EMN WORKING PAPER N°17 - OCTOBER 2022

EUROPEAN MICROFINANCE NETWORK

Financing green and digital transition: Assessing regional patterns

Javier Barbero, Economic Analyst - European Commission, Joint Research Centre

Anabela M. Santos Ernesto Economic Analyst European Commission, Joint Research Centre

Rodríguez-Crespo, Assistant Professor Universidad Autónoma de Madrid Department of Economic Structure and Development Economics

The twin green and digital transition is at the heart of the European Union (EU) post-pandemic recovery and a key element of the new EU growth strategy. In this context, the European Green Deal. Government actions, such as subsidies or grants, for green sustainable investment, appear a way to ensure such directionality and to reduce market gaps.

Given the existence of substantial spatial disparities at subnational level for European regions, understanding geographical patterns of green (or green digital) projects appear to be of extreme importance to support policy design and to make policy more effective and inclusive. The present paper aims to provide empirical evidence of the geographical location and concentration patterns of ERDF (European Regional Development Fund) projects associated with green and/or digital investments. Using a novel and unique dataset of ERDF projects during the 2014-2020 period covering 238 regions of the 27 EU countries, we perform a cross-sectional analysis for the 2014-2020 ERDF projects explained by regional characteristics in 2014. Our empirical framework is threefold: first, we apply text analysis to identify whether projects´ description are associated to green and digital technologies investments, thanks to the existing taxonomy in the ERDF database. Second, we estimate a location indicator and, finally, we apply a binary choice regression model to explain the factors pertaining concentration of ERDF projects in the above-mentioned areas. We find that ERDF green and green-digital projects follow a similar spatial pattern, since they tend to be concentrated in the most polluting regions and associated to network collaboration in these areas. Both the qualification of human resources and the quality of governance in a region seem to be more relevant when explaining the location of digital technologies projects than for green (green-digital) projects. We acknowledge the amount of funds devoted to green and green-digital projects is larger than the average, and shows a lower likelihood to be supported by a micro-subsidy (lower than €25,000).

Keywords: Green finance; Twin transition; EU funds; Location.

1. Introduction

The twin green and digital transition is at the heart of the European Union (EU) post-pandemic recovery. For instance, each EU Member State must use at least 37% of the funds provided by the Recovery and Resilience Facility (RFF) to ensure climate objectives and at least 20% for digital ones (Regulation (EU) 2021/41). Furthermore, the twin transition is also the key element of the new EU growth strategy, the European Green Deal.

Nevertheless, both transitions are inter-connected and cannot be understood as separate elements. On one hand, climate change awareness, new market trends, and changes in consumers' preferences for more eco-friendly solutions (Testa et al., 2021; Raptou and Manolas, 2022) are pushing the emergence of new digital technologies (Brauer et al., 2016) to develop cleaner production techniques. On the other hand, digital innovation is also an important element to facilitate the transition to a climate-neutral economy (Sharma et al., 2022).

Government actions, in the form of subsidies, grants, or loans for sustainable investment, can not only support such transition but also accelerate its achievement. Then, government intervention appears a way to ensure a directionality (Pontikakis et al., 2020) and to reduce market gap (Cowling and Liu, 2021; Xiang et al., 2022). The possibility on accessing to finance, thanks to subsidies, is particularly important for micro and small-sized firms which usually face more financial constraints (Santos and Cincera, 2022) that restraints their productivity levels compared to large firms. Furthermore, access to micro-financing schemes, especially targeted to small businesses, is also relevant to reduce social territorial inequalities (Arbolino et al., 2018) and to ensure an equitable and fair transition (OECD/European Commission, 2021).

