# The impact of information and communication technology on services exports: Evidence from developed and developing economies

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| A B S T R A C T |
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| **Objective:** The objective of the article is to examine direct and indirect channels through which information and communication technology affects exports of services. |
| **Research Design & Methods:** In this study a linear fixed effects panel regression model with country-specific fixed effects and with Driscoll and Kraay standard errors is fit to the data over the period 2000-2019. The samples cover the data sets for 80 countries, and separately for 44 high-income and 36 low and middle-income economies. |
| **Findings:** The findings show that the access to traditional and broadband digital connectivity has a positive impact on services exports, revealing a slightly stronger influence of the latter for the advanced economies. Additionally, exports and imports of the ICT goods appear to be complementary to services exports. |
| **Implications & Recommendations:** The detected dependencies indicate that in a digital era, connectivity infrastructure, as well as international flows of the ICT goods bring about significant effects for services exports. Both findings raise important implications for export-led growth policy that should account for new interdependencies between goods and services, and for further investments in digital infrastructure. |
| **Contribution & Value Added:** This study contributes to the relevant literature by extending the traditional factor-endowment approach used to explain the impact of information and communication technology on the exports of services. Besides specifying the exports of services as a function of internet market penetration, both a traditional and a broadband one, we consider the exports and the imports of ICT goods as the potential determinants of services exports. |

## INTRODUCTION

The rise of services trade is one of the most distinctive features of international trade in the 21$^{st}$ century. In the first two decades of a new millennium, the growth of services exports outstripped the growth of goods trade. From 2000 to 2019, the volume of global services exports almost tripled, whereas goods exports doubled over this time. Developing countries became the main actors of rapidly expanding international trade, as the pace of their exports, of both goods and services, clearly exceeded that of developed economies. Although developing economies have successfully expanded their shares in global trade, the prevailing position of high-income countries have remained strong, especially in services exports. In 2000, high-income countries provided about 84% of the world services exports, and in 2019 their shares only slightly decreased to around 80%. In goods trade, the asymmetry between developed

and developing countries has weakened to a larger extend, as low and middle-income economies shifted their shares of global goods exports from 18% in 2000 to 34% in 2019 (WDI database).

This study takes a close look at information and communication technology (ICT), seeking to explain how it affects the exports of services. While most of researchers focus on the role of digital infrastructure, including internet or mobile phone connectivity, our study extends this traditional factor-endowment approach. Thus, besides specifying the exports of services as a function of internet market penetration, both a traditional and a broadband one, we include the exports and the imports of ICT goods as the potential determinants of services exports. We contribute to the existing literature, accounting for the relationships between ICT goods trade and services exports that allow covering different international channels through which digital technology may affect trade in services. We expect that digitalization not only creates new types of services, but also gives rise to new interlinkages between goods and services. Thus, we hypothesize that digitalization affects services exports, both directly and indirectly. The existence of a complementarity between trade in ICT goods and the exports of services would imply important recommendations for trade policy-makers.

The rest of the paper is organized as follows. First, we briefly overview main tendencies in services trade over the last two decades. Then, we discuss the relevant literature on services exports, pointing to the different categories of tradable services and their determinants. Next section describes the variables, data sources, and methodology that we apply to the empirical analysis. The results and the discussion are presented in the next part. Eventually, in concluding remarks we present the implications of our findings for trade policy and point to the fields of further relevant studies.

