

## **The Impact of Digital Technology on Exports in Services in EU Countries: A Panel Data Approach\***

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### **Abstract**

This paper aims to demonstrate the impact of digital technology on service exports in EU countries and within subgroups of countries divided by GDP per capita (lower and higher-income countries). We use the Digital Economy and Society Index (DESI) and its components as proxies for the level of digitalization in a country and the value of digitally delivered services as a proxy for service exports. To examine relevant relationships, we employ a panel data model on EU countries from 2017 to 2022. Results show that in all EU countries and within their subgroups, DESI has a positive and significant effect on service exports. However, the importance of the main components of DESI varies. Additionally, the influence of digital transformation is more pronounced in lower-income countries. The findings indicate that the digital skills of human capital are key factors that enhance service exports. Therefore, these skills are essential for the absorption and dissemination of digital technology, which in turn boosts service exports and promotes economic growth and social modernization.

**Keywords:** Digital technology, DESI, service exports, lower and higher-income countries.

## Introduction

The most distinctive feature of international trade in the 21<sup>st</sup> century is the growing importance of services. Over the past two decades, the growth of services has outpaced the growth of goods trade, and as a result, services now account for about 54% of the world's trade in value-added terms (World Bank and WTO, 2023). Moreover, international trade in goods is decreasing, while trade in services, especially electronic services, remains on a relatively long-term upward trend, including cross-border data flows, which are growing exponentially (Borchert et al. 2020). Furthermore, trade in digital services within international trade is undoubtedly increasing.

The shift to the digital economy has accelerated since the COVID-19 pandemic as producers of goods and services connected with customers through online platforms (Drake-Brockman et al., 2020). This has led to rapid global growth in digital technology, highlighted by the rise of digital industrialization and industrial digitalization (Kong et al. 2024). New technologies such as artificial intelligence (AI), big data, cloud computing, Internet of Things (IoT), and blockchain have emerged. They provide innovative solutions to various challenges in the trade of services that play a transformative role by enabling new forms of service delivery. Additionally, digital technology can boost productivity, reduce costs, and eliminate barriers to the movement of traditional goods and services. Digitalization lowers the costs involved in international trade, making it easier for businesses and consumers worldwide to connect. It also encourages the sharing of ideas and technology and simplifies coordination within global value chains (Brouthers, Geisser, and Rothlauf 2016); it also increases economic openness (González and Ferencz (2018)) and trade opportunities by increasing digital connectivity and global data flows around the world (Meltzer and Lovelock (2018)). At the company's level, digitization opens new trade opportunities to sell more products to more markets, leading countries to diversify their export products. In this digital era, connectivity infrastructure and international flows of ICT goods greatly impact services exports (Wajda-Lichy et al. 2022).

While several studies examine the effects of digitalization on goods exports (e.g., Nham et al. 2023; Özsoy et al. 2022), relatively few analyze its role in service exports (to mention Kong et al. 2024; Nikensari et al. 2024). This paper is among the early studies exploring the significant impact of digital technology on international trade, specifically focusing on service exports in EU countries. To assess the impact of digital technology on exports, different proxy variables are used to reflect digitalization, such as internet subscriptions (Freunda and Weinhold, 2004), telecommunications access and technological infrastructure quality (Abedini, 2013), or the information and communication technology (ICT) index (Özsoy et al., 2022). This study measures digital transformation using a more comprehensive digitalization variable that reflects a country's level of digitalization in EU countries, such as the Digital Economy and Society Index (DESI), which captures digital connectivity, the integration of digital technology into business and commerce, digital public services (e-government), and the digital skills of human resources.

This paper aims to evaluate how digital technology affects service exports across European Union countries. Specifically, we examine the impact of DESI on service exports, represented by digitally delivered services using a panel data analysis for 27 countries from 2017 to 2022. Additionally, because the DESI components reflect the level of digitalization across different dimensions, we also analyze their effect on service exports. Moreover, as the impact of digitalization varies depending on a country's development level according to the technology gap approach (Harbi et al. 2014), we also estimate our panel model for two sub-samples of countries divided by GDP per capita.

