# Trade flows, spatial effects and cohesion policy in the EU regions

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**Abstract**

The European regions are increasingly interconnected and directly benefit from cohesion policy funds. To jointly study the two phenomena, we combine panel data on regional bilateral trade flows and information on the EU funds and apply a spatial panel origin-destination gravity model. Our empirical analysis points out that EU cohesion policy plays a relevant role for explaining bilateral regional trade flows in Europe. We also find that spatial interactions, both at the origin and destination, are important to understand regional trade flows. Our results are robust to alternative specifications and different sensitivity checks. In policy terms, the analysis points to the need to consider inter-regional and trade effects in the welfare assessment of cohesion policy, as well as to coordinate regional development and market integration policies.

*Keywords:* Trade integration; EU cohesion policy; spatial gravity panel models; spatial effects.

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## 1. Introduction

One of the key goals of European integration is the free movement of goods and services across Europe with the aim of creating a single, common market and promoting growth. This objective has been implemented through several reforms, the most notable ones coming from the Single European Act (1986), the Maastricht Treaty (1992), the Amsterdam Treaty (1997) and the Lisbon Treaty (2007). Integration has been largely achieved over the past fifty years, by leading to raising trade flows among the European Union (EU) Member States (Head and Mayer, 2021). From 2002 to 2023, the intra-EU trade of goods and services, measured by total imports and exports, increased by about 21%, approximately 7 p.p. more than the growth of extra-EU trade flows during the same period.[1]. The growth of European trade flows has been heterogeneous among countries (Azcona, 2022) and regions (Santamaría et al., 2023), by pointing out the importance of spatial factors, such as geography, agglomeration economies and industry location patterns, in explaining bilateral trade flows in Europe (Redding and Venables, 2004; Agnosteva et al., 2019). The investigation of the spatial dimension of trade flows is worthwhile (Behrens et al., 2012; Egger and Pfaffermayr, 2016) and progressively attracting research interest (Nijkamp and Ratajczak, 2021; Baltagi et al., 2024), though evidence is limited for the EU regions (Crucitti et al., 2023; Bettarelli et al., 2024).

Efforts to sustain convergence and promote balanced economic development patterns were equally remarkable. Starting from late 1980, the Cohesion Policy has been used to finance regional development in the EU. In the years 2021-27, the funds allocated to cohesion amount to 392 billion euro, about one-third of total EU budget, which raise up to about half a trillion euro after including national cofinancing. There is now agreement on the average positive impact of the cohesion funds on economic convergence across Europe (Commission, 2024), though with remarkable differences within Member States and between different phases (see, among others, Di Caro and Fratesi (2022); Destefanis and Di Giacinto (2023); Camagni et al. (2020)). The most positive result concerns the lastest entrants: in Central and Eastern Europe, for instance, the gross domestic product (GDP) percapita passed from about 52% of the EU's average in 2004 to around 80% in 2021,

[1]The welfare gains of EU trade are estimated to be around 4% on average for the Member States (Mayer et al., 2019). In 1993, the share of trade in goods in GDP for the 12 Member States that made up the Single Market at that time was 8. 4%, while in 2022 it increased to 17.6% for the EU-27; data available at https://single-market-scoreboard.ec.europa.eu

with differences within countries.[2]

What is missing, however, is the assessment of the trade effects of the EU cohesion policy, which is timely today for understanding the overall returns of place-based policies in a global context (Draghi, 2024).

The main objective of this paper is to study the role of the cohesion policy for explaining regional bilateral trade flows in the EU at NUTS-2 level. In detail, we apply a spatial gravity origin-destination flow model (LeSage and Pace, 2008; LeSage and Llano, 2016) to regional trade data covering the period 2000-2017 augmented with information on the EU cohesion funds. The spatial gravity approach allows for the consideration of multiple sources of spatial interactions in trade estimates (Thomas-Agnan and LeSage, 2021), which are likely to be relevant when looking at regional observations (LeSage, 2015; Jeong and Lee, 2024). In economic terms, we jointly investigate the relations between trade connections, spatial concentration of economic activities, and the availability of public funds (Piazolo, 1997; Behrens et al., 2007). This is grounded on the idea that public policies, such as industrial and regional policies, can influence trade in the areas that benefit from such funds through multiple channels like trade cost reduction, knowledge diffusion, production and consumption network effects (Antràs et al., 2012; Rotunno and Ruta, 2024).

Our work connects to the following strands of empirical literature. We first contribute to the large body of economic studies that look at the trade effects of the European integration process (Baldwin and Venables, 1995; Ito and Okubo, 2012; Pentecôte et al., 2015; Caliendo et al., 2021; Attinasi et al., 2023) along different dimensions. Thanks to the availability of regional trade data, we provide new, panel evidence on trade dynamics in the EU at a finer scale of analysis (i.e. regions), by further exploring the presence of territorial heterogeneity (Walz, 1997; Nicolini, 2003; Basile and Ciccarelli, 2018; Mayer et al., 2019). Moreover, the application of the spatial gravity model throws new light into the importance of spatial interactions for explaining regional trade (Head and Mayer, 2006; Bruna, 2024). We also explicitly look at the role of the EU cohesion policy as a source of trade integration across Europe, by integrating recent evidence on the interactions between trade and place-based policies (Blouri and Ehrlich, 2020; Magerman and Palazzolo, 2024). In addition, our study brings a new look at the literature on the impact of the EU cohesion policy, by directly connecting the availability of

[2] An overview of the indicators on the impact of CP is available at https://cohesiondata.ec.europa.eu/stories/s/fiy9-2zvn

structural funds to regional trade.[3] Differently from recent cohesion studies using trade relations in the evaluation of the impacts of EU funds (Fiaschi et al., 2018; Amendolagine et al., 2024), we adopt a novel perspective and provide an empirical assessment of the trade consequences of the EU cohesion policy in a trade gravity framework integrated with spatial interactions.

The rest of the paper is organized as follows. In Section 2, we discuss the background framework that motivates our empirical investigation. Then, in Section 3, we presents data and preliminary evidence. The empirical analysis, including methodology and main results, is in Section 4. In Section 5, we provide robustness and additional results. In the final section, we conclude our work.

## 2. Conceptual background

Public funds, such as the EU cohesion policy, can shape regional bilateral trade flows along different dimensions. The funding of physical infrastructures (e.g., roads, railways, etc.) and transports, which is of primary importance in terms of allocation of the European Regional Development Fund (ERDF), can contribute to the reduction of trade costs and barriers, the creation of trade networks, and the improvement of market accessibility (Redding and Venables, 2004; Fajgelbaum and Schaal, 2020). Such effects are not limited to regional-pairs (i.e. origin and destination regions), but they are likely to impact welfare in other, neighboring areas through cross-border effects (Arkolakis et al., 2023). The expected impact of the cohesion policy on regional bilateral trade flows through the trade cost channel, therefore, is likely to be positive for most of the EU regions particularly in the long-run (Boehm et al., 2023).