## LITERATURE REVIEW

Service exports was growing intensively worldwide during the recent decades, reaching in 2019, i.e. in a year before the Covid-19 pandemic, 25% of the volume of global trade in goods and services. Two crises, the Global Financial Crisis (GFC) and Covid-19 pandemic, have interrupted a steady growth of services exports. In 2009, the volume of global service exports collapsed by around 11%, both in high-income, and in low and middle-income economies. After rebounding in 2010, global exports of services reached their pre-crisis level, however, in 2015 when world economy slowed down services exports lost their momentum (Fig. 1).
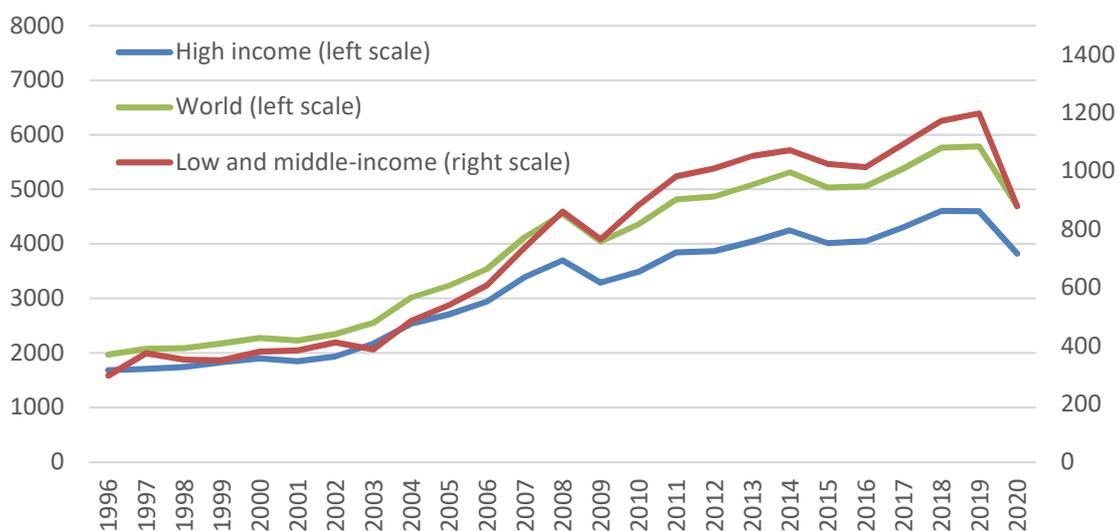


**Figure 1. Exports of services from different income-group countries
(in bln of USD, deflated by the GDP deflator)**
Source: own elaboration based on the data from WDI database.

In 2020, the Covid-19 pandemic restrictions such as social distance and lockdowns, particularly adversely affected services, whether supplied to domestic or international markets. In the first year of the

pandemic, the volume of the worldwide services exports fell by nearly 20%. This time, the collapse of services exports was much more severe in low and middle-income countries (-26%) than in developed economies (-17%). Apparently, the difference was due to the fact that the Covid-19 pandemic-driven shock mainly reduced exports of traditional services, like transport and travel, which account for a larger share of exports from developing, rather than from developed countries. For instance, in the year preceding the outbreak of the Covid-19 pandemic the share of travel in developing economies services exports amounted, on average, to 33%, whereas in developed countries the relevant average shares were below 20%. In particular, developing countries in Latin America and the Caribbean, North Africa and South-East Asia rely on travel services. The average shares of this category in total services exports from these regions, amounted in 2019 to 50%, 45%, and 35%, respectively. Given that in 2020 the decline in exports of travel services was by 70%, the economic impact of Covid-19 pandemic was extremely severe in these regions. It is worth noting that the exports of certain types of modern services, for instance, telecommunication, computer and information services, were steadily increasing in the Covid-19 pandemic times (Fig. 2). This was a natural consequence of adapting to the pandemic restrictions through the use of digital technologies in daily life. The intensification of online communication for work, study, commerce, and leisure contributed to the growth of international trade in ICT services.
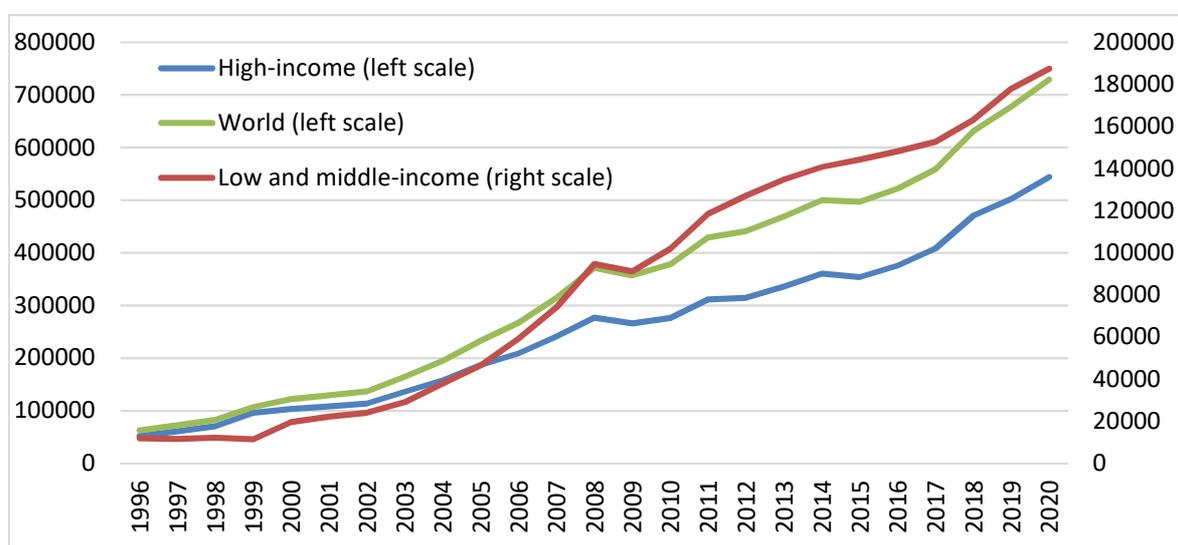


**Figure 2. Exports of ICT services from different income-group countries
(in mln of USD, deflated by the GDP deflator)**
Source: own elaboration based on the data from WDI database.

