Estimating the effects of connectivity in intra-EU digitally deliverable trade in services

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Number of words: 2556

1. Research question

This report corresponds to a first attempt to explore the **relationship between internet connectivity and digitally deliverable trade in services among the 27 member countries of the European Union (EU)**. This research seeks to assess how enhanced digital infrastructure within the EU has influenced the volume of digitally deliverable services exchanged among member states, providing insights into the evolving landscape of digital trade in an interconnected Europe.

The project is motivated by the significant increase in internet connectivity and speeds across the EU, where private household internet coverage (with speeds over 100 Mbps) rose from 45.5% in 2013 to 88.1% in 2023 (EUROSTAT, 2024). Additionally, Fiallos and Liberatore (2023) discuss that digitalization has significantly influenced trade in services, with technological advancements enabling the remote delivery of various service types. Between 2005 and 2021, globally, digitally deliverable services grew at an average annual rate of 7.7%, outpacing the 3.9% growth rate of non-digitally deliverable services (Fiallos, A. and Liberatore, A; 2023).

Digitally deliverable services refer to those that can be provided remotely over computer networks, though it is important to distinguish that the capability of digital delivery does not necessarily mean that services are always digitally delivered in practice; hence, the scope of digitally deliverable trade is broader than the subset of services that are actually delivered digitally (*IMF-OECD-UNCTAD-WTO,* 2023).

The study relies on international services trade data, aligning with the framework outlined in Chapter 4 of the *IMF-OECD-UNCTAD-WTO Handbook on Measuring Digital Trade* (2023). Key service categories analyzed include insurance and pension services, financial services, charges for the use of intellectual property n.i.e., telecommunications and IT services, research and development services, professional and management consulting, architectural and

engineering services, trade-related and other business services, audio-visual and related services, health and education services (excluding those linked to international travel), as well as heritage and recreational services. These categories are defined within the Extended Balance of Payments Services (EBOPS-2010) classification system.

2. Description of datasets in the project

The analysis relies on 4 publicly available datasets, find below a brief description of each of these datasets.

International trade in services - OECD (2024)

This dataset compiles detailed balance of payments data on international trade in services by partner country. According to the OECD, trade in services records the value of services exchanged between residents and non-residents of an economy, including services provided through foreign affiliates established abroad. Services include transport (both freight and passengers), travel, communications services (postal, telephone, satellite, etc.), construction services, insurance and financial services, computer and information services, royalties and license fees, other business services, cultural and recreational services, and government services.

GDP per capita - Eurostat (2024)

The Eurostat GDP per capita dataset is a comprehensive resource for analyzing economic performance and regional disparities across Europe. It provides GDP per capita values in purchasing power standards (PPS) or Euros, adjusted for inflation and purchasing power parity. The dataset spans multiple decades and includes granular data at national and regional levels. Key features include time-series data, standardized under ESA 2010, ensuring comparability across countries and regions. This dataset is ideal for exploratory data analysis, trend forecasting, and modeling economic inequality or growth. Variables include region/country identifiers, observation years, and GDP per capita metrics in current and constant prices.

Internet coverage - Eurostat (2024)

The Broadband Internet Coverage by Speed dataset from Eurostat tracks broadband accessibility across Europe, with data segmented by speed categories such as below 30 Mbps or above 100 Mbps. It highlights the percentage of households or populations covered by broadband services, offering insights at both national and regional levels over several years. The dataset is crucial for evaluating the progress of digital infrastructure, pinpointing disparities in internet access, and shaping strategies for improving connectivity. Key fields include geographic identifiers, year, and broadband coverage metrics by speed.

Gravity database - CEPII (2022)

The CEPII Gravity database provides, for any pair of countries, from 1948 to 2020, all the information required to estimate gravity equations. Each observation corresponds to a combination of an exporting country, an importing country and a year for which the CEPII provides trade flows, as well as geographic, cultural, trade facilitation and macroeconomic variables. Gravity is the main dataset, which contains the core information. Within the dataset, countries are referred to using the variable country_id, which combines a country's alphabetic ISO3 code with a number identifying potential territorial transformations of the country.