In this paper, we make two contributions to the existing literature. First, we are the first to empirically examine how digital technology affects service exports in EU countries, using the DESI index as a measure of digital development. Many studies have focused on the impact of digital technology on economic growth or goods trade, but few have explored how digital technology affects trade in services. Importantly, the influence of digital technology extends beyond boosting trade in services; it also creates new opportunities for economies to advance to the next stage of industrialization (Industry 4.0) and promote sustainable development.

Second, by examining the impact of the DESI components on service exports, we identify the aspects of digitalization that most influence trade in services for both EU countries and subgroups (lower and higher-income

countries). This enables us to specify which of the four dimensions of digitalization (connectivity, the integration of digital technology, digital public services, or ICT skills of human resources) should be further developed and improved, and also to determine the comparative impact of digital technology on service exports in lower and higher-income countries.

The paper is organized as follows: the first section presents information on digitalization and service export performance, the second covers the empirical specification, data, and results, while the final section provides the paper's conclusion.

## **Digitalization and service export performance**

There are various mechanisms through which digital technology affects trade in services (Kong et al., 2024). Firstly, digital technology enables the improvement of the tradability of services by converting initially non-tradable services into tradable ones, and thereby facilitating cross-border transactions and effectively enhancing the scope of tradable services. Secondly, digital technology reduces transaction costs and mitigates risk in the service trade sector, mainly due to the emergence of digital platforms that enable the integration of production, circulation, services, and consumption. This, in turn, allows a more efficient division of labour. Thirdly, digital technology fosters the creation of new business models and innovative developments in the service trade sector. Digital technologies, such as AI, blockchain, cloud computing, big data, and the Internet of Things (IoT), accelerate the digitalization process and contribute to the transformation of service trade.

Structural shifts in the world economy caused by rapid technological progress have made services and services trade central to economic transformation. Driven by advances in information and communications technologies (ICT), global exports of commercial services nearly tripled from 2005 to 2022, with notable changes in the composition of services trade, as exports of digitally delivered services grew nearly fourfold (World Bank and WTO, 2023). The growth of developing economy exports is becoming more linked to services provided across borders via digital means. Highlighting what is now called the 'servicification' of the global economy, services make up 50 percent of worldwide trade in value-added terms, compared to 16 percent for agriculture and 34 percent for industry. While services trade was severely impacted by the COVID-19 pandemic, digitally delivered services have driven the recovery in global services trade and proved crucial to increased economic resilience (World Bank and WTO, 2023). This explains why digitally delivered services are used as a proxy for service exports when analyzing the effect of digital transformation on service exports in EU countries in this study.

Digitally delivered trade is defined as: 'International transactions that are delivered remotely in an electronic format, using computer networks specifically designed for the purpose, such as the Internet, apps, emails, voice and video calls, and digital intermediation platforms (Handbook on Measuring Digital Trade, 2023). Some examples include financial and insurance services, telecommunications, computer and information services, charges for the use of intellectual property, as well as personal, cultural and recreational services, such as audiovisual services, which include the production and use (for instance through downloads or streaming) of music, film, radio and television programs. Looking at more recent trends, the UNCTAD data in 2023 show that digitally deliverable services account for 56% of services exports worldwide, and about 55% in Europe.

Digital technology is an evolving scientific concept that has not yet been fully defined. However, it has developed over time from its physical substance roots to being seen as a service-oriented concept (Lyytinen et al., 2016). This is the reason why the literature covers different indices to evaluate the development of the digital economy (Olczyk and Kuc-Czarnecka, 2022), to mention some: the Information Society Index (1997), E-Readiness Index (2000), ICT Development Index (2002), Digital Access Index (2003), Knowledge Economy Index (2005), and the newest one Digital Economy and Society Index, DESI (2014). These indices allow a thorough evaluation of how the digital revolution affects society and the economy across multiple dimensions.