Figures 1 and 2 show that since 2008 the growth of services exports has been faster in low and middle-income countries than in high-income economies. It should be noted, however, that despite this dynamic development, the shares of low and middle-income countries in the world services exports remain about four times smaller than those of high-income countries. This asymmetry is readily apparent in Figure 2 when considering that the scales on the right and left axes are different.

Apparently, the substantial predominance of developed economies in the global services exports reflects the differences in the GDP structure of high-income, and low and middle-income economies. In the former, services contributed in 2019 about 70% to GDP, whereas in the latter, the value added of services amounted to around 54% (Fig. 3). Thus, as the share of services in GDP increases along with economic growth, it is very likely that catching-up countries will increase their comparative advantages in trade of services. In the era of digitalization, when services become more tradable, the question arises about the distribution of gains from the expanding service exports between developed and developing countries.

The studies on services exports have been gaining in popularity as the share of services in global trade has grown. The research questions on services trade determinants have varied from the role of service trade liberalization policy (Evenett & Fritz, 2021; Gupta et al., 2022) through the innovative channels of services delivery, and the new types of tradable services, relating to such phenomena as

servicification (Bombińska, 2019), off-shoring and global value chains (Kordalska & Olczyk, 2021), or industrial revolution 4.0. Undoubtedly, the latter one, which includes the development of information and communication technology, has created a lot of opportunities for services trade, overturning the assumption, used for instance in the Balassa-Samuelson model, that services are not tradable.
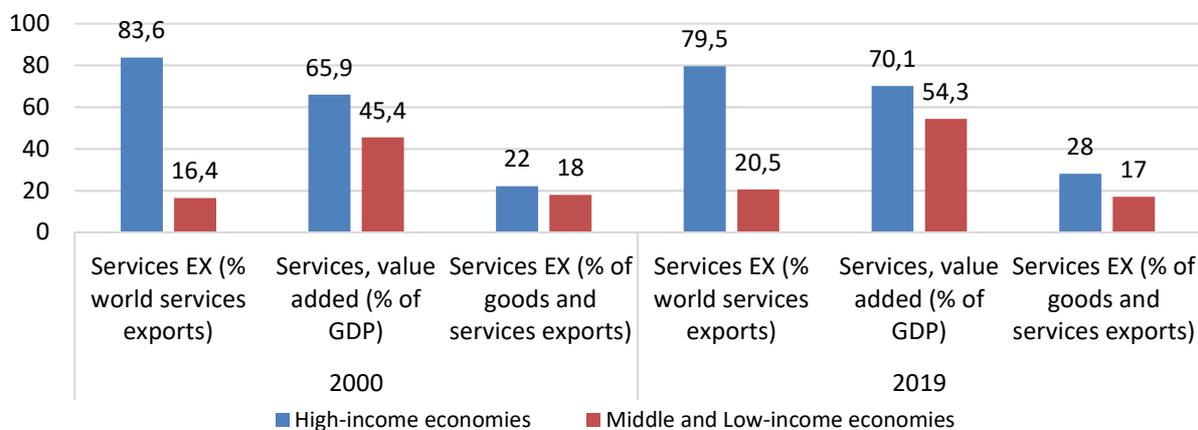


**Figure 3. Services exports as a percentage of countries' exports of goods and services, world services exports, and the value added by services to GDP**
Source: own elaboration based on the data from WDI database.

Many studies have confirmed that digital technology has played a pivotal role in supporting services trade, both in developed, and developing economies. For example, Nasir and Kalirajan (2014) using a stochastic frontier gravity model examine services exports performance of Asian emerging and developed countries. The authors show that labour skills and the ICT infrastructure are key factors fostering modern services exports. They also point to the role of services trade liberalization, which enhances trade in modern services, such as computer and information, business and professional, and telecommunication.

