategy to investigate our three research questions.

6.1 Development impact of ICT service exports

■ **Discrete approach.** To assess the development impact of ICT service exports through the discrete approach, we calculate the ICT service exports market share by countries' income groups as represented below.

$$\phi_{kt} = \frac{\sum_i y_{ikt}}{Y_t} \tag{1}$$

y_{ikt} denotes ICT services exports of country i in the income group k at the year t. Y_t is the global value of ICT service exports in year t. Therefore, ϕ_{kt} represents the ICT service exports market share of countries in income group k at year t.

More specifically, we fix k as the group of countries within the same income group at the baseline year 2005. Retaining the market share for baseline income groups allows to assess how countries at different levels of economic development in 2005 performed over the subsequent 15 years in terms of ICT services exports. However, we recognize that countries may graduate, i.e., they may move to a higher income group. Let's $\bar{k}$ denotes group k, but without countries that graduated at some point during the period of our analysis, i.e., 2005-2020.

We are interested in the following double difference in market shares between k and $\bar{k}$:

$$\Delta\phi = \Delta\phi_k - \Delta\phi_{\bar{k}} = (\phi_{kt} - \phi_{kt-1}) - (\phi_{\bar{k}t} - \phi_{\bar{k}t-1}) \tag{2}$$

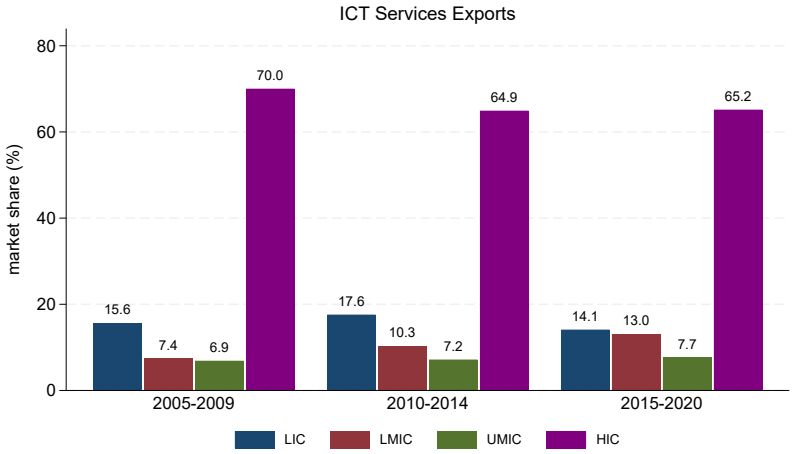
A positive double difference would mean that income group graduation, a proxy for economic development, is associated with ICT service exports. A negligible double difference would mean no association between ICT service exports and economic development, while a negative difference would yield an inconclusive outcome.

Figures 1 and 2 report the outcomes of this analysis, respectively ϕ_{kt} and $\phi_{\bar{k}t}$ by sub-periods of 5 years. First, Figure 1 shows that developing countries, i.e., low or middle-income countries, based on the 2005 classification, have consistently increased their ICT service exports market shares over 2005-2020, to the detriment of high-income countries. This is supported by a closer look at countries that gained or lost the most market share over that period. As reported in Table A-3 in the Appendix, with the exception of Ireland

who was a high-income country in 2005, all other top 10 countries that gained market share over 2005-2020 are developing countries. Consistently, the biggest losers of market shares in ICT service exports over that period are high-income countries.