This paper uses the latest index, the Digital Economic and Society Index (DESI), proposed by the European Union. It evaluates the digital transformation of EU countries from different dimensions represented by four main components: connectivity, human capital, the integration of digital technology (e-business, e-commerce) and digital public services (e-government).

The first dimension – connectivity – emphasizes the essential infrastructure for a digital economy and society. In economic research, interest in connectivity relates to its positive influence on economic growth (Kisefáková et al., 2019). Many studies show that high penetration of fixed and mobile broadband supports economic growth and, in some cases, boosts employment and labor productivity (Arvin & Pradhan, 2014). Therefore, this dimension of the DESI includes indicators that assess digital infrastructure and connectivity quality.

Human capital dimension of the DESI refers to basic and advanced digital skills, which are essential for adopting information and communication technologies (ICT). This aligns with the resources and appropriation theory (van Dijk, van Deursen, 2014), which considers digital skills crucial for effective ICT adoption. These skills enable individuals to handle daily tasks in a digital society, such as utilizing Internet resources, managing information and communication, conducting digital transactions, accessing government services, and ensuring online security. However, to adjust to changes in the labor market, more advanced skills are needed, as digitalization requires them to have high-level. More advanced skills are crucial for workers to adjust to shifts in the labor market, especially as digitalization demands high-level, non-standard cognitive abilities (OECD, 2019).

The integration of digital technology encompasses business digitalization and e-commerce. Business digitalization aims to enable automation, enhance data quality, and collect and organize information to support the use of advanced technologies. As Verhoef et al. (2021) note, the primary benefits of business digitalization include increased process efficiency, reduced transaction costs, and improved business processes. Consequently, business digitalization mainly boosts economic activity by increasing productivity (Elding, Morris, 2018). E-commerce is defined as the transfer of funds or data over the Internet to facilitate the buying and selling of goods and services. It primarily influences the economy through higher productivity resulting from lower digital transaction costs and secondarily through international trade enabled by easier access to global markets and decreased transportation costs (Birlea, Capatina, 2017).

The digital public services dimension (e-government) is designed to help companies and citizens communicate more effectively with the government, thereby meeting the needs of businesses and citizens (Aker, 2017). The influence of e-government on the economy is seen through improved service delivery, increased democratization, reduced corruption costs, and greater business competitiveness (Máchová et al., 2018, Hoa and Pan, 2016).

## Panel empirical models and data

The empirical study concerns the impact of the DESI (and its main components) on the export of services across EU countries. Due to the short time series (the DESI index has been available since 2017), this study does not employ the dynamic panel data approach; instead, it uses static panel data models.

To identify the effect of digital technology on service export (digitally delivered services), we construct the panel data regression as follows:

$$ServiceEX_{it} = \beta_0 + \beta_1 DESI_{it} + \delta Controls_{it} + \zeta_t + \eta_i + \varepsilon_{it},$$

where  $ServiceEX_{it}$  represents total digitally delivered services (export) for country  $i$  in year  $t$  in million US dollars,  $DESI_{it}$  corresponds to the level of digital technology development measured by the total DESI index.  $Controls_{it}$  include a series of control variables that may influence international trade in services, such as the percentage of employment in services ( $SEM_{it}$ ), service value added ( $SVA_{it}$ ) in % of GDP, import of goods and services ( $IM\_G\_S_{it}$ ) in constant US dollars, real effective exchange rate ( $REER_{it}$ ) based on 2015;  $\zeta_t$ ,  $\eta_i$  are added into the model to capture the country and year fixed effects, and  $\varepsilon_{it}$  is the error term. All variables are expressed as logarithms.