Eichengreen and Gupta (2013) examine determinants of modern services exports using country-level data for 60 developed and developing economies, and taking a close look at India, which performance in modern services has been exceptional, especially in the sector of information and telecommunication. The authors show that besides factor endowments, like communication infrastructure, access to foreign technology, availability of highly-skilled English-speaking labour, as well as the overall economic development, and goods trade have significant and positive impact on services exports. Introducing exports of goods as an explanatory variable into the services trade model, the authors accounted for network effects, as well as, complementarities between tradable goods and services. When, instead of goods exports, the authors incorporated goods imports and total goods trade into the model, the panel regression results showed that these variables also positively affected services exports. The identified linkages appear to be associated with supply-side factors used by the producers of services.

Similarly to the Eichengreen and Gupta's study (2013), Sahoo and Dash (2014) also examine an impact of goods exports on services exports, which allows capturing the network effects. Using the ARDL cointegration model, Sahoo and Dash (2014) identify for India's economy a positive and significant long-term relationship running from goods exports to modern services exports such as software and communication, and insurance and finance. Their findings imply that the existing trade networks in merchandise market are likely to support foreign sale of services. The authors also found that human capital, tele-density, foreign direct investments and exchange rates are important drivers of modern services exports.

While Sahoo and Dash (2014) point to goods exports as a determinant of services exports, López-González and Ferencz (2018) identify imports as the channel through which goods affect services exports. According to the authors such approach allows exploring complementarities emerging between

tradable goods and services in the digital era. They construct a new variable which captures the combined importance of digital connectivity and ICT devices. As the latter often derive from imports, it has been calculated as a product of the ICT goods imports and the density of digital connectivity. After having introduced it as an explanatory variable into the gravity model of trade, the results confirmed positive linkages between this new measure and exports of services. The identified relationship implies that imports of ICT goods contribute to the factor endowments, including digital infrastructure, which is used by producers and exporters of services. According to the authors, their finding suggests that digitalization not only affects services exports (especially digitally deliverable ones) directly, but also indirectly through the ICT-related goods.

An interesting empirical study on the role of ICT on exports, imports and total trade of different types of services is by Nath and Liu (2017). They construct the ICT development index, which captures three aspects of information and communication technology, such as access, use, and skills. Additionally, they employ real GDP per capita and population as control variables. Using the GMM method and estimating the models with data for 49 countries over the period 2000-2013, Nath and Liu (2017) identify a positive and significant effects of the ICT on total service trade, and also on exports or imports, separately. Their results show that the development of information and communication technology has contributed significantly to trade in the majority of the services, including telecommunication, business, financial, and insurance, which are classified as the ICT-enabled services. Moreover, real per capita GDP revealed to have a positive and statistically significant effect on exports, imports and total trade in more types of modern services. This finding explains the predominant position of advanced economies in international trade of ICT services.

More recent studies highlight the role of services in global value chains (GVC). This area of services performance attracts a lot of attention from both academics and policymakers (Mayer, 2018; Bombińska, 2019; Kordalska & Olczyk, 2021). The ongoing discussion concerns not only functional but also methodological issues of measuring and distribution of value added in trade. Since many services have been bundled with goods and sold as inputs, their evidence as separate trade flows became complex. A couple of new initiatives have been launched to deal with this methodological issue. For instance, the OECD released Trade in Value Added (TiVA) database, which delivers evidence on imports of foreign inputs to produce goods and services for exports, and also data on domestically produced inputs, which are then exported and used by foreign producers. Such statistics capture, respectively, backward and forward links of domestic entities with foreign partners that allows for better estimation of real contribution of services into the exports. According to TiVA evidence, services bring about 50% of the value added in exports, whereas Miroudot and Cadestin (2017) claim that this share may amount to about two-third. According to the authors, service activities provided within manufacturing firms, either as substitutes or complements to merchandises, may increase this contribution.

The importance of the strength of linkages between services and manufactures is confirmed by Kordalska and Olczyk (2021). They examine the role of goods and services bundling in the domestic markets on fostering trade by participation of domestic agents in GVC. The authors analyse backward and forward linkages between manufactures and different categories of tradable services, including: financial and insurance; business and management consulting; legal and accounting; and computer programming in seven Central and Eastern European economies. They found that positive intersectoral relationships between manufactures and services at the countries' level enforce comparative advantages and foreign trade of intermediary services used in international production chains. This result allows them to conclude that the role of complementarity between services and goods is more than just inputs. The mechanisms that bundle up manufactures and services, enhancing foreign trade, are also described by Bombińska (2019), who points to the various patterns and channels of international servicification. The author shows, that besides offshoring, also capital mobility, for example in the form of foreign affiliates, triggers international servicification and trade in services. These international channels, that link services to the production and the sale of goods are particularly important in integrated economies, e.g. the EU, where a common market ensures the free movement of goods, services, capital, and labour.