The availability of public transfers in a given area, as in the case of place-based policies funded at Union-wide level, can sustain local productivity and income and, in turn, produce trade and welfare gains (Blouri and Ehrlich, 2020; Evenett et al., 2024). On the demand side, for a given region, an increase of income induces higher expected imports from other areas that are located in the same country and/or in different trade partners (Dekle et al., 2007). One the supply side, the improvement of labor and capital productivity benefiting from the support of place-based policies can translate in higher export activities, thanks to the increased firm performance particularly in the manufacturing sector (Head and Mayer, 2006). In this case, the net impact of public funds on bilateral trade flows

[3]It is outside the boundaries of this work to review the large literature on cohesion policy; for recent discussions see (Bachtler and Mendez, 2020; Fratesi, 2023).

depend on region-specific features, such as skill distribution, wage adjustment, market integration, and migration patterns (Caliendo et al., 2021; Lambertini and Proebsting, 2023).[4]

There are other channels of potential influence of the cohesion policy on bilateral trade flows. Provided that the EU structural funds can operate as shock-absorber mechanism during recessions (Arbolino and Di Caro, 2021; Di Caro and Fratesi, 2023), we can expect a positive relation between cohesion funds and demand for imports from main trade partners at time of crises (Azcona, 2022; Boffardi et al., 2022). The EU regions, all benefiting from cohesion funds though not with the same intensity, are increasingly connected inter-regionally through supply chains. This implies that place-based policies, particularly those targeted at improving firm competitiveness and the allocation of input factors, can produce trade and welfare gains through the creation and/or support of input-output linkages (Magerman and Palazzolo, 2024). Place-based policies, moreover, can be used to create/sustain Krugman-type externalities at a local level (Kucheryavyy et al., 2023) and, in turn, they can support tradable activities and the trade performance of given areas. Lastly yet importantly, the EU funds are also employed to support innovation and R&D activities (Hervás-Oliver et al., 2021), by favoring cross-border knowledge creation diffusion with positive implications on trade in goods and services (Cai et al., 2022).

## 3. Data and preliminary evidence

In the empirical analysis, we construct a balanced panel of regional bilateral trade flows for 201 NUTS-2 level EU regions belonging to 27 Member States for the period 2000-2017 (T=18). Trade flows are obtained by using regional trade flow data provided by the European Commission-JRC (Thissen et al., 2019; Barbero et al., 2024) for different years.[5] The data, which are increasingly used

[4]As for the EU regions, which share common Union-wide institutions and the same currency for the majority, the impact of public spending on trade through nominal exchange change effects is likely to be of minor importance (Müller, 2008).

[5]Regional trade flow data from the EU Commission are available for the years 2000-2010; 2013; and 2017; source: https://data.jrc.ec.europa.eu/dataset/432cf8a7-fd5e-4816-a70c-633a7380c77c. To obtain panel data covering all the years from 2000 to 2017, we first use linear interpolation for the missing years. The resulting regional trade flows are compared to a different source of regional bilateral trade data for the period 2008-2018 (Huang and Koutroumpis, 2023). We also check for the reliability of data for missing years by constructing region trade flows after applying regional trade weights to (available) information on intra-EU trade flows at country level;

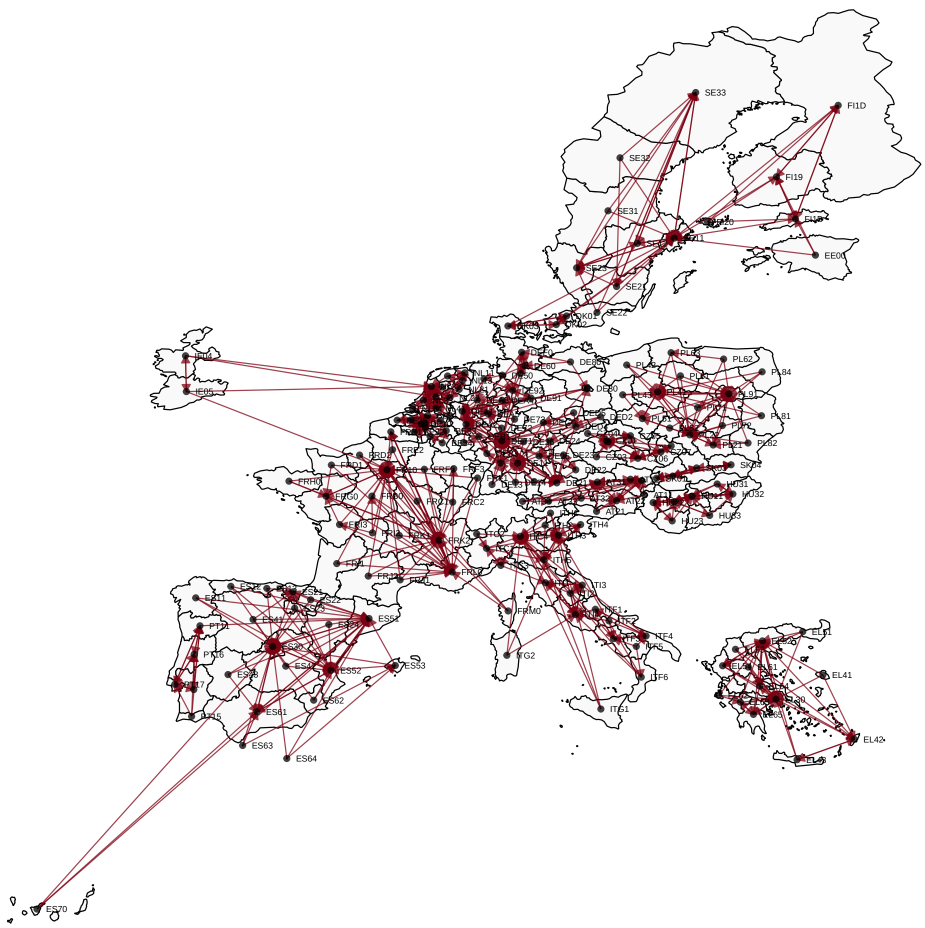
in empirical analyses on the cohesion funds (Blouri and Ehrlich, 2020; Crucitti et al., 2023), are useful to calculate bilateral regional trade flows (in quantity), as obtained from regional exports and imports information available in input-output tables.

In the graphs below, we show preliminary evidence on internal trade flows in the EU, as deriving from the dataset used in this study. In particular, in Figure 1, we show regional bilateral trade flows connecting the EU regions over the sample period, by focusing on trade data for the three main trade partners.[6] The circle graph in Figure 2 shows the regional bilateral trade flows, for all trade partners, after aggregating them at country level, for expositional convenience. Two aspects are worth commenting on. First, regional bilateral trade flows across Europe, which also includes internal (for a given country) trade connections, show evident national effects but also linkages beyond the national borders and geographical proximity (Piribauer et al., 2023). Second, as it can be observed from the width of the country-specific area in the circle graph in Figure 2, most of the bilateral trade flows occur within and/or with EU MS that play a pivotal role in the EU economy such as France, Germany, Italy and Spain (Santamaría et al., 2023). Interestingly, moreover, smaller but very open economies like Belgium and the Netherlands are central players when looking at the trade connections among the EU regions.

data from Eurostat. Results available upon request.