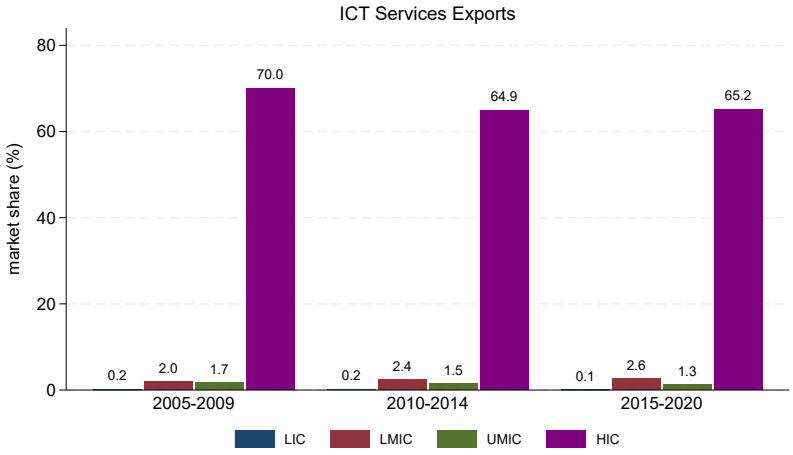
Compared to the estimates on Figures 2, it turns out that the gain in market share is primarily driven by developing countries who graduated. For instance, between the sub-periods 2005-2009 and 2010-2014, low income countries from 2005 gained 2 percentage points of market share, but such a gain disappeared in absence of those low income countries who graduated between these sub-periods ($\Delta\phi_k - \Delta\phi_{\bar{k}} = 2\%$). The comparison is not conclusive between 2010-2014 and 2015-2020. For lower-middle income countries, they gained 3 percentage points market share between 2005-2009 and 2010-2014, and the same performance between 2010-2014 and 2015-2020. These gains compared to respectively 0.4 and 0.2 percentage point gain over the same periods without those countries who graduated. The same applies to upper-middle income countries: they gained 0.3 and 0.5 percentage points versus a market share loss of 0.2 and 0.2 respectively, i.e., $\Delta\phi$ of 0.5 and 0.7 percentage point respectively.

Figure 1: Global Share of ICT Service Exports by Income Groups



Source: Authors calculations based on data on ICT shares in exports from UNCTAD and exports data from the World Bank and IMF. Based on countries with ICT exports data over the entire period (2005-2020), i.e., 137 countries for both ICT goods and services exports. Income groups at the baseline year 2005.

Figure 2: Global Share of ICT Service Exports by Income Groups



Source: Authors calculations based on data on ICT shares in exports from UNCTAD and exports data from the World Bank and IMF. Based on countries with ICT exports data over the entire period (2005-2020) and constant income status over the entire period. That is countries that graduated from a certain income status to a higher income status were excluded. of the 137 countries considered in the study, only 62 countries remained in the same income status over the entire period. Income groups at the baseline year 2005

■ **Continuous approach.** The discrete approach provides an initial evidence of a potential impact of ICT service exports on development, but remains insufficient to claim a causal impact of digital trade on development. The discrete approach is fairly stringent as it requires a country to graduate to qualify impact, whereas graduation takes time. For instance, a country may progress within its income group as a result of digital trade, and such a progress would not be captured under the discrete approach. Further, income group graduation depends on several growth determinants that could enable digital trade. Examples include technology, human capital, and physical capital that are all important for digital trade.

As a result, we consider a continuous approach which looks at the impact of digital trade on economic development in a more systematic manner. Instead of taking economic development as an aggregate concept through measures like the GDP per capita, we resort to a more granular measure of development, focusing on specific channels through which trade in ICT services can affect economic development. Such a granular approach also provide a better framework for assessing causal impact as GDP is driven by so many unobservable factors like technological progress that may also affect digital trade.

We borrow from the three channels determined by the framework proposed by Nayyar *et al.* (2021) to explain the impact of trade in services on economic development. We develop the econometric models below to test the validity of each channel.

For the **scale channel**, we consider the following model:

$$Y_{it}^{-} = \alpha + \beta y_{it} + \gamma X_{it} + \mu_i + \mu_t + \epsilon_{it} \tag{3}$$

In equation 3, y_{it} denotes ICT service exports of country i in year t; and Y_{it}^{-} represents exports of non-ICT services from the same country and the same year. Both variables have been normalized by GDP. X_{it} is a vector of controls, and μ_i and μ_t are country and year fixed effects; ϵ_{it} denotes the residuals. Under this model, we expect ICT service exports to

strengthen trade linkages, especially for non-ICT services and, as such, the coefficient β to be positive. The country fixed effects are expected to capture all time-invariant determinants of service exports, including countries' comparative advantages and tariffs. The year fixed effects is expected to capture global common trends in ICT service exports. In the estimation, we also considered region-specific shocks which may jointly drive ICT and non-ICT service exports. Further, we tested the role of skills by introducing secondary enrollment rate as a control variable.

The fixed effects estimates are reported in the first three columns of Table 2. The point estimate of β is positive across all three specifications, but with a falling magnitude, resulting in some loss of statistical significance. Specification (1) only includes country and year fixed effects in addition to the share of ICT service exports in GDP as the explanatory variables, and we find that a percentage point increase in the share of ICT service export in GDP is associated with 0.89 percentage point increase in the share of non-ICT service exports in GDP. However, the magnitude of that association drops to 0.67 after controlling for common regional shocks, and further down to 0.53 after controlling for skills, though the coefficient of that latter is not significant, with a large drop in the number of observations due to missing values.