The literature review and prior empirical results allowed to assume the following research hypotheses:

**H1:**    There is a positive relation between internet connectivity and services exports.

**H2:**    Export of ICT goods is positively related to services exports.

**H3:**    Import of ICT goods enhances services exports.

## RESEARCH METHODOLOGY

The annual country-level data that we used in our research come from the World Bank database (WDI). The size and period of the sample are dictated by the availability of the data on trade in ICT goods. Using three data sets, i.e. for 80 countries and separately for 44 high-income and 36 low and middle-income economies over the period 2000-2019, we run panel regressions of services exports on ICT goods exports, ICT goods imports, and internet connectivity, both traditional and broadband. These four types of the ICT-related data used as the explanatory variables, allow capturing different channels through which ICT can affect exports of services.

In addition, estimating the models for the whole sample and then for the two sub-samples, selected by income per capita, provided a comparative perspective. A classification of countries by income-group is according to the World Bank that defines high-income economies as those in which GNI (Gross National Income) per capita in 2020 exceeded USD 12,695. Middle-income economies are those in which 2020 GNI per capita was between USD 1,046 and USD 12,695. And, if GNI per capita was USD 1,045 or less in 2020, the countries have been classified as low-income.

The services exports model is specified in equation (1):

$$\ln EXS_{jt} = a_{j0} + a_1 \ln GDP_t + a_2 \ln ICT_{jt} + a_3 \ln INT_{jt} + a_4 \ln REER_{jt} + \varepsilon_{jt} \tag{1}$$

where $j$ stands for a country and $t$ refers to the year. Exports of services (EXS), which is our dependent variable, include different types of services defined as economic output of intangible commodities that may be produced, transferred, and consumed at the same time (WDI database). Taken in the US dollars, they were then deflated with the GDP deflator for the US economy. The variable ICT1 stands for imports (in model 1 and 3) and ICT2 for exports (in model 2 and 4) of the ICT goods, depending on the models. Each of these variables may affect services exports, accounting for the different channels of international diffusion of technology. Thus, we consider, alternatively, imports and exports of the ICT goods that are given, respectively, as a percentage of country's imports and exports of total goods. According to the WDI data definition, the ICT goods include computers and peripheral equipment, communication equipment, consumer electronic equipment, electronic components, and other information and technology goods. The other explanatory variable, denoted as INT captures the access to the traditional (INT1) and modern internet network (INT2). In models 1 and 2, the INT1 gauges individuals using the internet as a percentage of population, whereas in models 3 and 4, the INT2 covers the access to the broadband connectivity and it is given as a number of fixed broadband subscriptions per 100 people.

Following the literature, we have also introduced demand-side and cost-related factors as variables that traditionally explain services exports. They are proxied with the world GDP (GDP) and the real exchange rates (REER). The former is given in constant US dollars, whereas the latter measures the value of domestic currency against a weighted average of foreign currencies of the main trading partners, divided by a price deflator or index of costs.

Panel data are characterized by time series observations for a set of countries. This kind of data typically displays both contemporaneous correlation across countries (cross-sectional dependence), country level heteroscedasticity and serial correlation making inference from standard errors produced by ordinary least squares suboptimal. Panel-corrected standard errors or "robust" standard errors help to account for these issues and allow for better inference. Different standard errors estimators are preferred in one or the other branch of applied econometrics. For moderately-sized panel time series in macroeconomics Driscoll and Kraay (DK) "robust" standard errors (Driscoll & Kraay, 1998) are usually recommended. In this study a linear fixed effects panel regression model with country-specific fixed effects and with DK standard errors was fit to the data (Driscoll & Kraay, 1998).

## RESULTS AND DISCUSSION

Tables 1-4 show the results for each of our four models of services exports, accounting for different gauges of digital connectivity and two flows (exports and imports) of ICT goods trade as potential determinants of services exports. Tables 1 and 2 present the results for models including traditional internet, whereas tables 3 and 4 show the estimates for models with broadband connectivity as a proxy for digital communication infrastructure. The results estimated for all countries in our panel data, and also for two panel sub-sets selected by countries' income per capita, are presented in columns. Our findings imply, that the access to digital connectivity network, as well as trade in ICT goods are important drivers of services exports. Moreover, foreign demand proxied by the world GDP positively affects services exports, taking the highest values of the regression coefficients (ranging from 1.40 to 1.79, depending on the model). These findings have been confirmed when the models were estimated for a sample of all countries, and for the samples, selected by income-group countries.