The explained variable  $ServiceEX_{it}$  and controls are sourced from the World Data Bank, and DESI is derived from the Digital Scoreboard (European Commission, 2024). Selecting control variables, we rely on theories of international trade and empirical studies in the literature, such as Agosin et al. (2012), Cadot et al. (2011), Espoir (2020), Gngangnon (2019), and Parteka and Tamberi (2013), Nham et al. (2023).

Besides the DESI index, we examine the influence of its components separately, namely connectivity (DESI\_CONN), human capital (DESI\_HCap), integration of digital technology (DESI\_IDT), and digital public services (DESI\_DPS). We also aim to analyze whether the impact of DESI and its components on service exports varies according to countries' different levels of development. To do this, we first divide the sample into two groups based on their GDP per capita. The dividing point is the median GDP per capita in 2017.

**Table 1. The impact of digital technology on service export for all EU countries**

Variables	1	2	3	4	5
	RE	RE	FE	FE	RE
DESI TOTAL	0.882***				
DESI CONN		0.392***			
DESI DPS			0.848***		
DESI HC				2.531***	
DESI IDT					0.744***
SEM	1.485**	2.474***	0.448	-0.511	1.402**
SVA	1.165*	1.30*	0.008	1.566*	1.417**
IM G S	0.981***	1.007***	1.156***	1.331***	0.993***
REER	2.166***	2.633***	2.023***	1.981***	1.790***
C	-46.72***	-51.89***	-40.24***	-50.80***	-44.13***
Obs.	162	162	162	162	162
R2	0.847	0.853	0.994	0.995	0.835
Hausman test	6.86	5.76	13.34**	15.52***	7.4

Note: RE – random effect model, FE – fixed effect model. \*\*\*, \*\*, \* indicate statistical significance at the 1%, 5% and 10% level, respectively.

The estimation results, which show the effect of the DESI and its components on service exports across all EU countries, are presented in Table 1. The results indicate that digital transformation has a positive and statistically significant impact on service exports. This finding aligns with prior studies, such as Özsoy et al. (2022) and Nham et al. (2023). The positive influence of digitalization on service exports can be attributed to benefits like increased competitiveness in foreign markets due to technological changes (Azar and Ciabuschi, 2017), cost reduction (Porter and Heppelmann, 2014), or improved industrial efficiency (Dalenogare et al., 2018).

Regarding the impact of the total DESI and its components, such as connectivity (CONN), digital public services (DPS), human capital (HC), and the integration of digital technology, human capital skills are the most important factor in boosting digitally delivered service exports, outweighing the influence of the overall DESI. This suggests that ICT skills play a crucial role in the digital transformation of the economy and society that supports service exports. Therefore, to gain clearer insights and identify transmission channels through which digitalization can promote exports, it is better to consider the impact of individual DESI components on service exports. The overall DESI score, being a composite, weighted index, may be less informative about its effect on service exports. Additionally, its components are correlated, as noted by Olczyk and Kuc-Czarnecka (2022), which may lead to the double counting of underlying variables.

As the results of Table 1 show, besides improving human capital skills, the development of business digitalization and e-commerce (IDT component) and digital public services (e-government) are crucial for enhancing service exports. This indicates that business digitalization can make production processes more efficient, and e-commerce can facilitate access to global markets without administrative barriers and at lower transportation costs, thereby boosting service exports (Nassrullah et al. 2019). The development of digital public services enables companies and citizens to communicate more effectively and helps meet citizens' and businesses' needs by leveraging the benefits of digital platforms to deliver services more quickly and conveniently (Aker, 2017).