For the **innovation channel**, we considered the following model:

$$\rho_{it} = \alpha + \delta\rho_{it-1} + \beta lny_{it} + \gamma X_{it} + \nu_i + \nu_t + \varepsilon_{it} \tag{4}$$

Where ρ_{it} denotes the growth rate of total factor productivity in country i at year t; lny_{it} represents the natural logarithm of the value of ICT service exports; X_{it} is a vector of controls, and ν_i and ν_t are country and year fixed effects; ε_{it} denotes the residuals. We used a dynamic panel model to reflect the dynamic nature of growth rate, particularly that of total factor productivity, which may leads to an overestimation of coefficient β. Indeed, ICT services exports may grow faster in countries experiencing faster productivity growth. Further,

we also controlled for the logarithm of GDP as we only used the logarithm of ICT service exports to ensure normalization across countries with different size of their economies.

The outcomes of the fixed effects estimation are reported in columns (4) and (4-) of Table 2. At the global scale, the coefficient β is positive but not statistically significant. The coefficient of the lagged variable of TFP growth is positive and less than 1 as expected. Similarly, the coefficient of GDP is negative and statistically significant reflecting some growth convergence or a diminishing returns to scale. We also test whether the lack of significance is driven by countries at nascent stage of ICT services exports by removing specific regions from the sample. It turned out that the sample without Africa came with a significant β at the 10% level. As such, a 1 percent increase in ICT service exports is associated with a 0.079 percentage point acceleration of TFP growth. This estimate recognizes the 'Nickel bias' which would result in an underestimation of β (Nickell, 1981). This means the estimated effect of ICT service exports is fairly conservative, but yet positive and significant.

Finally, we explore the **spillover channel** using the following equation:

$$z_{it} = \alpha + \beta y_{it} + \gamma X_{it} + \nu_i + \nu_t + \varepsilon_{it} \tag{5}$$

z_{it} denotes ICT usage in country i at year t. We used two measures of ICT usage: the percentage of adults making or receiving digital payment, as well as the percentage of adults receiving digital payment. The former is restricted to individuals above 25 as making digital payment often requires an ID which is available at legal majority age, while digital payment can be received by individuals above 15 years old. These indicators are used as a proxy for the development of the digital economy, as digital payment is one of the most popular use cases of digital connectivity, especially in developing countries.[7] y_{it} is the share of ICT service exports in GDP, X_{it} is a vector of controls, and ν_i and ν_t are country and year fixed effects respectively; ε_{it} denotes the residuals.

[7] GSMA Global Consumer Surveys.

The outcomes of the fixed effects estimation are reported in columns (6) and (7) of Table 2. The estimate of coefficient β is positive and significant in both specifications, meaning that ICT services exports are associated with higher usage of ICT services. In particular, a percentage point increase in ICT service exports in GDP is associated with 3.4 percentage point increases in the percentage of adults making or receiving digital payments, and a 2.6 percentage point increases in the percentage of adults receiving digital payments. Both the coefficients of GDP per capita and the penetration of mobile internet are negative, reflecting the fact that digital payments are more prevalent in developing countries than in developed economies over the period of our analysis.

Table 2: Development impact of ICT services exports

	non_ictSX_GDP			tfp_growth		digitpay-rm	digitpay-r
	(1)	(2)	(3)	(4)	(4-)	(6)	(7)
share_ictServGDP	0.897***	0.671**	0.535*			3.432**	2.618*
	(0.267)	(0.270)	(0.284)			(1.552)	(1.501)
ln_ict_serX				0.015	0.079*		
				(0.024)	(0.046)		
L.tfp_growth				0.761***	0.778***		
				(0.032)	(0.036)		
ln_gdp				-0.253***	-0.330***		
				(0.091)	(0.091)		
enroll_secondary			0.011			0.020	0.047
			(0.044)			(0.235)	(0.220)
gdp_pc_const						-0.000***	-0.000***
						(0.000)	(0.000)
MobInternetPen						-0.541***	-0.540***
						(0.195)	(0.183)
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region x Year FE		Yes	Yes				
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.112***	0.114***	0.113***	6.544***	7.305***	0.692***	0.693***
	(0.002)	(0.002)	(0.036)	(2.371)	(2.666)	(0.208)	(0.196)
Observations	2,392	2,392	1,774	1,117	921	202	202
R-squared	0.952	0.955	0.962	0.692	0.726	0.359	0.351
Number of country_id				81	67	113	113