**Table 1. Model 1 estimation results for services exports**

| Independent variables | Sample (1) All countries | Sample (2) High-income countries | Sample (3) Low and middle-income countries |
|---|---|---|---|
| World demand for services GDP | 1.56*** | 1.55*** | 1.40*** |
| | (0.19/0.0000) | (0.17/0.0000) | (0.24/0.0000) |
| Internet connectivity INT1 | 0.13*** | 0.14*** | 0.14*** |
| | (0.02/0.0000) | (0.03/0.0000) | (0.03/0.0000) |
| REER | 0.55*** | 0.31*** | 0.68*** |
| | (0.06/0.0000) | (0.08/0.0001) | (0.07/0.0000) |
| ICT1 | 0.08*** | 0.11*** | 0.06** |
| | (0.02/0.0002) | (0.03/0.0013) | (0.03/0.0186) |
| $R^2$ | 0.988 | 0.985 | 0.985 |
| Countries/Observations/Years | 80/1513/12-20 | 44/842/13-20 | 36/671/12-20 |

Notes: Asterisks denote statistical significance at ***: 0.01, **:0.05, *: 0.10 level. Driscoll-Kraay robust standard errors and p-values are in parentheses.
Source: own calculations in R.

**Table 2. Model 2 estimation results for services exports**

| Independent variables | Sample (1) All countries | Sample (2) High-income countries | Sample (3) Low and middle-income countries |
|---|---|---|---|
| World demand for services GDP | 1.55*** | 1.55*** | 1.41*** |
| | (0.19/0.0000) | (0.19/0.0000) | (0.24/0.0000) |
| Internet connectivity INT1 | 0.15*** | 0.16*** | 0.16*** |
| | (0.02/0.0000) | (0.03/0.0000) | (0.02/0.0000) |
| REER | 0.63*** | 0.42*** | 0.73*** |
| | (0.06/0.0000) | (0.11/0.0001) | (0.07/0.0000) |
| ICT2 | 0.01** | 0.03** | 0.01 |
| | (0.00/0.0245) | (0.01/0.0107) | (0.01/0.4562) |
| $R^2$ | 0.988 | 0.985 | 0.985 |
| Countries/Observations/Years | 80/1506/12-20 | 44/842/13-20 | 36/665/12-20 |

Notes: Asterisks denote statistical significance at ***: 0.01, **:0.05, *: 0.10 level. Driscoll-Kraay robust standard errors and p-values are in parentheses.
Source: own calculations in R.

The coefficients of traditional internet connectivity, as expected, have positive signs. They are statistically significant at 1 percent level in all of the models. As tables 1 and 2 show, the values of coefficients of internet access range from 0.13 to 0.16 (depending on the model), whereas those of the broadband connectivity amount to 0.04-0.06 (table 3 and 4). Thus, the traditional internet connectivity (INT1) appears to have a greater impact on services exports than the broadband connectivity (INT2). This property was identified for high, as well as for low and middle-income economies. When compar-

ing our findings to other relevant studies, we noted that the results obtained by López-González and Ferencz (2018) indicated that traditional internet infrastructure has a positive impact on service exports, with the strength of the impact varying for different types of services. For instance, the model of post and telecommunication services gives the coefficient of 0.335, for computer and related services the coefficient amounted to 0.323, and for hotels and restaurants the coefficient was 0.175. When the authors tested the influence of internet connectivity on the overall exports of digitally enabled services, the average coefficient was 0.222., implying that a 1 percent increase in internet connectivity (proxied by a number of internet users) enhances, on average, the exports of digitally enabled services by 0.222 percent. The sample, tested by López-González and Ferencz (2018), covered both developed and developing economies. It is worth to note, that the authors also examined the impact of internet access on goods trade in each group of countries separately. They found a stronger relationship of the impact of internet infrastructure on exports in developed countries (the coefficient of 0.509) than in developing ones (the coefficient of 0.012).

**Table 3. Model 3 estimation results for services exports**

| Independent variables | Sample (1) All countries | Sample (2) High-income countries | Sample (3) Low and middle-income countries |
|---|---|---|---|
| World demand for services GDP | 1.57*** | 1.51*** | 1.77*** |
| | (0.15/0.0000) | (0.18/0.0000) | (0.11/0.0000) |
| Broadband digital connectivity INT2 | 0.05*** | 0.05*** | 0.04*** |
| | (0.01/0.0000) | (0.02/0.0004) | (0.01/0.0000) |
| | 0.43*** | 0.24** | 0.56*** |
| REER | (0.07/0.0000) | (0.11/0.0323) | (0.07/0.0000) |
| ICT1 | 0.09*** | 0.10*** | 0.07*** |
| | (0.02/0.0000) | (0.03/0.0009) | (0.03/0.0043) |
| $R^2$ | 0.988 | 0.984 | 0.985 |
| Countries/Observations/Years | 80/1464/13-20 | 44/833/15-20 | 36/631/13-20 |

Notes: Asterisks denote statistical significance at ***: 0.01, **:0.05, *: 0.10 level. Driscoll-Kraay robust standard errors and p-values are in parentheses.
Source: own calculations in R.