Table 1: Datasets used in this report

Dataset	Observations	Variables	Period
International trade in services	13538757	15	1961-2023
GDP per capita	970	6	2012-2023
Internet coverage	1176	7	2013-2023
Gravity model	4699296	87	1948-2021

3. Data analysis

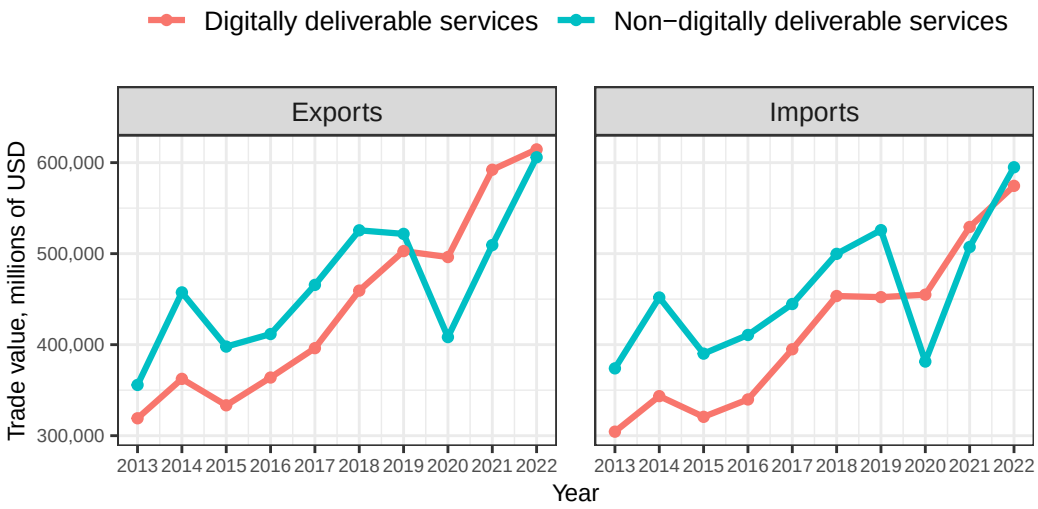
What do the data say? A visual exploration

Evolution of digitally deliverable services

Trade in digitally deliverable services has grown at a significantly faster pace compared to non-digitally deliverable services. At the global level, during the period from 2005 to 2021, digitally deliverable services experienced an average annual growth rate of 7.7%, substantially outpacing the 3.9% growth rate recorded for non-digitally deliverable services (Fiallos and Liberatore, 2023).

Figure 1 illustrates the contrasting evolution of these two types of services within the European Union (EU). The data highlights a particularly pronounced surge in the trade value of digitally deliverable services during 2020 and 2021, a period marked by the COVID-19 pandemic, which accelerated the adoption of digital tools and remote work practices. This growth enabled digitally deliverable services to outgrow non-digitally deliverable services in terms of trade value. By 2022, the exports of digitally deliverable services within the EU had surpassed those of non-digitally deliverable services.

Figure 1: Trade value by digitally deliverable and non−digitally deliverabl
Intra EU trade from 2013 to 2022