*Note: (4-) Excluding Sub-Saharan Africa. Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1*

6.2 Inclusivity of digital trade

To assess the inclusivity of digital trade, we resorted to a descriptive evidence using the Herfindahl-Hirshman Index to assess the degree of concentration of trade.

$$HHI_{jt} = (\sum_{i} \phi_{ijt}^2) * 10,000 \tag{6}$$

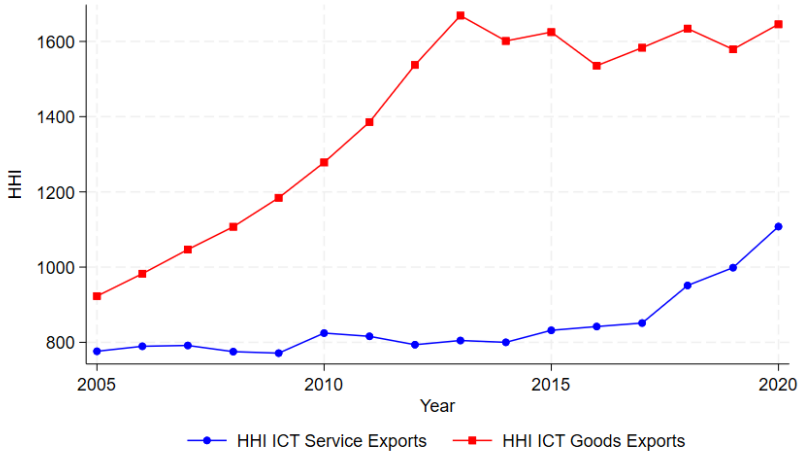
Where ϕ_{ijt} is the market share of country i in trade j at year t. j could be ICT services/goods exports or non-ICT services/goods exports.

The outcomes of the calculations are reported on Figures 3 and 4. The HHI of ICT services exports is slightly higher but comparable to that of non-ICT services exports, at around 800, until 2015, potentially reflecting some degree of specialization of countries in international trade. However, since 2015, we observed a significant and consistent increases in the HHI of ICT service exports while that of non-ICT services remains broadly flat. Over 2015-2020, the HHI of ICT service exports rose by 300 points, a fairly significant change when compared to historical variations. Over the same period, the HHI of ICT goods exports was broadly flat and consistent with that of non-ICT goods exports.[8]

It is interesting to complement these results with the list of top winners and bottom losers in Tables A-3 and A-4 in the Appendix. Overall, top winners in digital trade over 2005-2020 are low or middle income countries like China, Ukraine, Romania, Belarus and Brazil for ICT services exports, and China, Vietnam, India, Panama and Romania for ICT goods, to the detriment of developed economies like the UK, Italy, Germany, Sweden and Canada, for ICT services exports, and Japan, the US, UK, Germany and France for ICT goods exports. However, it turnout out that these gains are not equally distributed across low or middle income countries. Rather, they are becoming increasingly concentrated in fewer emerging economies.

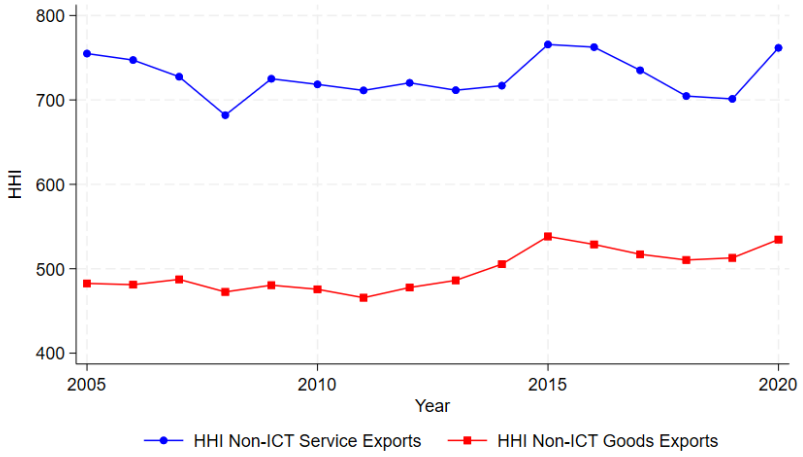
[8]This recognizes that The HHI of ICT goods exports also experienced a dramatic surge between 2005 and 2012.