Despite the potential existing complementarities between green and digital transitions, and the importance of public support to enhance them, studies focusing on both dimensions and in understanding the allocation to EU funds to finance them[1], they have been less explored in academic research. Indeed, the lack of existing data on digital technologies adoption and sustainability-related indicators at the subnational level has motivated only conceptual analyses, and to the best of our knowledge, empirical evidence seems to be overlooked. At the subnational level, firms concentrate on specific areas to reap information and knowledge flows derived from their interaction with other firms (e.g., Duranton and Puga, 2005; Miguélez and Moreno, 2015). Such interactions can be considered as a key element when developing cleaner production techniques.

The present paper aims to contribute to the existing literature by understanding the geographical location and concentration patterns of ERDF[2] (European Regional Development Fund) projects associated with green and digital investments. The analysis takes advantage of a novel and unique dataset (Bachtrögler et al., 2021), including around 600,000 observations on ERDF project beneficiaries during the 2014-2020 period and covering the EU27, to identify regional green and digital financing patterns. To the best of our knowledge, this is the first study that benefits from the outcomes pertaining this database.

To develop our analysis, we combine three different methodologies. First, text analysis techniques are used to identify digital investments projects by using strategic keywords. Green projects are identified thanks to Bachtrögler et al. (2021) taxonomy existing in the database. Afterwards, we estimate a funding concentration indicator at the regional level (NUTS 2), which is subsequently used as a dependent variable in our baseline empirical strategy to assess the determinants of the projects' locations. We follow a similar methodological approach, as Ben Kheder and Zugravu (2012), who assessed the determinants of businesses decision location.[3] However, our framework differs from the previous one for three reasons. First, it is adapted to the subnational level by introducing the existence of spatial disparities. Second, instead of assessing the determinants of business location we focus on the ERDF investment projects location. Third, our analysis is not only devoted to green transition and we also consider digital transition. This fact allows us to explore the existence of potential trade-offs between such transition to determine projects´ location.

By means of a sample of 238 European regions for the year 2014, together with a funding scheme for the period 2014-2020, a glimpse of our results shows the following findings. First, ERDF green and green-digital projects follow a similar spatial pattern, since they tend to be concentrated in

1. Some exceptions are the studies of Vicente et al. (2020) and García-Muñiz et al. (2021) that use data of the 7th Framework Program (targeted exclusively to R&D investments with calls launched at EU level). The present study uses data of the ERDF (Cohesion Policy), and includes R&D and non-R&D investments.
2. ERDF finances programmes that aims to enhance economic, social and territorial cohesion in the European Union by reducing inequalities between its regions. It is one of the five funds of the EU Cohesion Policy.
3. According to Ben Kheder and Zugravu (2012), instead of deciding to locate their businesses in areas with lower environmental stringency aligned with the pollution haven hypothesis, firms may opt to agglomerate closely in certain areas to share information and knowledge.

the most polluting regions and associated to network collaboration in these areas. Both the qualification of human resources and the quality of governance in a region seem to be more relevant when explaining the location of digital technologies projects than for green (green-digital) projects. The study aims to become at the cutting edge for academic literature by bringing patterns on new empirical evidence and policy-decision making. Indeed, understanding geographical patterns of green (or green digital) projects appear to be of extreme importance to support policy design and to make policy more effective.

2. Related literature

2.1 Green and digital transition: The importance of subnational level

There is a vast academic literature documenting the impacts of both sustainability (e.g., Ghisetti et al., 2015; Luederitz et al., 2017; Williams and Robinson, 2020) and digital transition (e.g., Parviainen, 2017; Zolas et al., 2021). From a general point of view, productivity increases have been reported when firms improve their production systems either by introducing cleaner production techniques (e.g., Porter and Van der Linde, 1995) or greater levels of digitalization (e.g., Bresnahan et al., 2002; Gal et al., 2019). However, such increases in productivity do not only require rising production but also reduce the proportion of environmentally harmful goods. Accordingly, firms need to implement a joint digital and sustainability transition.