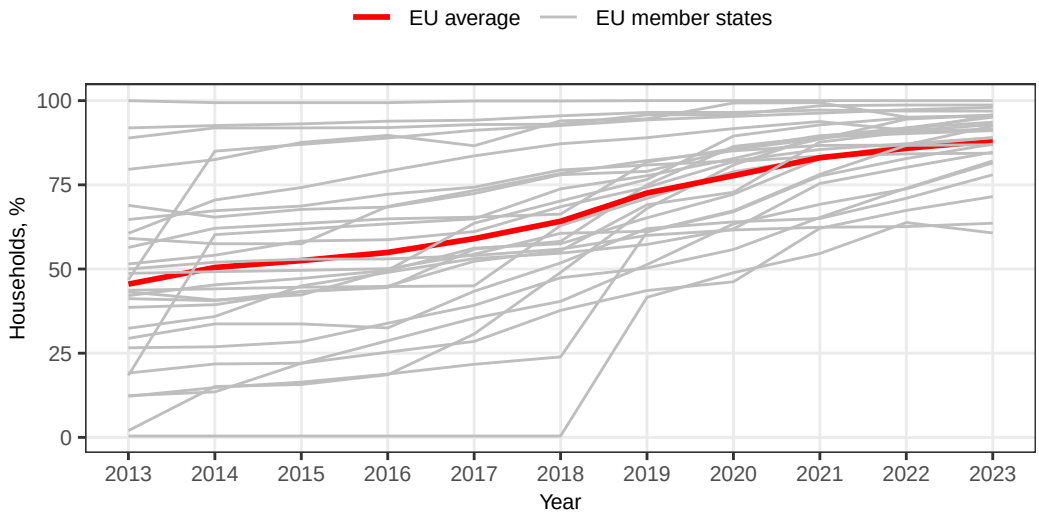
Source: Own elaboration with data from OECD. (2024).

Evolution of internet coverage in the EU

There has been a significant increase in internet connectivity and speeds across the EU. Private household internet coverage with speeds exceeding 100 Mbps rose from 45.5% in 2013 to 88.1% in 2023 (EUROSTAT, 2024). **Figure 2** illustrates the evolution of high-speed internet coverage in private households over this period, highlighting a growth of more than 40 percentage points in the EU average within 10 years.The graph contrasts the EU average with individual country data, showing that by 2023 all member states achieved coverage rates above 60%.

Figure 2: Evolution of internet coverage in EU member states from 2013−2023

Percentage of households with internet connection faster than 100 Mbps

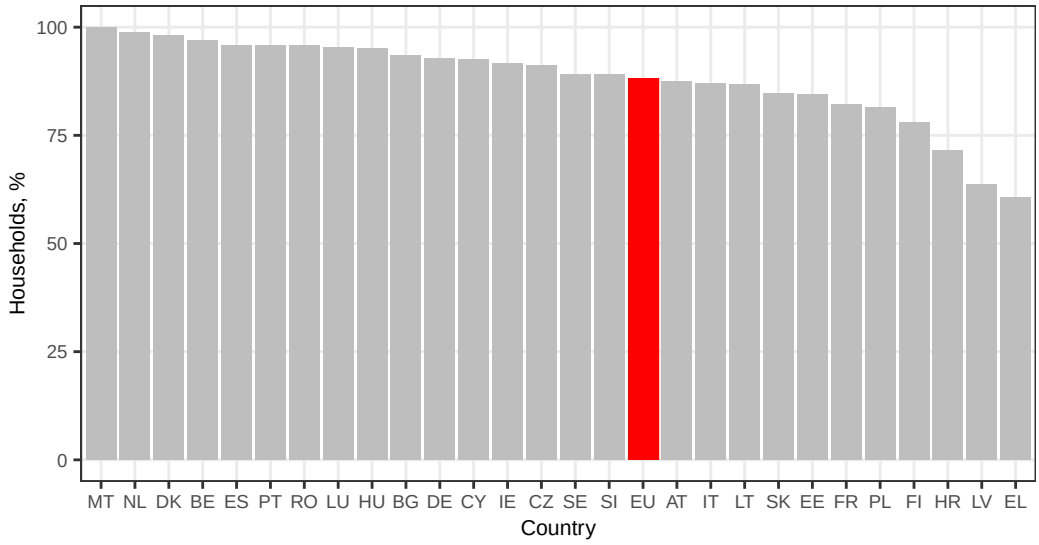


Source: Own elaboration with data from Eurostat and OECD. (2024).

Figure 3 further examines the state of internet coverage by EU member countries in 2023. Malta, the Netherlands, and Denmark achieved the highest coverage in the union, while Greece, Hungary, and Latvia reported the lowest, although still above the 60% threshold.