Figure 3: Global HHI of ICT Exports



Source: Authors calculations based on data on ICT shares in exports from UNCTAD and exports data from the World Bank and IMF. Based on countries with ICT exports data over the entire period (2005-2020), i.e., 137 countries for both ICT goods and services exports.

Figure 4: Global HHI of Non-ICT Exports



Source: Authors calculations based on data on ICT shares in exports from UNCTAD and exports data from the World Bank and IMF. Based on countries with ICT exports data over the entire period (2005-2020), i.e., 137 countries for both ICT goods and services exports.

6.3 Determinants of ICT services exports

To investigate the determinants of ICT services exports, we rely on the following equation:

$$y_{it} = \alpha + \beta X_{it} + \nu_i + \nu_t + \varepsilon_{it} \tag{7}$$

Where y_{it} denotes the share of ICT services exports in GDP in country i at year t. X_{it} is vector of potential determinants retrieved from the literature. These include connectivity variables such as international connectivity bandwidth per user, fixed or mobile broadband Internet penetration, and the secondary school enrollment.

Table 3 reports the outcomes of the fixed effects estimators of the coefficients in equation 7. Specifications (1) to (3) test different variables for digital connectivity. In particular, specification (1) investigate the role of international digital connectivity and found a positive and significant impact on ICT service exports. The magnitude of that impact drops when we introduced mobile internet penetration in specification (2), suggesting an equally important role for domestic digital connectivity. In specification (3), we replaced the mobile internet penetration by fixed broadband penetration, a technology that can carry greater traffic than mobile broadband and often used by businesses. While the sample size is well preserved, the coefficient of fixed broadband penetration is positive but only significant at the 10% level, with limited change in the coefficient of international digital connectivity. Our results are consistent with the broader literature on trade in services. Nayyar & Davies (2023), concludes that the diffusion of digital technologies have a potential to raise the growth potential of the service sector. Similarly, Benz *et al.* (2022) find the adoption of ICTs as a key driver of trade in services.

As a result, we retained (2) as our preferred specification. Next, we sought to account for the heterogeneous trends in digital trade across countries as observed from the previous section. We introduced two new trend variables: one for countries that gained market share

over 2005-2020, and another for those that lost market share, as reported in Table A-3. This represents our specification (4) in Table 3. As expected, the new variables captured well the trends in digital trade of their corresponding group of countries. However, the coefficient of mobile broadband is no longer significant as a result of a large drop in its magnitude. The coefficient of international digital connectivity also drops but to a lesser extend. This suggests that while international digital connectivity is crucial for digital trade, domestic connectivity plays a decisive role in determining winners among developing countries.

All four specifications include secondary education enrollment as a proxy for skills. While the coefficient is positive, it is not statistically significant.

Table 3: Drivers of ICT Service Exports

	share_ictServGDP			
	(1)	(2)	(3)	(4)
bandwith_puser	5.245**	3.121*	5.337**	4.087**
	(2.601)	(1.813)	(2.568)	(1.906)
MobInternetPen		0.020**		0.003
		(0.009)		(0.008)
FixedBbPen			0.014*	
			(0.008)	
c.topcountry#c.year				0.004**
				(0.002)
c.botcountry#c.year				-0.000
				(0.000)
enroll_secondary	0.008	0.012	0.012	0.017
	(0.016)	(0.019)	(0.017)	(0.017)
Year FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Constant	0.001	-0.006	-0.003	-0.838**
	(0.013)	(0.018)	(0.015)	(0.355)
Observations	1,669	1,185	1,657	1,185
R-squared	0.085	0.097	0.099	0.333
Number of country_id	142	136	142	136

*Note: Robust standard errors in parentheses, clustered at the country level. *** p<0.01, ** p<0.05, * p<0.1*

7 Conclusion

The empirical analysis in this paper provides some conclusive evidence to our research questions. First, we found a number of supporting evidence to the hypothesis that digital trade, especially ICT services exports, supports economic development through stronger trade linkages, beyond the digital sector, faster productivity growth, and faster development of the digital economy. We also found that while developing countries are taking advantage of digital trade, participation remains limited to a few countries which increasing concentration over the past few years. Finally, our analysis also identified both domestic and international digital connectivity as key drivers of digital trade, with a decisive role of domestic digital connectivity in determining the top winners. Our analysis does not find a clear role of the availability of skills within a country for participation in digital trade for that country.