**Table 2. The impact of digital technology on service export for countries with higher GDP levels than the median GDP in 2017**

Variables	1	2	3	4	5
	FE	FE	FE	FE	FE
DESI TOTAL	0.903***				
DESI CONN		0.418***			
DESI DPS			1.089***		
DESI HC				2.458***	
DESI IDT					0.745***
SEM	-3.364***	-2.545	-3.387**	-5.042***	-3.89**
SVA	1.683*	1.813*	1.641*	2.146*	1.298
IM G S	0.905***	0.879***	0.919***	1.326***	0.976***
REER	0.838	1.075	0.539	1.176	0.473
C	-19.66**	-21.66**	-17.89**	-29.61***	-14.05*
Obs.	89	89	89	89	89
R2	0.995	0.994	0.995	0.992	0.995
Hausman test	27.2***	22.04***	22.6***	21.3***	44.1***

Note: FE – fixed effect model. \*\*\*, \*\*, \* indicate statistical significance at the 1%, 5% and 10% level, respectively.

A well-developed ICT sector and a high level of digitalisation of the economy provide lower-income countries with significant opportunities for development. It is therefore important to determine the comparative impact of DESI (and its components) on service exports in both high- and lower-income countries, measured by GDP per capita. Tables 2 and 3 present the results in this context. The influence of DESI (and its components) on service exports appears to be positive and significant for both groups of countries. However, the role of digital transformation is more noticeable in countries with GDP below the median than in those above it (Tables 2 and 3). This also applies to individual DESI components, especially human capital (DESI\_HC), which is the primary DESI factor affecting service exports. This indicates that the development of ICT-skilled human resources has a key role in enhancing service exports. Countries with GDP above the median outperform those with lower GDP levels mainly regarding the impact of digital public services (Tables 2 and 3). Higher-income countries with advanced ICT infrastructure initiated their digital transformation much earlier than lower-income countries, especially in sectors like business, commerce, and public services, which further enhances their export capabilities. The next most influential DESI factors affecting service exports, aside from human capital, are digital public services (DPS) and the integration of digital technology (IDT) for both groups of countries, although with a greater impact observed in lower-income countries.

**Table 3. The impact of digital technology on service export for countries with lower GDP levels than the median GDP in 2017**

Variables	1	2	3	4	5
	FE	FE	FE	FE	FE
DESI TOTAL	1.293***				
DESI CONN		0.508***			
DESI DPS			0.769***		
DESI HC				2.950***	
DESI IDT					0.869***
SEM	2.886**	4.321***	2.664*	0.864	3.504**

SVA	-0.589	0.524	-1.018	0.937	0.478
IM_G_S	0.279	0.597**	0.888***	0.979***	0.671**
REER	3.815***	4.501***	3.317***	2.918***	3.104***
C	-37.17***	-55.3***	-44.58***	-50.41***	-47.42***
Obs.	73	73	73	73	73
R2	0.987	0.984	0.981	0.986	0.985
Hausman test	24.9***	15.8***	25.3***	28.04***	25.6***

Note: FE – fixed effect model. \*\*\*, \*\*, \* indicate statistical significance at the 1%, 5% and 10% level, respectively.

All these findings support the technology gap theory, which states that ‘catching-up’ countries can grow faster than developed, ‘leader’ countries that have completed their industrialization through advances in existing knowledge and technology (Harbi et al., 2014). This means that increasing technological development, technical knowledge, infrastructure, investment in R&D, and progress in ICT may have a greater leverage effect on boosting exports in lower-income countries than in countries with more advanced technology, as they have already achieved competence in this field, and the positive impact of digitalisation development is not so visible. The positive impact of digital transformation on exports may bring, through the technology spillover effect along companies of lower-income countries, the incentive to further transform economies by implementing economic and social policies such as tax incentives and labor market regulations to attract foreign direct investments (Özsoy et al., 2022).