Figure 3: Internet coverage in EU member states in 2023

Percentage of households with internet connection faster than 100 Mbps



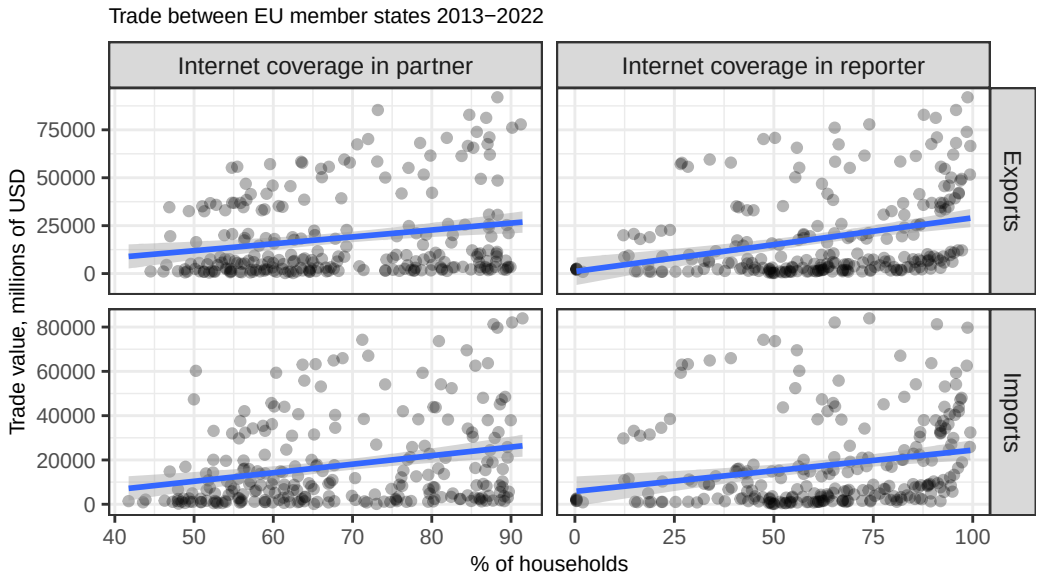
Source: Own elaboration with data from Eurostat. (2024).

Digitally deliverable trade and internet coverage

Figure 4 illustrates the relationship between digitally deliverable trade within EU countries and internet coverage. The graph shows exports and imports, considering both the internet coverage of the reporting countries and their trade partners. This visualization allows for the exploration of whether digitally deliverable trade is more strongly influenced by a country's own connectivity or that of its trading partners. The figure aggregates trade values by reporter, year and flow, correlating them with two measures: internet coverage in the reporting country and a trade value-weighted average of internet coverage in partner countries.

The visualization suggests a relationship between the variables under study: higher levels of internet coverage are associated with greater digitally deliverable trade, both in exports and imports. However, while the graph reveals this positive relationship, it does not indicate whether the internet coverage of the reporting country or that of its trade partners plays a more significant role.

Figure 4: Digitally deliverable trade and internet coverage



Source: Own elaboration with data from Eurostat and OECD. (2024).

Econometric analysis: a gravity model

This study applies a model inspired by the gravity model developed by Liberatore and Wettstein (2021), which examines global bilateral trade in services. Liberatore and Wettstein employed various specifications of a base model depending on the availability of regressor data. In contrast, our research focuses on estimating a single model, which is a modified version of what they termed their "full model."

A notable innovation in our approach is the inclusion of internet coverage as an explanatory variable for both the reporting and partner countries, which is meant to capture the impact of internet coverage in digitally deliverable services trade. The model specification is as follows:

$$\begin{aligned}\textbf{digital\_trade}_{ijt} = \beta_0 &+ \beta_1 \textbf{gdp\_pc}_{it} + \beta_2 \textbf{gdp\_pc}_{jt} + \beta_3 \textbf{distance}_{ij} \\ &+ \beta_4 \textbf{contiguity}_{ij} + \beta_5 \textbf{common\_language}_{ij} + \beta_6 \textbf{total\_serv}_{ijt} \\ &+ \beta_7 \textbf{factor(year)}_t + \beta_8 \textbf{factor(partner)} + \beta_9 \textbf{internet\_coverage}_{it} \\ &+ \beta_{10} \textbf{internet\_coverage}_{jt} + \epsilon\end{aligned}$$

where each of the variables is defined as:

- $\textbf{digital\_trade}_{ijt}$: Bilateral digitally deliverable trade between country i and j in year t.
- $\textbf{gdp\_pc}_{it}$: GDP per capita of reporting country i in year t.
- $\textbf{gdp\_pc}_{jt}$: GDP per capita of partner country j in year t.
- $\textbf{distance}_{ij}$: Distance between countries i and j in year t.
- $\textbf{contiguity}_{ij}$: 1 if countries i and j are neighboring countries.
- $\textbf{common\_language}_{ij}$: 1 if countries i and j share a common language.
- $\textbf{total\_serv}_{ijt}$: Total trade in services between countries i and j in year t.
- $\textbf{internet\_coverage}_{it}$: Internet coverage in reporting country i in year t.
- $\textbf{internet\_coverage}_{jt}$: Internet coverage in partner country j in year t.
- $\textbf{factor(year)}_t$: Fixed effects of year t.
- **factor(partner)**: Fixed effects of partner country.
- ϵ: Error term.

Poisson Pseudo Maximum Likelihood (PPML)

The Poisson Pseudo-Maximum Likelihood (PPML) estimation method is widely used for gravity models within the framework of generalized linear models (GLMs). It involves estimation through a GLM with a quasipoisson distribution and a log-link function. Originally introduced by Silva and Tenreyro (2006), PPML has become a standard method for analyzing trade flows.

In this study, the proposed econometric specification is estimated using the PPML method. The data is divided into exports and imports, and two separate regressions are estimated, one

Table 2: Results of PPML regressions

	Exports		Imports	
	Est.	S.E.	Est.	S.E.
(Intercept)	−0.964**	0.341	−0.329***	0.060
GDP per capita: reporter	0.041***	0.004	−0.030***	0.004
GDP per capita: partner	0.058+	0.032	0.064***	0.004
Distance	0.000	0.000	0.000	0.000
Contiguity	−0.104***	0.008	−0.091***	0.008
Common language	−0.041***	0.012	−0.035**	0.012
Total services traded	0.225***	0.002	0.223***	0.002
Internet coverage: reporter	0.030***	0.003	0.019***	0.003
Internet coverage: partner	0.011*	0.005	0.031***	0.003
Num.Obs.	5844		5839	
RMSE	0.71		0.75	

Significance levels: + p<0.1, * p<0.05, ** p<0.01, *** p<0.001

for each flow. The results are summarized in **Table 2**. Note that, for relevance, the fixed effects for year and partner countries are not included in the table.

Results

The estimated coefficients indicate a positive and statistically significant relationship between the trade value of digitally deliverable services and internet coverage in both the reporting and partner countries, for both export and import flows within EU countries between 2013 and 2022, under the proposed model specification. For exports, the internet coverage in the reporting country appears to have a slightly stronger influence than in the partner country (estimated coefficients of 0.030 versus 0.011). This suggests that the availability of reliable and widespread internet infrastructure in the exporting country plays a crucial role in facilitating digitally deliverable trade.

In contrast, for imports, internet coverage in partner countries seems to have a slightly greater influence than in the reporting country (estimated coefficients of 0.031 versus 0.019). This could indicate that the ability of a country to access and consume digitally deliverable services is more dependent on the internet infrastructure of the partner country, rather than that of the reporting country. Nevertheless, the internet coverage in the reporting country remains an explanatory factor.

4. Robustness testing

To ensure that our results are not sensitive to the choice of data subsets, we apply the same PPML method separately to Eastern and Western Europe. For this analysis, Eastern Europe includes Bulgaria, Hungary, Croatia, the Czech Republic, Estonia, Latvia, Lithuania, Poland, Romania, Slovakia, and Slovenia. All other countries are classified as part of Western Europe. The data remains divided into imports and exports but is further segmented by Eastern and Western regions. This distinction is based on the reporter country for each trade flow. The results of the regressions are displayed in **Table 3**.