Our results means that while digital trade offers a pathway to economic development, such a pathway might not be available for all developing countries. Digital connectivity remains a crucial drivers of a country participation in digital trade. As such, investing in international digital connectivity capacity such as submarine cables and satellites should remain a priority, as well as ensuring access to quality digital connectivity.

The impact of digital trade on economic development is fairly consistent with the literature on trade. However, the distributional welfare effects of digital trade within countries remain unclear, but crucial for understanding its long term impact on development. Future research could investigate those effects. Further, in this research we focused on investigating correlations while controlling for potential sources of omitted variables biases. However, reverse causality may remain an issue, given that economic development can support digital trade, and digital trade can also support digital connectivity. Future research could further test the causal interpretation of our results through appropriate estimation strategies.

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Appendix

A-1 Missing data analysis

We started with a panel dataset of 215 countries, covering the period 2000 to 2023, focused on our variables of interest (ICT services/goods exports/imports) sourced from the UNCTAD database. However, due to a lack of information on the variables of interest before 2005 and after 2020, we restricted the dataset to the period 2005-2020. A total of 33 countries were excluded from the sample due to missing data across all the four variables of interest over the entire period of the study.[9] This reduced our data points from 5,375 to 2, 592, consisting of 162 countries for the period 2005 to 2020. The majority of excluded countries are islands.

Among the 162 countries in the sample, 19 countries (Andora, Anguilla, Antigua and Barbuda, Aruba, Brunei Darussalam, Cuba, Dominica, Greenland, Grenada, Jordan, Palau, Qatar, Saudi Arabia, South Africa, St. Kitss and Nevis, St. Lucia, St. Vincent and the Grenadines, Switzerland and Taiwan) do not have data for ICT service exports and imports over the entire period of the study; while 4 countries (Chad, Equatorial Guinea, Haiti and South Sudan) had missing data for ICT goods exports and imports over the entire period. The Bahamas and Turks and Caicos Islands have data for ICT service exports only while Guinea-Bissau and Iraq have data for ICT goods exports only.

Table A-0 shows the number of missing points after excluding countries that have missing points over the entire period. The missing information were filled using the neighborhood approach. The following 13 countries countries have complete data set after replacing missing values with immediate values: Austria, Azerbaijan, Belgium, China, Comoros, Cyprus, Honduras, Kenya, Korea, Kuwait, Nicaragua, Nigeria, Sri Lanka.

[9] American Samoa, British Virgin Islands, Eritrea, Gibraltar, Guam, Isle Of Man, Kosovo, Liberia, Liechtenstein, Marshall Islands, Monaco, Nauru, Northern, Mariana Islands, Puerto Rico, Saint Barthélemy, San Marino, Somalia, ST. Martin (French Part), Turkmenistan, Virgin, Islands (U.S.)

Table A-0: Number of countries with missing data on ICT trade

Year	serv. exp.	serv. imp.	good exp.	good. imp.
2005	47	54	35	32
2006	42	48	33	29
2007	36	42	30	24
2008	35	43	32	25
2009	34	41	31	28
2010	30	34	31	24
2011	21	25	32	26
2012	17	21	30	25
2013	17	19	30	25
2014	10	12	27	23
2015	11	12	24	23
2016	16	16	29	28
2017	12	11	24	23
2018	12	13	28	28
2019	13	14	36	35
2020	9	12	36	38

Note: Summary statistics of missing information after excluding countries with missing variables across all variables for the entire period.