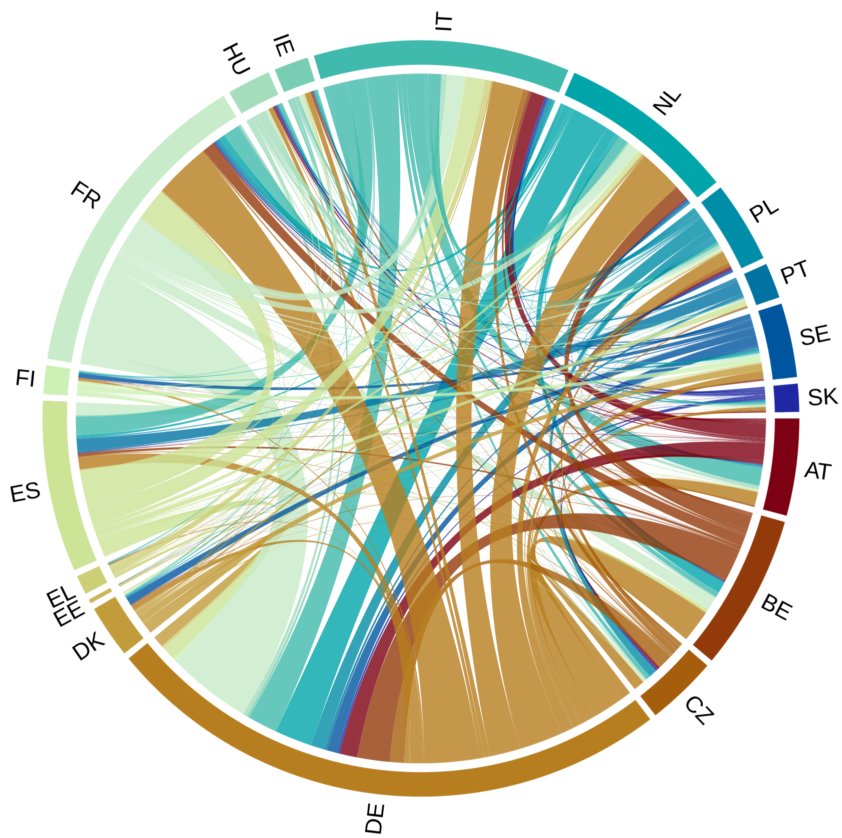
[6] In the Appendix, we show maps of EU regional bilateral trade flows based on different selections of the trade partners.

Figure 1: Mapping EU regional bilateral trade flows




Note: Trade flows are calculated on average for the years 2000-2017 for the three main regional trade partners. Our elaboration from EU Commission's trade data.

Figure 2: EU regional bilateral trade flows, by country




Note: The circle graph reports the trade flows for all trade partners, as calculated on average for the years 2000-2017, by aggregating for EU countries. Our elaboration from EU Commission's trade data.

To describe the EU cohesion policy, we use historic 'modeled' data provided by the EU Commission on 'regionalised' NUTS-2 (NUTS- 2013 version) annual EU expenditures.[7] Specifically, we use information on the ERDF that is the main

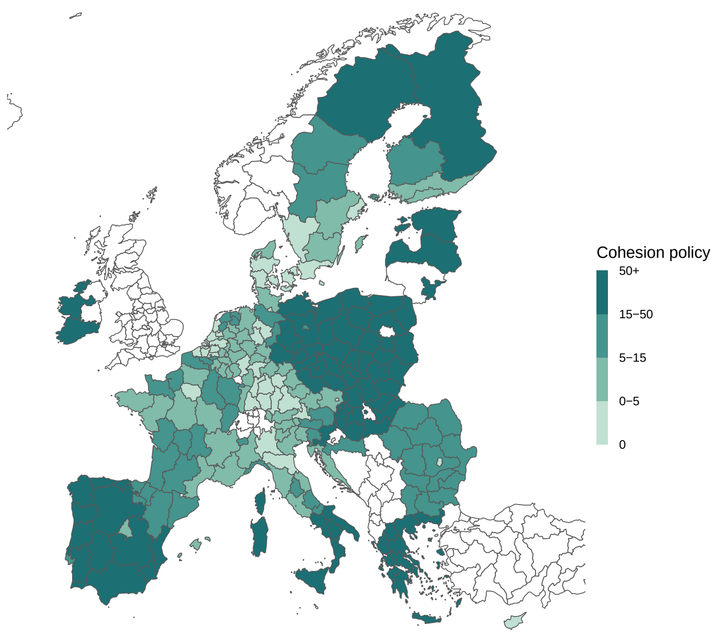
[7]Data are available at https://data.europa.eu/data/datasets/eu-cohesion-policy-historic-eu-

financial tool for funding projects for regional convergence, infrastructures, and firm competitiveness. Thus, it is the most appropriate measure of the EU cohesion policy to analyze the impact of EU funds on trade rather than other policies like the EU social fund, etc. (Di Caro and Fratesi, 2023). These data allows for the coverage of different cohesion policy programming periods and the reduction of some empirical issues, including the overlapping of years when two cohesion cycles are present (i.e. final and initial period years[8]) (Di Caro and Fratesi, 2022), and the correct imputation of funds covering different years to the year of reference of funded projects (Fidrmuc et al., 2024). In Figure 3, we show the regional distribution of the EU regional cohesion policy, as measured on average over the period 2000-2017, which shows a remarkable consistency with the levels of development, especially at the country level, while funding inside countries is less strictly related to income per capita (Dotti, 2013).

payments-regionalised-and-modelled?locale=en.

[8]Due to the complex institutional mechanisms, the start of funding in any programming period is normally delayed and, also for this reason, 2 or 3 additional years for spending have normally been granted (N+2 or N+3 rules).

Figure 3: EU cohesion policy (ERDF) per inhabitant




Note: The graph reports the distribution of the ERDF flows, as calculated on average for the years 2000-2017. Our elaboration from EU Commission's trade data.

In the empirical analysis, we use data on regional economic variables (e.g., GVA, population, etc.) obtained from Cambridge Econometrics - Ardeco dataset. Data on regional distance among the EU Regions are taken from (Persyn et al., 2020b), where different information on geographical distance based on multiple road segments (arcs) containing highways, primary and secondary roads (including bridges and tunnels), and ferries, including additional information on the characteristics of the roads such as the presence of traffic lights and roundabouts, the curvature, and the surface material. To save space, summary statistics and additional information on data are in the Appendix.

## 4. Empirical analysis

### *4.1. Methodology*

In the non-spatial trade gravity modeling framework, the explanation of bilateral trade flows $y^{od}$ from an origin region $o = 1, ..., O$ to a destination region

$d = 1, \ldots, D$ combines region-specific variables at both origin $X^o$ and destination $X^d$ (i.e. push and pull factors), distance-based measures $d^{od}$ capturing the degree of geographical proximity, and other factors usually referred as multilateral resistance barriers (Yotov, 2024).[9] Amid the region-specific variables at both origin and destination, we include the region-specific allocation of the EU cohesion policy in order to investigate the impact of cohesion funds in explaining trade relationships among the EU regions.