When looking at the academic literature, we find the interest has shifted to study both transitions, but as separate elements, thereby neglecting their potential synergies and tradeoffs. Although innovation has been alleged to contribute to cope with sustainability (e.g., Melville et al., 2010; Evans et al., 2017; Fernández-Fernández et al., 2018), we acknowledge how rapid technology is evolving as a consequence of globalization (McAfee, 2019; Baldwin and Forslid, 2020), which has required to incorporate emerging technologies into this debate apart from the traditional ones. A recent strand of literature has begun to analyze how digitalization efforts can be also helpful to cope with the transition to sustainability (e.g., Sarc et al., 2019; Vinuesa et al., 2020).

New Economic Geography can be considered as one of the most fruitful advancements to explore the dynamics of economic activity at the subnational level. According to its main findings, economic activity is unevenly distributed across space, giving rise to increasing spatial inequalities (Krugman, 1991). By assuming a twofold core-periphery structure, industrial activity tends to concentrate on the core rather than on peripheral regions (Fujita et al., 1999), as firms seek to share knowledge flows derived from proximity relations. As a consequence, sharp and profound inequalities between core and peripheral regions arise and, more importantly, it is necessary to study which factors contribute to mitigate such differences.

In a context of growing concerns related to environmental issues, the study of such differences has become a must, as most of the academic efforts have found a positive association between industrial concentration and pollution at the subnational level (Cheng et al., 2016; Dong et al., 2020; Wang and Zhou, 2021). An institutional response to this phenomenon has come in terms of increasing levels of environmental stringency, leading to a pollution haven hypothesis, which encourages firms to relocate their activities to other places with laxer environmental regulations (e.g., Zheng and Zhao, 2009; Chen et al., 2018). We find also a growing debate on whether better access to information technology keeps a relationship with agglomeration. To the best of our knowledge, the findings obtained are inconclusive, as they depend on factors such as the type of technology, the firm and the sector of economic activity (Ioannides et al., 2008). On the one hand, firms may be more proactive to increase agglomeration to benefit from the effects derived from technology. This fact has been confirmed for those firms with lower technological intensity (Liand and Goetz, 2018). On the other hand, the adoption of technology may deter agglomeration, as firms may implement most of their activities from distant places (Dingel and Neiman, 2020), leading to increase fragmentation of production (Antràs and Chor, 2019).

Measuring industrial concentration at the subnational level can be helpful in shedding light on the lumpiest behind firms´ agglomeration. For this reason, several contributions have aimed to assess the degree of industrial concentration at the subnational level (e.g., Dekle, 2002; Devereux, 2004; Duranton and Puga, 2005; Puga, 2010).

When moving to the study of digital and sustainability transition, we find how specific contributions have already emphasized addressing sustainability transition from a spatial perspective (Coenen and Truffer, 2012; Coenen et al., 2012; 2021) and the importance of digitalization arising from Industry 4.0 to address such transition at the subnational level (De Propris and Bailey, 2021). European Union has been highly proactive in promoting digital and sustainability transition through specific initiatives, such as the carbon neutrality in 2050 or the Second five-year Digital Agenda, launched in 2020. However, we find that academic efforts have circumvented the joint study of both transitions at subnational level.

2.2 Knowledge flows and projects

Although the importance of digitalization and sustainability as transition drivers toward cleaner production processes is widely acknowledged, several elements make difficult to implement such transition at subnational level. First, the consideration of information technologies as General Purpose Technologies requires understanding the importance of time to accommodate the new technology to production processes, as it may be subject initially to decreasing returns to scale (Bresnahan and Trajtenberg, 1995). Second, there exist numerous barriers to innovation and technology adoption, among we can find the location, size, or context (Hervás-Oliver et al., 2021).