A-2 Data and summary statistics

Table A-1: Variables and sources

Variable Name	Type	Unit	Label	Source
year	float	Year	Calendar year in which the data was collected or reported	World Bank WDI
country	string	-	Name of the country	World Bank WDI
iso_code	string	-	ISO 3166-1 alpha-3 code representing the country	World Bank WDI
Region	string	-	Region where the country is located	World Bank WDI
Incomegroup	string	-	Income group classification	World Bank WDI
MobileBroadbandConnections	double	Percentage	Number of mobile broadband connections	GSMA intelligence
TotalMobileConnection	double	Percentage	Total number of mobile connections	GSMA intelligence
UniqueMobileInternetSubs	double	Percentage	Number of unique mobile internet subscribers	GSMA intelligence
UniqueMobileSubs	double	Percentage	Number of unique mobile subscribers	GSMA intelligence
FbbPenetration	string	Percentage	Fixed broadband penetration rate	Telegeography
bandwith	double	Mbps	Total bandwidth available in the country	Telegeography
dig_tra_serv_import	double	Percentage	digitally delivrable service imports as % of total service	UNCTAD
dig_tra_serv_export	double	Percentage	digitally delivrable service exports as % of total service	UNCTAD
ShareIctImport	double	Percentage	Share of ICT services in total services imports	UNCTAD
ShareIctExport	double	Percentage	Share of ICT services in total services exports	UNCTAD
ShareIctGoodExp	double	Percentage	Share of ICT goods in total goods exports	UNCTAD
ShareIctGoodImp	double	Percentage	Share of ICT goods in total goods imports	UNCTAD
imports_bop	double	USD	Imports of goods and services (BoP, current US$)	World Bank WDI
exports_bop_usd	double	USD	Exports of goods and services (BoP, current US$)	World Bank WDI
goods_exports_d	double	USD	Goods exports (BoP, current US$)	World Bank WDI
merchandise_exports_d	double	USD	Merchandise exports (current US$)	World Bank WDI
service_exports_d	double	USD	Service exports (BoP, current US$)	World Bank WDI
goods_imports_d	double	USD	Goods imports (BoP, current US$)	World Bank WDI
service_import_d	double	USD	Service imports (BoP, current US$)	World Bank WDI
elec_access	double	Percentage	Access to electricity (% of population)	World Bank WDI
gdp_const	double	USD	GDP (constant 2015 US$)	World Bank WDI
pop_total	double	Number	Population, total	World Bank WDI
enroll_secondary	double	Percentage	School enrollment, secondary (% gross)	World Bank WDI
tfp_growth	double	Percentage	Annual growth in total factor productivity	World Bank
digitpay-rm	double	Percentage	Percentage of adults that made or received digital payments	Findex, World Bank
digitpay-r	double	Percentage	Percentage of adults that received digital payments	Findex, World Bank

A-3 Definition of ICT trade variables

The ICT sector combines manufacturing and services industries whose products primarily fulfill or enable the function of information processing and communication by electronic means, including transmission and display.[10]

ICT service exports: refer to the international sale and delivery of information and communication technology services, which encompass computer services, telecommunications (including postal and courier services), and information services such as computer data processing and news-related transactions. These services are a subset of the broader category of service exports, measured within a country's Balance of Payments (BoP) framework, a double-entry accounting system that tracks economic transactions between residents and non-residents. The data on ICT service exports are aggregated using a weighted average method. The data collection and reporting methodologies for these exports are aligned with the International Monetary Fund's Balance of Payments Manual (BPM6).[11]

ICT service imports: refer to the acquisition of services related to information and communication technologies from foreign suppliers. These services include:

- Telecommunications Services: Encompassing services like telephony, internet access, and data transmission. These services are essential for the basic functioning of communication networks.

- Computer Services: Covering a wide range of services, including software development, IT consulting, data processing, hosting services, and other computer-related services.

- Licensing Services for Software: Includes the right to use or reproduce software. This

[10] https://www.oecd-ilibrary.org/science-and-technology/ict-goods-exports/indicator/english_b4d99334-en

[11] *Source: World Bank*: https://databank.worldbank.org/metadataglossary/world-development-indicators/series/BX.GSR.CCIS.ZS

is often categorized under intellectual property-related transactions but is critical for accessing software functionalities.

The aggregation method for this indicator is a weighted average, ensuring accurate representation across different economies.

ICT Goods Exports: refer to the international sale of information and communication technology products, including computers and peripheral equipment, communication equipment, consumer electronics, electronic components, and other related goods.[12] The data are aggregated using a weighted average method to reflect the relative importance of different transactions. ICT goods are classified according to the OECD's Guide on Measuring the Information Society 2011, adapted to the Harmonized System 2012 by UNCTAD. This classification includes 93 goods defined at the six-digit level. The methodology and data collection are consistent with international standards as outlined by UNCTAD and are primarily sourced from the UN COMTRADE database.[13]

ICT goods imports: refer to the international purchase of information and communication technology products, including computers and peripheral equipment, communication equipment, consumer electronics, electronic components, and other related goods. The data are aggregated using a weighted average method to reflect the relative importance of different transactions. ICT goods are classified according to the OECD's Guide on Measuring the Information Society 2011, adapted to the Harmonized System 2012 by UNCTAD. This classification includes 93 goods defined at the six-digit level. The methodology and data collection are aligned with international standards as outlined by UNCTAD, with data primarily sourced from the UN COMTRADE database.