**Table 4. Model 4 estimation results for services exports**

| Independent variables | Sample (1) All countries | Sample (2) High-income countries | Sample (3) Low and middle-income countries |
|---|---|---|---|
| World demand for services GDP | 1.57*** | 1.53*** | 1.79*** |
| | (0.15/0.0000) | (0.20/0.0000) | (0.12/0.0000) |
| Broadband digital connectivity INT2 | 0.06*** | 0.06*** | 0.05*** |
| | (0.01/0.0000) | (0.02/0.0011) | (0.01/0.0000) |
| | 0.49*** | 0.30** | 0.61*** |
| REER | (0.07/0.0000) | (0.14/0.0304) | (0.06/0.0000) |
| | 0.02*** | 0.04*** | 0.02*** |
| ICT2 | (0.00/0.0000) | (0.01/0.0001) | (0.00/0.0000) |
| $R^2$ | 0.988 | 0.984 | 0.985 |
| Countries/Observations/Years | 80/1459/13-20 | 44/833/15-20 | 36/627/13-20 |

Notes: Asterisks denote statistical significance at ***: 0.01, **:0.05, *: 0.10 level. Driscoll-Kraay robust standard errors and p-values are in parentheses.
Source: own calculations in R.

Our findings also identified complementarities existing between exports of services and trade in ICT goods. On the one hand, services exports are higher when ICT goods imports increase. The strength of these relationships varies for the income-groups samples. Tables 1 and 3 demonstrate that high-income economies reveal stronger positive relationships between exports of services and imports of ICT goods (the coefficients 0.1-0.11) than developing countries (the coefficients 0.06-0.07). On the other hand, services exports appear to be complementary with exports of ICT goods, implying inter-sectoral dependencies operating by goods-related services or bundled services. These relationships

also turn out to be stronger for developed than for developing countries. It is worth adding, that the coefficients of ICT goods exports take lower values than those of the ICT goods imports, ranging from 0.02 to 0.03 for low and middle-income countries, and from 0.03 to 0.04 for high-income economies. The finding that imports of ICT goods positively affect services exports is in line with the results by López-González and Ferencz (2018), who identified complementarities between imports of ICT goods and exports of digitally deliverable services. The coefficient of 0.009, obtained by the authors, was also relatively small, however, it should be underlined, that they proxied the ICT goods imports by a new combined measure of internet penetration and imported ICT devices.

Our results on price-related factors, included in the explanatory variable as the real effective exchange rate, imply that an appreciation of the domestic currency is associated with an increase in exports of services. This positive relationship may be due to an increase in demand for the domestic currency, used as the invoicing currency of service exports payments. The coincidence in the short term of capital inflows that cause exchange rate appreciation with the export of services is characteristic for services requiring direct contact between supplier and consumer., e.g. travel, tourism, or transport services. This interpretation has been apparently confirmed by the values of the coefficients for REER, which are higher in middle-income countries recording higher shares of traditional services in total services exports, than in high-income countries. Depending on the model, the values of REER coefficients range from 0.56 to 0.73 for low and middle-income countries, and from 0.24 to 0.42 for high-income countries.

Our results have important and far-reaching implications on trade and growth policies. The first implication is that export-led growth focusing on services exports requires digital infrastructure capabilities, supporting production and exchange of services. Since traditional internet has already reached 90% of the market penetration in high-income economies, more scope for investments in this area is left in low and middle-income countries, whose 50% of population has access to traditional internet infrastructure. Therefore, investment in information and communication infrastructure should be at the centre of developing countries' growth strategies. Given rapid advances in digital technology, development of broadband connectivity network should be a first priority. There is much to be done in this area, both in high- and in low and middle-income countries, as the broadband penetration of their markets is relatively low. On average, the number of fixed broadband subscriptions per 100 people amounts to 35 in high-income and only to 15 in low and middle-income countries. Accounting for more advanced digital products that require high speed of data transmission, a development of the broadband internet infrastructure appears to play a key role in digital-led growth policy. Additionally, the increasing number of internet users, both producers and consumers, need high-speed bandwidth connectivity enabling upstream and downstream data-carrying capacity. This kind of supply-side factors seems especially relevant for supporting the development of modern services exports that can be digitally delivered.