Since we are interested in considering spatial interactions in the trade gravity equation (Jin et al., 2023; Bruna, 2024), and we agree with the view that disregarding the interdependence of cross-sectional observations on bilateral trade flows may lead to biased and/or inconsistent estimates (Egger and Pfaffermayr, 2016; LeSage and Llano, 2016), we adopt the log-linear spatial autoregressive (SAR) gravity model (LeSage and Pace, 2008; Fischer and LeSage, 2020) that allows for the incorporation of neighboring relations at origin, destination, and origin-destination levels (LeSage and Thomas-Agnan, 2015; Thomas-Agnan and LeSage, 2021).[10]

Using matrix notation (Porojan, 2001), the SAR gravity model reads as follows:

$$Y = \rho_o W_o Y + \rho_d W_d Y + \rho_w W_w Y + \beta_0 L_n + \beta_1 X^o + \beta_2 X^d - \beta_3 d^{od} + \varepsilon \qquad (1)$$

where:

- $Y$ denotes (in matrix form) the (log of) trade flows $y^{od}$ from the origin region $o = 1, \ldots, O$ to the destination region $d = 1, \ldots, D$, with trade flows measured by exports[11];

[9] It is outside the boundaries of the present paper to provide a full description of the trade gravity models and the theoretical background; for a recent discussion see (Baltagi et al., 2024).

[10] The SAR gravity model belongs to the broad fast-growing area of spatial gravity models (Beenstock and Felsenstein, 2015; Baltagi et al., 2024), where different spatial econometric approaches have been used to incorporate spatial effects in the trade gravity equation (Behrens et al., 2012; Egger and Pfaffermayr, 2016; Egger et al., 2021).

[11] Using exports to measure bilateral trade flows is common in the gravity literature, but it can influence the results since different (log) normalization of the trade variables, such as trade shares and/or import measures, can lead to different economic interpretation and results (Santamaría et al., 2023). In the Section 5, which contains the sensitivity analysis, we further discuss this aspect.

- weights in the spatial matrices $W$ are given by the transport-based geographical distance between regions; the weight is higher if the geographical distance to the point is smaller and gradually reduces if the distance increases;
- $\rho_o$, $\rho_d$ and $\rho_w$ are parameters that capture spatial dependence;
- $L_n$ is a N $\times$ 1 matrix with all elements equal to 1;
- $X^o$ and $X^d$ relate to origin and destination factors;
- $d^{od}$ is the physical geographical distance between two regions;
- $\beta_1, \beta_2, \beta_3$ are parameters to be estimated; $\varepsilon$ is the error term.

In the relation (1), the spatial lag $W_oY$ measures the origin-based spatial dependence on the origin of the trade flow; $W_oY$ measures the destination-based spatial dependence on the destination of the trade flow; and, $W_wY$ measures the origin-destination dependence due to the interplay of spatial effects at the origin and destination of trade flows, as well (Lesage and Polasek, 2008). In economic terms, the three sources of spatial dependence describe how, and to which extent, trade flows from region $o$ to region $d$ are influenced by: (a) trade connections from neighbors of region $o$ to region $d$ arising from agglomeration forces and production/consumption linkages (Fujita et al., 2001; Antràs et al., 2012); (b) connections from region $o$ to neighbors of region $d$ useful to capture market accessibility effects (Krugman, 1991; Head and Mayer, 2014); and, (c) connections from neighbors of region $o$ to neighbors of region $d$ including trade diversification and trade diversion effects (Eaton and Kortum, 2002).

From an empirical perspective, one of the main issues of the model in (1) is that the origin-destination flows requires the vectorization of the $n \times n$ square matrix of regional flows from each of the $n$ origin regions $o$ to each of the $n$ destination regions $d$. This implies that we have to deal with a $n^2 \times 1$ vector of trade flows obtained by stacking the columns of the flow matrix into a vector representing our dependent variable $Y$. Starting from a single row-standardized spatial weight matrix $W$, moreover, we need to construct three different spatial matrices in order to decompose the different sources of spatial dependence.[12] We define the matrix $W$ as the $n \times n$ spatial weight matrix derived from the geographical

[12]The three matrices are: $W_o$, the spatial weight matrix capturing 'origin-based' spatial dependence $(W \otimes I_n)$; $W_d$, the spatial weight matrix capturing the 'destination-based' spatial dependence $(I_n \otimes W)$; and, $W_w = W \otimes W$, the spatial weight matrix reflecting an average of flows from neigh-

transport-based distance that incorporates information on transport network information with the support of the geographical information system (PostGIS) (Persyn et al., 2020a). The $W$ has been normalized by the maximum-eigenvalue method proposed in Kelejian and Prucha (2010) and, in the main analysis, we have opted for a cut-off distance threshold of 250 kilometers.[13]

### 4.2. Main results

In Tables 1 and 2, we report the main results of our empirical analysis, based on the application of the model in equation (1) to total bilateral trade flows (Table 1), as measured by summing domestic and foreign (across the EU MS) trade flows, and trade flows across the EU countries only (Table 2). This choice is motivated, and consistent with theoretical models on trade flows, by the importance of considering the impact of explanatory variables in trade gravity models after accounting for domestic trade (Yotov, 2022). In each table, we report: non-spatial gravity results without and with the cohesion policy as explaining variable (models 1 and 2); spatial gravity results without and with the cohesion policy as explanatory variable (models 3 and 4).

Since in all models our findings confirm the positive role of origin- and destination-specific factors, including GVA and population, and the negative impact of geographical distance for explaining regional bilateral trade flows, in line with previous studies (Porojan, 2001; Head and Mayer, 2014), we limit the main comments to the estimated impact of the variables of interest of this study, namely the EU cohesion policy and spatial effects.

bors of the origin region to neighbors of the destination region. The term $\otimes$ is the *Kronecker product* that allows obtaining vectors without having to deal directly with $n^2 \times n^2$ matrices by improving computational efficiency (LeSage and Thomas-Agnan, 2015).

[13] The selection of the specific cut-off distance is based on the best trade-off (i.e., the lower the better criterion) between the AIC value and the spatial Lagrange Multiplier (LM - Anselin et al. 1996) test's statistics. We have also checked the robustness of our results to alternative definitions of the $W$ matrix by using the Moran's Index; results reported in the Appendix.

Table 1: Results for total regional bilateral trade flows in the EU

| | *Dependent variable:* | | | |
|---|---|---|---|---|
| | Total trade flows | | | |
| | (1) | (2) | (3) | (4) |
| GVA origin | 0.600*** | 0.637*** | 0.422*** | 0.451*** |
| GVA destination | 0.455*** | 0.504*** | 0.315*** | 0.353*** |
| Population origin | 0.061*** | −0.005 | 0.082*** | 0.033*** |
| Population destination | 0.226*** | 0.140*** | 0.206*** | 0.144*** |
| Road distance | −1.372*** | −1.407*** | −1.078*** | −1.101*** |
| ERDF origin | | 0.032*** | | 0.024*** |
| ERDF destination | | 0.041*** | | 0.030*** |
| Spatial dependence on the origin (WoY) | | | 0.194*** | 0.191*** |
| Spatial dependence on the destination (WdY) | | | 0.192*** | 0.190*** |
| Spatial interdependence (WwY) | | | −0.165*** | −0.162*** |
| Observations | 727,218 | 727,218 | 727,218 | 727,218 |
| $R^2$ | 0.696 | 0.701 | 0.746 | 0.748 |
| *Note:* | | | | *p<0.1; **p<0.05; ***p<0.01 |