To overcome such transition barriers, firms can engage in collaboration networks to share and benefit from knowledge flows and ideas. Although the topic of collaboration networks has been substantially addressed by academic scholars (e.g., Balland, 2012), the recent increasing intensity of R&D collaborations has engaged multiple agents from different geographical and institutional contexts (Scherngell, 2021). Among the existing multiple ways of collaborating, formal collaboration through joint R&D projects is one of the most common ones, as they favor knowledge spillovers. Such knowledge spillovers are key to understand the subnational level, as they have given rise to the geography of innovation (Feldman, 1994; Asheim and Gertler, 2005) and, in particular, the diffusion of knowledge presents a substantial spatial component (Miguélez and Moreno, 2015).

Although it would be desirable to assess how such programs have impacted on regional economic performance such evidence seems to be strongly overlooked at subnational level, mainly due to the absence of data. To the best of our knowledge, only two studies have unveiled this impact but limited to the 7th "Framework Programmes for Research and Technological Development" (FP). Vicente et al. (2020) use a sample of 245 European regions to explore how 7th FP, together with ICT, has spurred total factor productivity. In a later study (García-Muñiz et al., 2021), they use a similar sample to find not only how FP7 and ICT have increased regional competitiveness, but also the importance of fostering collaboration networks between core and peripheral regions.

By considering previous research gaps, the objective of the present study is to contribute to the existing literature by understanding the geographical location and concentration patterns of ERDF (European Regional Development Fund) co-funding projects associated with green and digital investments. The paper doesn't intend to assess the effect or impact of the above-mentioned projects, but rather to understand where they are located. Its objective is to evaluate if, for instance, such projects are located in the most polluting regions or regions more financially constrained, i.e. in regions most in need and where funding can be most effective.

2.3 Time to reap: why access to finance and microfinance matters

Access to financial resources is a key element to achieve a green and digital transition, especially when studies have already point out to an existing green financing gap (e.g. Polzin and Sanders, 2020; Cowling and Liu, 2021). The high demand of green investments, in a context of market uncertainty and high risk of green innovation, have lead traditional financial market (e.g. bank loans) to be unable to fully met this new demand of capital (Cowling and Liu, 2021; Xiang et al., 2022). Government subsidies have showed to be an significant alternative source of financing of green investments (Liu et al., 2020; Xiang et al., 2022). Public funds are particular important in the early stage of green innovative investments, when return is uncertain and risk is high (Owen et al., 2018). By having a kind of "demonstration effect", government support can also enhance access to other source financing, as debt and equity (Owen et al., 2018; Xiang et al., 2022). Within this framework, the access to microfinance is also particularly acknowledged, to ensure an equitable and just transition. Indeed, it can contribute to boost economic activity and reducing inequalities by means of giving access to financial resources to the most vulnerable agents (OECD/European Commission, 2021).

When analyzing the subnational level in Europe, microfinancing could be a fundamental element to reduce spatial inequalities. To the best of our knowledge, only Arbolino et al. (2018) have analyzed such impact for Italian regions with sustainability purposes and conclude that microfinancing could contribute to implementing sustainable development. Although these results demonstrate the importance of microfinancing to facilitate the regional sustainability transition, it is fundamental to shed light on at the subnational level to help to improve regional development programs in the European Union.

Our study aims to contribute to existing literature by understanding whether the regions that are simultaneously the most polluting, less developed and more financially constrained are those that are using the most the ERDF for ensuring the twin transition. Furthermore, the current analysis also allows us to determine in which regions microfinance subsidies (i.e. below €25.000) are the most relevant ones.

3. Empirical strategy

3.1. Research model and estimation strategy

Our empirical methodology consists of three main steps. The first step is to identify whether research projects are devoted to digital and/or green transition. The second step deals with the estimation of a proper location indicator. Third, we integrate the results pertaining previous steps to estimate an empirical model. All these steps are described below.