The second policy implication stems from our finding that services are complementary to ICT goods, both imported and exported ones. On the one hand, the ICT imported goods contribute to digital factor endowments, providing technology-advanced devices used by the producers and exporters of services. Our study shows, that imports of ICT goods are positively related to exports of all services, not only in the ICT sector. Thus, the imported technology in the form of ICT goods can both directly and indirectly support the provision of services abroad. For example, exports of ICT services such as software-related services, data-processing services, or the broadcast or transmission of sound, images, are directly supported by ICT goods, whereas the export of traditional services use ICT goods rather in indirect way. The latter may involve supporting the transport services with satellite navigation or transit payment applications, and backing the travel services by digital accommodation databases, online travel tickets, currency exchange applications, etc.

Moreover, since the imports of ICT goods worsen trade balance, countries with structural external deficits may resort to protectionism. As protectionist behaviour intensified in the aftermath of the Covid-19 crisis and many economies began to insulate their domestic markets, from foreign competition, the awareness that imports of ICT goods support exports of services should temper the inclination to implement trade restrictions. Hence, liberal trade policies, as well as regulations governing trade in ICT goods and related intangible assets, should be a key element of export-driven strategies of growth.

In other words, trade policy-makers should account for new opportunities for enhancing exports, which emerged from the interlinkages between ICT goods and services. It should also be emphasised, that a liberal trade policy towards imports of ICT goods may be not sufficient to achieve the benefits of high-tech tangible assets. The experience of successful ICT service exporting countries, including India or Ireland, shows that human capital also plays a pivotal role in modern service exports.

On the other hand, the exported ICT goods also drive services exports either directly, for instance by enhancing post-sale services, such as maintenance and repair, or indirectly, for example, through network effects. The observation that complementarities between ICT goods trade and services exports appeared stronger in advanced rather than in developing economies, can be explained by the fact that the former build their comparative advantages in modern services such as financial or ICT, which according to López-González and Ferencz (2018), are more digitally-relayed.

## CONCLUSIONS

This study examined the key drivers of services exports performed in high-income and low and middle-income economies. Seeking to explore the role of the factors related to the information and communication sector, we took a close look at the connectivity infrastructure and international trade in the ICT goods as potential determinants of services exports. This two-fold approach allowed capturing direct and indirect channels through which digital technology can affect exports of services. Moreover, running panel regressions for different data sets selected by the countries' income per capita, we shed light on the differences in the determinants of services exports between high-income and low and middle-income economies.

In sum, the detected dependencies indicate that in a digital era, not only connectivity infrastructure, but also international flows of the ICT goods bring about significant effects for services exports. In other words, the ICT, operating either directly, through infrastructure endowments, or indirectly, through the ICT goods trade, may enhance exports of services. Our findings showed a slightly stronger influence of broadband connectivity on services exports in advanced economies rather than in low and middle-income economies. Additionally, exports and imports of the ICT goods appeared to be complementary to services exports in both of the countries' groups. The strength of these relationships also appeared greater in the models tested for high-income than for low and middle-income countries. Since our dependent variable captures total services exports, including traditional, such as transport, travel, or construction, as well as the modern ones, such as financial, software-related services or data-processing services, the results we obtained suggest that exports of both types of services are driven by the ICT goods, both exported and imported.

Given the continued development of the ICT and its positive influence on services exports, our study provides useful implications for economic policymakers. Firstly, export-led growth focusing on services exports requires digital infrastructure, thus further investment, especially in high-speed internet connectivity is required. Secondly, the detected complementarities between ICT goods trade and services exports imply that trade regulations imposed on both exports and imports of ICT goods should account for their impact on services exports. This conclusion seems extremely important when in the aftermath of the GFC and the Covid-19 pandemic, many countries have imposed trade barriers, aiming at reducing their vulnerabilities to external shocks.

Further research on services exports focusing on cross-sectoral approach could reveal additional channels and mechanisms behind the interdependencies of goods and services. In the digital era, a particular field for further research, covers global value chains of services, including data chains. Data collection and data processing are two pivotal activities within global data chains. As almost all internet users are involved in global data chains, but there are relatively few service providers, e.g. the owners of digital platforms, the major issue that digitalisation raises for global economy is the distribution of the benefits of international trade. Moreover, digital trade raises the security issues, therefore international regulation of the protection of intangible assets, the protection of personal data and the security of digital payments, should be on the agenda. To conclude, the biggest challenge for modern international trade

appears to be the adjustment of existing regulations to new products, services and the relationships emerged between them in digital era, without reducing the level of trade liberalisation.

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## Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.