Table 2: Results for regional bilateral trade flows in the EU without domestic trade

| | *Dependent variable:* | | | |
|---|---|---|---|---|
| | Foreign trade flows | | | |
| | (1) | (2) | (3) | (4) |
| GVA origin | 0.647*** | 0.666*** | 0.210*** | 0.227*** |
| GVA destination | 0.502*** | 0.533*** | 0.174*** | 0.193*** |
| Population origin | 0.018*** | −0.016*** | 0.081*** | 0.051*** |
| Population destination | 0.183*** | 0.129*** | 0.140*** | 0.108*** |
| Road distance | −1.053*** | −1.073*** | −0.024*** | −0.035*** |
| ERDF origin | | 0.017*** | | 0.014*** |
| ERDF destination | | 0.026*** | | 0.016*** |
| Spatial dependence on the origin (WoY) | | | 0.448*** | 0.447*** |
| Spatial dependence on the destination (WdY) | | | 0.454*** | 0.453*** |
| Spatial interdependence (WwY) | | | −0.275*** | −0.273*** |
| Observations | 727,218 | 727,218 | 727,218 | 727,218 |
| $R^2$ | 0.595 | 0.597 | 0.713 | 0.714 |
| *Note:* | | | | *p<0.1; **p<0.05; ***p<0.01 |

As for the impact of the cohesion policy on bilateral trade flows among the EU regions, two main aspects are worth commenting on. First, in all the estimated relations, the ERDF at the destination region plays a major role compared to the ERDF at the origin region, by possibly suggesting the prevalence of export-driven demand effects of the availability of the EU funds. Other things being equal, this finding suggests that the higher the funds available in a given trade partner the more the regional exports. This is particularly important when looking at bilateral flows without domestic trade, as in Table 2, by confirming the cross-country spillover effects of the cohesion policy (Fiaschi et al., 2018; Pfeiffer et al., 2023). In other words, our findings point out the trade impact of the cohesion policy within and across the EU member states, a quite unexplored research area (Amendolagine et al., 2024).

From the comparison of models (2) with (Table 1) and without (Table 2) the inclusion of domestic trade flows, it results that the cohesion policy plays a relevant role for explaining trade within the same country. This effect is particularly important when comparing the coefficient measuring the impact of the ERDF at the origin in the two tables, by suggesting that cohesion policy funds raising the competitiveness of a given regional economy also support its capacity to export. Our finding provides confirmation to the relevance of domestic regional trade flows across Europe, where intra-country trade still explain bilateral trade flows in most of the EU regions (Santamaría et al., 2023).

The estimated values of the coefficients capturing the three sources of spatial dependence can be interpreted as follows. We find positive, significant spatial dependence at the origin, as resulting from the estimates of the coefficient $\rho_o$. This suggests the presence of production network effects and agglomeration forces that encompasses regional borders (Antràs et al., 2012). Simply put, bilateral trade flows between a given region pair can benefit from the trade connections of the neighbors of the origin region with the destination region (Fujita et al., 2001).

We also find positive, significant spatial dependence at the destination, that is, the coefficient $\rho_d$ has a positive sign: trade flows of a given region pair are positively influenced by the trade connections of the origin region with the neighbors of the destination region. In economic terms, this finding can be due to the presence of: hub-and-spoke network effects, scale economies, and macro-regional organization of retail activities (e.g., whole-sale retailing organized by macro-areas) at the destination. This probably reflects the increasing impact of market accessibility factors across Europe (Krugman, 1991; Head and Mayer, 2014).

In addition, we find negative, significant spatial dependence for the origin-destination coefficient $\rho_w$. Ohter things being equal, this suggests substitability between trade-partners and, more specifically, means that the higher the trade flows among the neighbors of a given origin-destination region pair the lower bilateral trade of the region pair. In the EU, where tradable activities are likely to be concentrated across the space (Basile and Ciccarelli, 2018), this implies that the occurrence of trade relations among the neighbors of a given (origin/destination) region produces trade diversification effects, by subtracting trade flows to the exchanges of a given region pair (Arkolakis et al., 2023).

Lastly yet importantly, from the comparison of the spatial dependence coefficients in Tables 1 and 2, it is worth observing that spatial effects for all dimensions (i.e. origin, destination, origin-destination) are particularly relevant for understanding cross-border regional trade compared to domestic trade. Indeed, from the estimates for trade flows without domestic trade, the values of the coefficients for $\rho_o$, $\rho_d$ and $\rho_w$ are more than twice those obtained from the model estimated for total regional bilateral trade. This finding provides confirmation to the progressive trade integration of the EU regions beyond the national borders (Santamaría et al., 2023; Pfaffermayr, 2023), where domestic frictions are not present (Agnosteva et al., 2019). In other words, agglomeration forces, production and consumption network, and market accessibility are likely to mostly operate at the EU-level than at the national one, by pointing out the growing trade integration of the EU economies also at regional dimension (Head and Mayer, 2021). This also provides confirmation to the emergence of European global value chains located in different regions not necessarily belonging to the same country (Bolea et al., 2022).

## 5. Sensitivity analysis and further evidence

### *5.1. Additional results*

In this Section, we provide further evidence, as deriving from the application of the model in (1) when extending the set of explanatory variables based on economic arguments. To save space, the additional results are reported for total bilateral trade flows with the inclusion of domestic trade.[14] In Table 3, we replicate our estimates by including a dummy variable, at both origin and destination, which captures the effect of the Euro currency on regional bilateral trade flows. Our findings confirm the positive and significative impact of the adoption

[14] Additional results for bilateral trade data without domestic trade are available from the authors upon request.

of the Euro on regional bilateral trade flows, in line with previous evidence using country-level data (De Nardis and Vicarelli, 2003; Kunroo et al., 2016).

Table 3: Total bilateral trade flows with Euro currency variables

| | *Dependent variable:* | | | |
|---|---|---|---|---|
| | Total trade flows | | | |
| | (1) | (2) | (3) | (4) |
| GVA origin | 0.565*** | 0.606*** | 0.381*** | 0.413*** |
| GVA destination | 0.411*** | 0.465*** | 0.266*** | 0.307*** |
| Population origin | 0.095*** | 0.026*** | 0.126*** | 0.075*** |
| Population destination | 0.269*** | 0.179*** | 0.258*** | 0.194*** |
| Road distance | −1.375*** | −1.409*** | −1.107*** | −1.127*** |
| Euro currency origin | 0.118*** | 0.102*** | 0.139*** | 0.126*** |
| Euro currency destination | 0.092*** | 0.081*** | 0.120*** | 0.110*** |
| ERDF origin | | 0.031*** | | 0.023*** |
| ERDF destination | | 0.040*** | | 0.029*** |
| Spatial dependence on the origin (WoY) | | | 0.190*** | 0.187*** |
| Spatial dependence on the destination (WdY) | | | 0.186*** | 0.185*** |
| Spatial interdependence (WwY) | | | −0.165*** | −0.162*** |
| Observations | 727,218 | 727,218 | 727,218 | 727,218 |
| $R^2$ | 0.697 | 0.702 | 0.747 | 0.749 |
| *Note:* | | | | *p<0.1; **p<0.05; ***p<0.01 |

In Table 4, we report the results obtained from extending the model in (1) with the inclusion of a dummy variable, at both origin and destination, for the regions that belong to the new EU member states located in Central and Eastern Europe (CEE). Indeed, it is interesting to investigate the trade integration effects of the participation to the EU of the CEE countries (Breuss and Egger, 1999; Bussière et al., 2008), in the light of the consideration of additional explaining factors such as the availability of cohesion funds and spatial effects. From the results in Table 4, it emerges that being part of the CEE's regions, at both origin and destination, negatively influences bilateral trade flows in the EU. One main reason for that may point out to a still incomplete integration of these countries, which joined in 2004, 2007 and 2013 with the rest of the EU whose partnership has been longer. Furthermore, this finding can be explained by noting that most of the EU regions part of the new MS are net importers of goods produced elsewhere in Europe and, thus, their net exports are negative (Papazoglou et al., 2006).