Table 3: Results of PPML regressions by region

	Exports - Eastern Europe	Exports - Western Europe	Imports - Eastern Europe	Imports - Western Europe
(Intercept)	−1.430*	−0.830*	−1.706***	−0.321***
	(0.647)	(0.329)	(0.181)	(0.071)
GDP per capita: reporter	0.042*	0.050***	0.073***	−0.023***
	(0.019)	(0.004)	(0.019)	(0.005)
GDP per capita: partner	0.053	0.078*	0.082***	0.071***
	(0.060)	(0.031)	(0.008)	(0.005)
Distance	0.000	0.000***	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Contiguity	−0.057***	−0.093***	−0.081***	−0.097***
	(0.015)	(0.008)	(0.014)	(0.009)
Common language	−0.031	−0.009	0.059*	−0.008
	(0.031)	(0.011)	(0.029)	(0.012)
Total services traded	0.284***	0.171***	0.272***	0.201***
	(0.005)	(0.003)	(0.003)	(0.002)
Internet coverage: reporter	0.024*	0.035***	−0.016	0.026***
	(0.011)	(0.002)	(0.011)	(0.003)
Internet coverage: partner	0.034***	0.005	0.054***	0.022***
	(0.010)	(0.005)	(0.006)	(0.004)
Num.Obs.	2502	3342	2487	3352
RMSE	0.68	0.60	0.68	0.71

Standard errors in parentheses
Significance levels: * p<0.05, ** p<0.01, *** p<0.001

The separate regressions for Eastern and Western Europe confirm a significant relationship between the trade value of digitally deliverable services and internet coverage in the partner country for both imports and exports involving Eastern European countries. Specifically, the estimated coefficient indicates that a 1% increase in the internet coverage of a partner country leads to a 0.034% increase in digitally deliverable exports from Eastern Europe, and to a 0.054% increase in parallel for imports.

Overall, the findings highlight regional differences in the magnitude of key factors influencing trade. The coefficients for Eastern Europe tend to be smaller than those for Western Europe, reflecting potential disparities in digital infrastructure or trade capacity. For instance, in the global analysis of exports, the estimated coefficient for internet coverage in the reporting country is 0.030. This compares to 0.024 for exporting countries in Eastern Europe and 0.035 for those in Western Europe. Despite these smaller coefficients for Eastern Europe, the positive and statistically significant relationships remain consistent. These results underscore

the critical role of internet connectivity in facilitating trade in digitally deliverable services, while also pointing to regional variations in the extent of this effect.

5. Conclusion

This research represents an initial exploration into the relationship between internet connectivity and digitally deliverable trade in services among the 27 member countries of the European Union (EU). By analyzing data spanning from 2013 to 2022, the study reveals a significant and positive relationship between enhanced digital infrastructure and the volume of digitally deliverable services exchanged within the EU. The findings suggest that improved internet coverage, both in the reporting and partner countries, plays a crucial role in facilitating trade in digitally deliverable services.

The analysis indicates that for exports, the internet coverage in the reporting country has a slightly stronger influence on trade volumes than the internet coverage in partner countries. This highlights the importance of reliable and widespread internet infrastructure in the exporting country for enabling the remote delivery of services. Conversely, for imports, the internet coverage in the partner country appears to be more influential, emphasizing that the ability of a country to access and consume digitally deliverable services is largely dependent on the connectivity available in the partner country, though the reporting country's internet infrastructure also remains a significant factor.

These findings underscore the growing significance of internet infrastructure in driving digitally deliverable trade, a sector that continues to expand as technology evolves. As digital services such as cloud computing, software, and digital media increasingly define global trade flows, the quality and availability of internet coverage will continue to be pivotal in shaping these exchanges. Moreover, the results of this study offer insights into how EU member states can strategically invest in digital infrastructure to further enhance cross-border trade trough digital means.

In conclusion, this research contributes to the understanding of the role of internet connectivity in fostering trade in services within the EU. It also paves the way for future studies to explore deeper relationships between internet infrastructure and specific sectors of digitally deliverable services, potentially guiding policies aimed at strengthening digital trade within and beyond the EU.

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