Considering the impact of control variables, the estimation results show a positive and statistically significant effect of employment in the service sector (SEM), service value-added (SVA), imports of goods and services (IM\_G\_S), and the real effective exchange rate (REER) on service exports for all EU countries (Table 1). However, this impact varies across different groups of countries. The effect of service employment is positive in lower-income countries, but negative in higher-income countries (Tables 2 and 3). This result reflects the differences in human resource skills, meaning that in the former countries, employees have more basic ICT skills and still need more workers to increase exports; in contrast, in the latter countries, ICT skills are much more advanced due to higher levels of digitalization and automation, enabling growth in exports with fewer employees. Regarding the effect of service value added (SVA), differences also exist between country groups. This effect on service exports is significant (at the 10% level) in higher-income countries, but not in lower-income countries. The result seems to be related to differences in the overall economic growth and the level of digitalization, meaning that countries with advanced economic and social development, based on technology and digitalization, tend to focus on exporting products with high added value rather than those with lower added value (Bournakis and Tsoukis, 2016). Furthermore, the impact of REER on service exports is positive in both groups, meaning that an appreciation of the domestic currency is associated with an increase in service exports (Wajda-Lichy et al., 2022); however, it is only significant in lower-income countries. This may be due to the heightened importance of exchange rate fluctuations caused by higher operational risks in lower-income countries, such as political instability, high inflation, and slower economic growth, compared to higher-income countries, which are considered more stable (Özsoy et al., 2022).

Finally, the effect of imports of goods and services is positive and significant in both groups of countries, reflecting that the imports contribute to digital factor endowments by providing technology-advanced devices used by producers and exporters of services. Therefore, imported technology can support the provision of services abroad both directly and indirectly (Wajda-Lichy et al., 2022).

## Conclusions

The goal of this paper is to examine the impact of digital technology on service exports across EU countries and within subgroups of countries categorized by GDP per capita. To do this, we employ a panel data model, where digital technology is represented by the DESI and its components (connectivity, the integration of digital technology, digital public services, or ICT skills of human resources), and service exports are measured by digitally delivered services.

Our research shows the positive impact of digitalization on service exports across all EU countries and their subgroups (lower and higher-income countries). This results from the advantages digital transformation offers in service exports, such as increased competitiveness in foreign markets through technological innovations, reduced costs, and improved industrial efficiency.

When it comes to identifying the most important dimensions of digitalization among the four, our results show that digital skills of human capital are the key factor that enhances service exports in EU countries and their subgroups. This indicates that these skills are essential for the absorption and dissemination of digital technology, which in turn enhances not only service exports but also fosters economic growth, development, and social modernization (Hidalgo, 2015; Özsoy et al., 2022). The use of knowledge can help countries evolve into modern societies, defined by their capacity to utilize collective and shared knowledge (Hidalgo, 2015). This confirms that the most important determinant of development is the accumulation of knowledge, which directly influences the products and services countries produce, deliver, and export. In addition to improving human capital skills, the integration of digital technology (e-business and e-commerce) and digital public services significantly impacts the growth of service exports, primarily through increased productivity, lowered transportation costs, and shorter times to generate and deliver services (Aker, 2017; (Nassrullah et al. 2019).

However, the influence of digital transformation is more pronounced in lower-income countries across all DESI dimensions, except for digital public services, where a greater effect on service exports appears in higher-income countries. These findings support the technology gap theory, which suggests that catching-up countries can grow faster than leading countries that experienced earlier industrialization through advances in existing knowledge and technology.

Given the ongoing advancement of digital technology and its positive effect on service exports, this study offers valuable insights for economic policymakers. Export-driven growth focused on service exports requires digital infrastructure; therefore, additional ICT investment—highlighted as one of the key factors boosting exports (Farooqi et al., 2020)—is especially necessary in lower-income countries to develop into digitally advanced economies with modern service exports. Recognizing the positive effects of digitization through spillover effects among companies can offer motivation for economic and social policies aimed at further transformation —such as tax incentives and labor market reforms—to attract foreign direct investment. As protectionist actions increased after the Covid-19 pandemic and many economies started to protect their domestic markets from foreign competition, the understanding that importing goods and services supports the export of services should reduce the desire to impose trade restrictions. Therefore, liberal trade policies, along with regulations governing trade in ICT goods and services, should be a central part of export-oriented growth strategies.

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