Table 4: Regional trade flows with CEE dummy variables

| | *Dependent variable:* | | | |
|---|---|---|---|---|
| | Total trade flows | | | |
| | (1) | (2) | (3) | (4) |
| GVA origin | 0.600*** | 0.354*** | 0.422*** | 0.225*** |
| GVA destination | 0.455*** | 0.100*** | 0.315*** | 0.037*** |
| Population origin | 0.061*** | 0.282*** | 0.082*** | 0.270*** |
| Population destination | 0.226*** | 0.552*** | 0.206*** | 0.475*** |
| Road distance | −1.372*** | −1.473*** | −1.078*** | −1.181*** |
| ERDF origin | | 0.029*** | | 0.021*** |
| ERDF destination | | 0.035*** | | 0.026*** |
| Est regions origin | | −0.683*** | | −0.548*** |
| Est regions destination | | −0.476*** | | −0.396*** |
| Spatial dependence on the origin (WoY) | | | 0.194*** | 0.179*** |
| Spatial dependence on the destination (WdY) | | | 0.192*** | 0.181*** |
| Spatial interdependence (WwY) | | | −0.165*** | −0.156*** |
| Observations | 727,218 | 727,218 | 727,218 | 727,218 |
| $R^2$ | 0.696 | 0.712 | 0.746 | 0.755 |
| *Note:* | | | | *p<0.1; **p<0.05; ***p<0.01 |

### *5.2. Robustness checks*

To check for the robustness of our results, we have performed different sensitivity checks. Our bilateral regional trade flows include several zero trade flows, since some of the EU regions simply do not trade with other EU regions, thus requesting a different methodological approach (Breinlich et al., 2024).[15] In Table 5, we report the results obtained from the application of the Poisson pseudo maximum likelihood (PPML) estimator (Silva and Tenreyro, 2006), which also has the advantage of modeling heteroskedasticity in the trade data. As it can be observed, the main results of our work remain unchanged when using the PPML model. The main findings remain substantially unchanged when using origin- and destination-fixed effects, instead of origin- and destination-specific variables, in order to account for potential omitted variables bias (Redding and Venables, 2004; Baltagi et al., 2024); results available upon request.[16]

[15]In our case, zero trade flows are of minor importance, by representing around 0.22% of total bilateral trade flows.

[16]We have not included multiplicative dummy variables for origin-destination pairs, usually employed in the trade literature to account for multilateral resistance terms, since the spatial terms

Table 5: Results with PPML model

| | *Dependent variable:* | | | |
|---|---|---|---|---|
| | Total trade flows | | | |
| | (1) | (2) | (3) | (4) |
| GVA origin | 0.166*** | 0.179*** | 0.120*** | 0.129*** |
| GVA destination | 0.115*** | 0.131*** | 0.079*** | 0.091*** |
| Population origin | 0.058*** | 0.038*** | 0.061*** | 0.047*** |
| Population destination | 0.119*** | 0.093*** | 0.110*** | 0.091*** |
| Road distance | −0.369*** | −0.376*** | −0.274*** | −0.278*** |
| ERDF origin | | 0.008*** | | 0.006*** |
| ERDF destination | | 0.011*** | | 0.008*** |
| Spatial dependence on the origin (WoY) | | | 0.057*** | 0.056*** |
| Spatial dependence on the destination (WdY) | | | 0.056*** | 0.056*** |
| Spatial interdependence (WwY) | | | −0.048*** | −0.047*** |
| *Note:* | | | | *p<0.1; **p<0.05; ***p<0.01 |

In Tables 6 and 7, we report the results after introducing the variable describing the cohesion policy funds with one and two lags, respectively. This choice is motivated by two main reasons: the EU funds are likely to play a role on economic activities after some periods (i.e. infrastructure and trade cost reduction need time to operate); it reduces the occurrence of reverse causality bias in the estimates (Mohl and Hagen, 2010). From the observations of these additional results, it can be noted that our main findings remain valid. We have also checked for the reliability of our results after modifying the cut-off values of the spatial weight matrix (Anselin et al., 1996); test results reported in the Appendix to save space.

used in our model allows for the consideration of resistance barriers among all trade partners (Cipollina et al., 2016; Egger and Pfaffermayr, 2016; Jin et al., 2023).

Table 6: Results with ERDF variables (one lag)

| | *Dependent variable:* | | | |
|---|---|---|---|---|
| | Total trade flows | | | |
| | (1) | (2) | (3) | (4) |
| GVA origin | 0.600*** | 0.621*** | 0.407*** | 0.424*** |
| GVA destination | 0.455*** | 0.494*** | 0.304*** | 0.332*** |
| Population origin | 0.061*** | 0.008** | 0.106*** | 0.063*** |
| Population destination | 0.226*** | 0.151*** | 0.224*** | 0.170*** |
| Road distance | −1.372*** | −1.407*** | −1.031*** | −1.048*** |
| ERDF origin (lag1) | | 0.032*** | | 0.025*** |
| ERDF destination (lag1) | | 0.040*** | | 0.029*** |
| Spatial dependence on the origin (WoY) | | | 0.220*** | 0.220*** |
| Spatial dependence on the destination (WdY) | | | 0.213*** | 0.213*** |
| Spatial interdependence (WwY) | | | −0.174*** | −0.172*** |
| Observations | 686,817 | 686,817 | 686,817 | 686,817 |
| $R^2$ | 0.696 | 0.699 | 0.754 | 0.756 |
| *Note:* | | | | *p<0.1; **p<0.05; ***p<0.01 |

Table 7: Results with ERDF variables (two lags)

| | *Dependent variable:* | | | |
|---|---|---|---|---|
| | Total trade flows | | | |
| | (1) | (2) | (3) | (4) |
| GVA origin | 0.600*** | 0.605*** | 0.407*** | 0.411*** |
| GVA destination | 0.455*** | 0.483*** | 0.304*** | 0.323*** |
| Population origin | 0.061*** | 0.020*** | 0.106*** | 0.071*** |
| Population destination | 0.226*** | 0.162*** | 0.224*** | 0.178*** |
| Road distance | −1.372*** | −1.409*** | −1.031*** | −1.044*** |
| ERDF origin (lag2) | | 0.032*** | | 0.025*** |
| ERDF destination (lag2) | | 0.039*** | | 0.028*** |
| Spatial dependence on the origin (WoY) | | | 0.220*** | 0.221*** |
| Spatial dependence on the destination (WdY) | | | 0.213*** | 0.215*** |
| Spatial interdependence (WwY) | | | −0.174*** | −0.173*** |
| Observations | 646,416 | 646,416 | 646,416 | 646,416 |
| $R^2$ | 0.696 | 0.697 | 0.754 | 0.754 |
| *Note:* | | | | *p<0.1; **p<0.05; ***p<0.01 |

## 6. Concluding remarks

The European Union has historically followed several objectives, among them two of paramount importance are the integration of its formerly separated national economies and the balanced economic development of all of its regions, i.e. the pursue of territorial cohesion.