[12] https://unctadstat.unctad.org/EN/Classifications/DimHS2017Products_Ict_Hierarchy.pdf

[13] *Source: World Bank*: https://databank.worldbank.org/metadataglossary/world-development-indicators/series/TX.VAL.ICTG.ZS.UN

Table A-2: Summary statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
year	2,592	-	-	2005	2020
MobileBroadbandConnections	2,144	45.43	44.10	0	321.82
TotalMobileConnection	2,580	94.06	45.31	0.28	321.82
UniqueMobileInternetSubs	1,767	34.13	21.68	0.00	92.71
UniqueMobileSubs	2,580	49.05	22.41	0.28	95.11
FbbPenetration	2,493	30.81	31.51	0.00	121.1
bandwith	1,896	2631.138	9485.674	0.0091678	137190.1
dig_tra_serv_import	1,711	33.53122	16.32709	2.31	95.05
dig_tra_serv_export	1,693	27.71238	19.79237	0.43	93.17
ShareIctImport	2,462	4.650585	3.538315	0	38.58
ShareIctExport	2,514	8.07369	8.777254	0	61.45
ShareIctGoodExp	2,478	3.883085	7.934984	0	57.95
ShareIctGoodImp	2,528	6.522302	5.927807	0.46	56.81
imports_bop	2,453	1.21E+11	3.16E+11	2.02E+07	3.12E+12
exports_bop_usd	2,453	1.22E+11	3.06E+11	2627019	2.74E+12
goods_exports_d	2,453	9.40E+10	2.43E+11	144863.6	2.51E+12
merchandise_exports_d	2,539	9.54E+10	2.46E+11	0	2.59E+12
service_exports_d	2,453	2.80E+10	7.52E+10	2290242	8.91E+11
goods_imports_d	2,453	9.47E+10	2.55E+11	9615961	2.56E+12
service_import_d	2,453	2.61E+10	6.44E+10	9514239	5.93E+11
elec_access	2,559	81.66905	27.96477	2.7	100
gdp_const	2,519	4.29E+11	1.69E+12	2.85E+07	2.01E+13
pop_total	2,559	4.27E+07	1.51E+08	9912	1.41E+09
enroll_secondary	1,875	84.06736	27.689	9.15985	164.0798
tfp_growth	1,266	0.98378	1.1245	-2.884	6.7105
digitpay-rm	262	0.4124155	0.2589369	0.0269255	0.9332641
digitpay-r	262	0.3934684	0.2556512	0.0265838	0.9286363

A-4 ICT trade performance

Table A-3: Top winners and bottom losers in global ICT service exports: 2005-2020

Country	Market share in 2005, %	Change in market share: 2005-2020, percentage points
Top winners		
Ireland	16.5	10.4
China	1.8	6.5
Poland	0.4	1.2
Ukraine	0.1	0.8
Cyprus	0.2	0.5
Romania	0.6	0.4
Belarus	0.1	0.4
Brazil	0.2	0.2
Bulgaria	0.1	0.2
Lithuania	0.1	0.1
Uruguay	0.1	0.1
Vietnam	0.1	0.1
Bottom losers		
Belgium	3.0	-0.6
Austria	2.2	-0.7
India	12.8	-1.2
Canada	3.6	-1.4
Sweden	4.5	-1.9
Germany	8.3	-2.4
Italy	5.1	-3.6
United Kingdom	9.5	-4.5

Table A-4: Top winners and bottom losers in global ICT good exports: 2005-2020

Country	Market share in 2005, %	Change in market share: 2005-2020, percentage points
Top winners		
China	30.8	20.7
Vietnam	0.1	5.6
Singapore	3.7	3.6
Poland	0.3	0.6
India	0.1	0.2
Slovakia	0.4	0.2
Israel	0.3	0.1
Panama	0.0	0.1
Romania	0.0	0.1
Latvia	0.0	0.1
Russian Federation	0.0	0.0
Bottom losers		
Hungary	1.5	-0.8
Sweden	1.5	-0.9
Canada	1.4	-1.0
Ireland	2.3	-1.1
France	2.7	-1.7
Malaysia	5.9	-2.6
Germany	7.0	-3.4
United Kingdom	5.0	-4.2
United States	12.6	-5.4
Japan	9.4	-6.5