While evidence exists on the fact that trade linkages can affect the impact of EU cohesion policy and this is one of the conditioning factors of differentiated policy results, no analysis so far investigated whether cohesion policy investments could affect trade. Motivated by the need of uncovering the different aspects of the regionalization of the global economy (Frankel, 2007), this paper has provided novel evidence on the role of the cohesion policy in terms of bilateral trade flows.

Conceptually, this paper first showed that cohesion policy investments can impact trade through several channels: on the demand side thanks to the increase of income which they induce in destination regions, on the supply side thanks to the increase of productivity and competitiveness that they induce in the origin regions. Additionally, structural funds also operate as shock absorbers, so shielding trade patterns from crises, and, given that one objective of these funds is also the establishment of cross-border relationships, they can facilitate international intra-EU trade. Furthermore, spatial mechanisms can also be at play because some regions can act as hubs for trade or be the focal points for input-output relationships.

These issues were investigated thanks to the assembly from several unrelated sources of a 18-year long balanced panel of EU regions, their characteristics, trade connections and cohesion policy expenditure. With these data, estimations used a log-linear spatial autoregressive gravity model to detect origin, destination and spatial effects of structural fund expenditure on inter-regional trade in the EU.

Results point out to significant demand effects. Regions which received more structural funds were destination of more trade flows, consistent with the idea that these funds were able to generate production and income growth and this, in its turn, generated larger imports by both people and firms. Supply effects are also significant, since regions with more structural funds were origin of more trade-flows, consistent with the idea that cohesion policy investments are not just demand-side but contribute to the competitive structure of regions and, as such, also make them on average more successful in exporting goods and services.

Spatial effects are positive and significant at the origin, suggesting the presence of network effects and agglomeration economies spanning across neighbouring regions, and positive and significant at the destination, suggesting scale economies, network effects and macro-regional organization of retail. Spatial effects are instead negative on the origin-destination coefficient, signalling that substitutability is present between trade partners.

Finally, it is interesting to notice that the trade effects of EU cohesion policy are, as expected, reinforced by the presence of the Euro, while they are lower in CEE countries, signalling that their integration into the Union is still lower than that of longer-standing members.

Results are robust to several robustness tests and in particular to the introduction of lags and estimations with a Poisson pseudo maximum likelihood model which accounts for the presence of zeroes in several trade flows, especially between small regions very far from each other.

Two consequences arise from this exercise. The first one concerns the need to consider the role of trade when assessing the impacts of EU cohesion policy. This is especially important in a period in which there is strong debate on the future Multi-Annual Financial Framework and in particular on the role of several possibly alternative measures to induce growth at the EU level. In these moments, understanding the costs and benefits of each type of expenditure in all its possible outcomes is even more relevant.

The second consequence is more directly concerned with policy design. This paper has clearly shown that structural fund investment is also able to induce trade. Although the data cannot allow to separate intermediate from final trade, the evidence presented here is a clear signal of the importance of regional development policies on the national and international economies. For this reason, it will be important to introduce significantly more extended coordination between cohesion policy and other policies of the EU such as those for competitiveness, for the single market and for competition so that their benefits are maximized.

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## Appendix A. Summary statistics and additional results

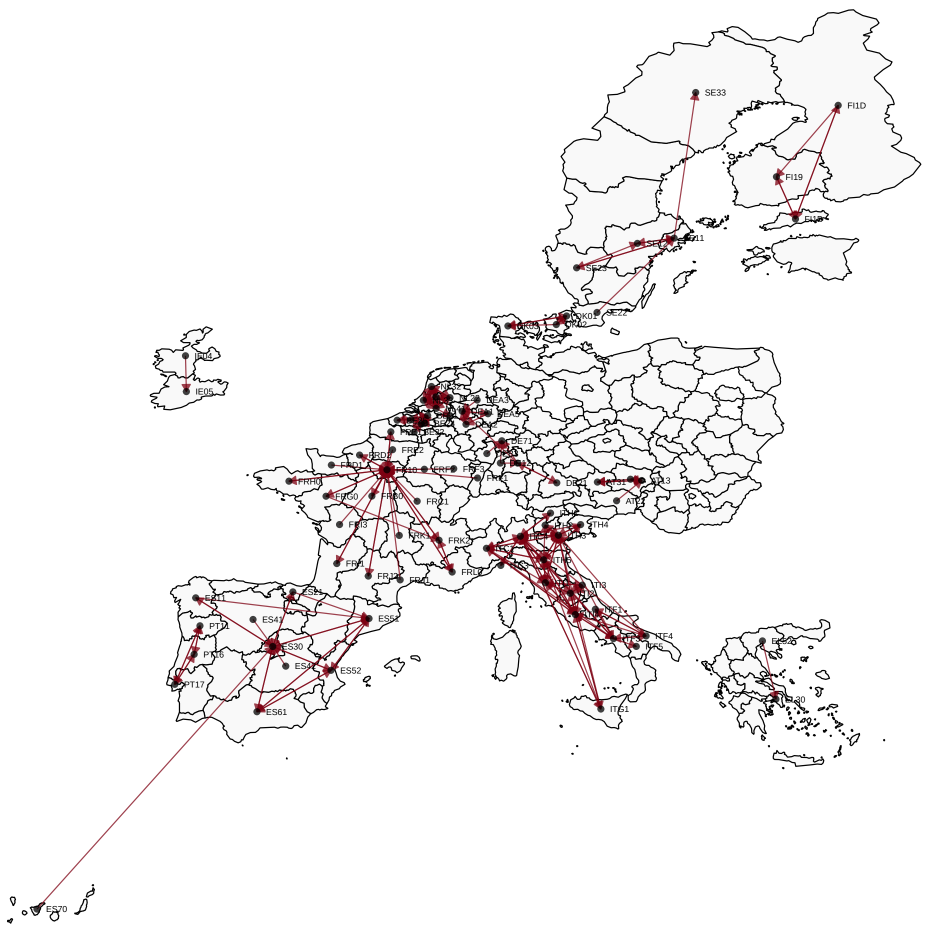
In Table A.1, we report summary statistics for the main variables used in the empirical analysis. In the Figures A.1 and A.2, we map regional bilateral trade flows with different selections of regional trade partners.

Table A.1: Descriptive statistics

| Statistic | Mean | St. Dev. | Min | Max |
|---|---|---|---|---|
| Total trade flows (log) | 3.055 | 1.848 | 0.000 | 14.156 |
| GVA per-capita (log) | 10.281 | 1.040 | 6.924 | 13.342 |
| Population (log) | 14.114 | 0.898 | 10.156 | 16.319 |
| ERDF (log) | 16.558 | 2.848 | 0.095 | 21.271 |
| Road distance | 1,420.1 | 882.6 | 1.861 | 6,312 |

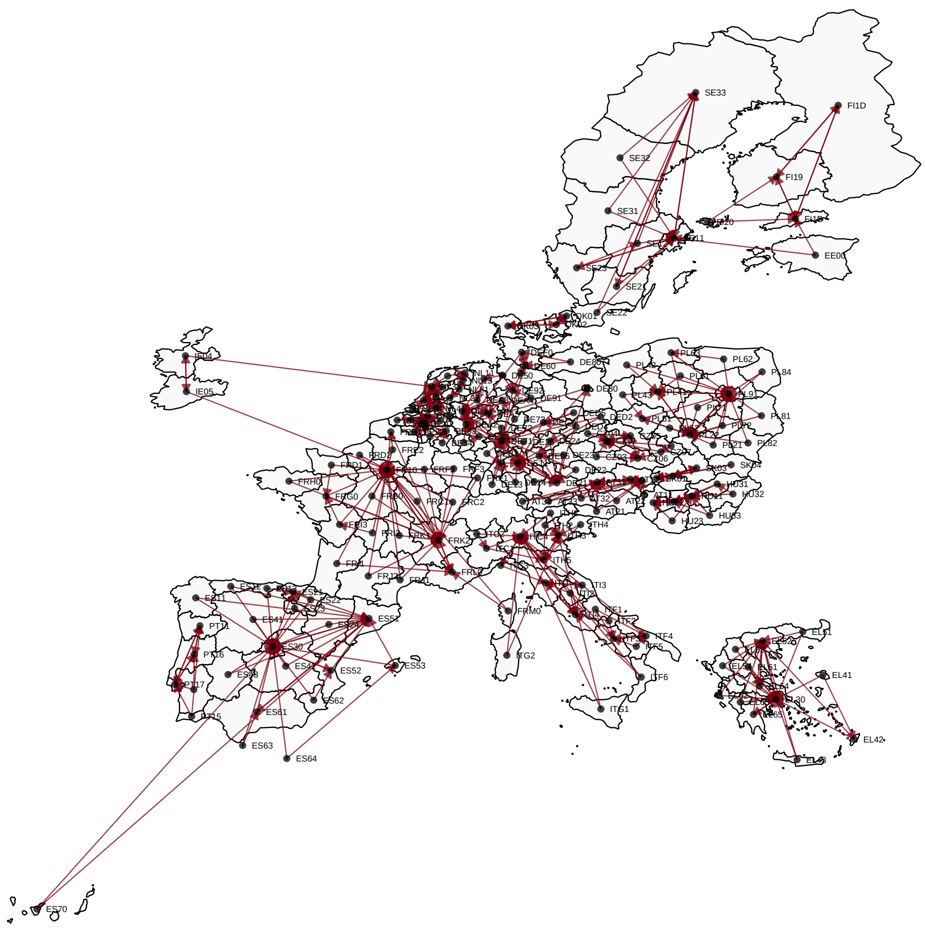
Note: N=201, T=18

Figure A.1: Mapping EU regional bilateral trade flows, additional results-1



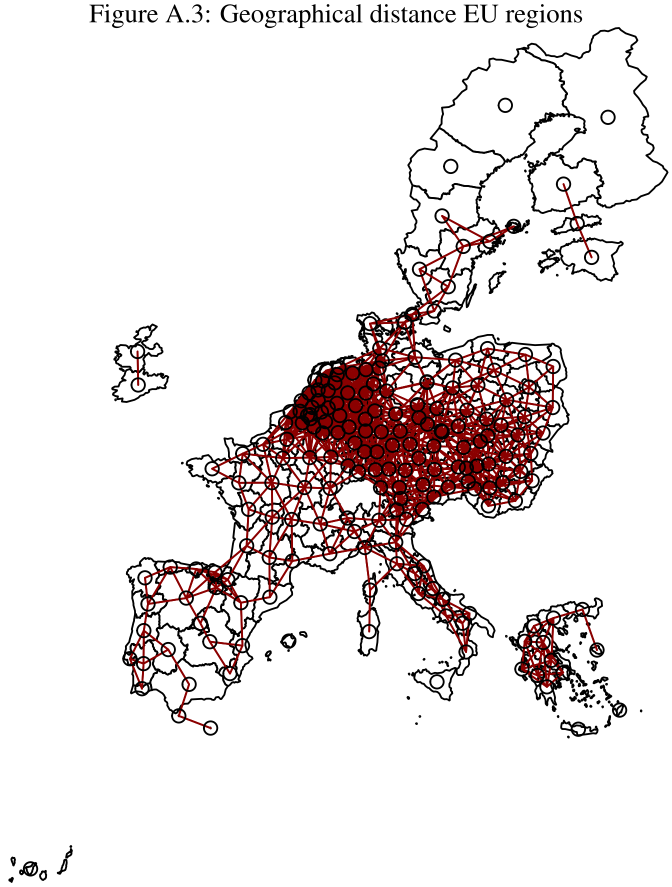

Note: Trade flows are calculated on average for the years 2000-2017 for all the regional trade partners. Our elaboration from EU Commission's trade data.

Figure A.2: Mapping EU regional bilateral trade flows, additional results-2




Note: Trade flows are calculated on average for the years 2000-2017 for the two main trade partners. Our elaboration from EU Commission's trade data.

Figure A.3: Geographical distance EU regions



Note: Geographical distance of the EU regions based on a cut-off distance of 250 kilometers. Our elaboration from Persyn et al. (2020c)'s data.

In Figure A.4, we report the sensitivity test checks that result from the application of alternative spatial weight matrix definitions in our SAR gravity model.

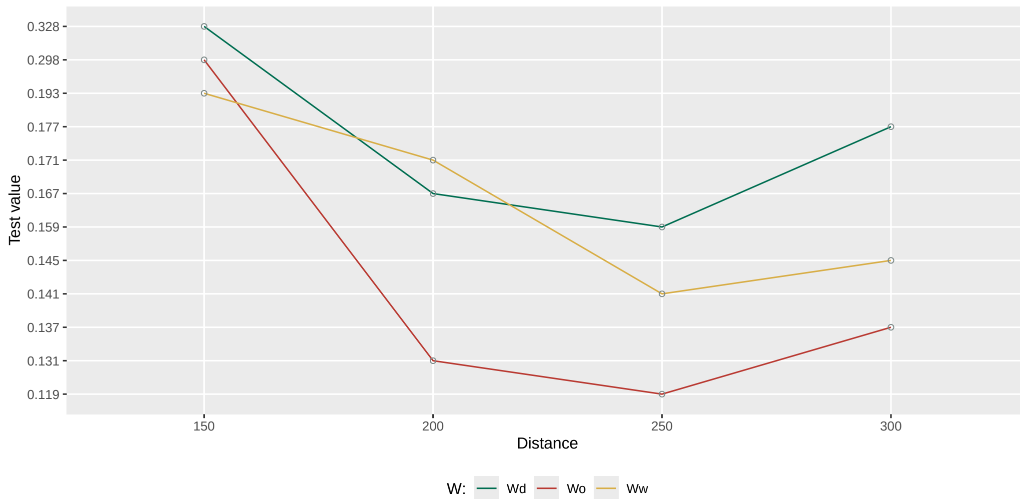



Figure A.4: W Sensitivity analysis