Step 1: Identification of digital and/or green projects

We use Bachtrögler et al. (2021)´s database to extract regional information on the ERDF projects in the fields of green and digital investments. This dataset includes the list of projects co-funded by the ERDF in the EU27 during the programing period 2014-2020. In addition to the project location at NUTS 2 level, the dataset also includes the project descriptions and their classification by Societal Grand Challenges (SGC). For the present study, we consider green projects the ones classified in the Bachtrögler et al. (2021) database with a contribution to the SGC "Climate action, Environment, Resource Efficiency and Raw Materials". To identify digital projects, we used text analysis techniques. Based on a list of specific keywords and taxonomies[4], several text algorithm runs are made on the text of project descriptions to identify those investments related to digital technologies. Text analysis can be considered as state-of-the art techniques to compare texts and, more importantly, to capture the finest regional disparities. For this reason, recent studies at subnational level have used text analysis for their computations (e.g., Llano-Verduras et al., 2021; de Lucio and Mora-Sanguinetti, 2022).

Step 2: Estimation of a proper location indicator

How to determine regional location can be considered as one of the most relevant issues in economic geography (e.g., Fujita et al., 1999; Duranton and Overman, 2005), since it allows us to unveil spatial concentration patterns in determined areas. Most of these approaches, however, rely on indices that depend strongly on the level of industrial aggregation. Increasing levels of industrial aggregations are associated with a lower degree of information on the spatial distribution of activities. A solution could be, as shown by Billings and Johnson (2012), developing statistical measures of inference such as the Location Quotient Index (LQI). In contrast to the traditional indicators measuring location, LQI removes factors associated to count scale differences at the subnational level leading to a more accurate and clear measure of the dynamics of industrial concentration. Equation (1) defines LQI:

1) $LQI_{i,j}=X_{i,j}/\Sigma X_i)/(X_{EU,i}/(\Sigma X_{EU})$

where $LQI_{i,j}$ refers to the location quotient for region i regarding the investment area j; $X_{i,j}$ is equal to the total funding allocated to area j in region i; ΣX_i comprises the total funding allocated to region i; $X_{EU,j}$ corresponds to the total funding in all EU regions allocated to area j ; and ΣX_{EU} comprises the total funding allocated in all EU regions. Investment area j includes three categories: green or climate, digital technologies and green-digital technologies. Region i comprises the 240 NUTS-2 level regions of the EU27. Following Doussineau and Bachtrögler-Unger (2021), we consider the existence of EU funds concentration in region i and area j if the $LQI_{i,j}$ is greater than 1. A value higher than 1 means that the region i is concentrating more funds in the investment area j than the EU average.

Step 3: Defining the empirical model

To define our baseline model, we resort to Ben Kheder and Zugravu (2012) binary choices model approach to explain the most influential factors behind locating decisions. Our dependent variable $C_{j,i}$ assumes the value of 1 if there is a concentration of EU funds in region i and area j, if $LQI_{i,j}>1$, and 0 otherwise. Our binomial probit model (2) expresses the probability of having $C_{j,i}=1$ depending on a vector x_i containing regional characteristics that may influence the locating decision. The estimation of the parameters in function $G(.)$ is based on the maximum likelihood methodology.

2) $P\{C_{j,i}=1|x_i\}=G(x_i,\beta)$

Based on the scientific literature, we have identified the following regional characteristics (x_i) able to influence the decision to invest associated to EU funds. The first one is the stock of CO2 emissions intensity, expressed per gross value added (CO2), with the aim of measuring environmental stringency. This is a key variable to measure sustainability transition by assuming that agents can locate in places with laxer environmental regulations (e.g., Zheng and Zhao, 2009; Fernández-Fernández et al., 2018). At the subnational level, pollution may be also considered a spreading force that prevents firms´ agglomeration in line with the postulates from New Economic Geography (e.g., Lange and Quaas, 2007). However, at the same time, when agglomeration exceeds certain thresholds at subnational level, it can reduce pollution (Chen et al., 2020). In the context of European Union, initiatives like European Trading Scheme are lowering the profitability of firms to locate their businesses in foreign pollution havens (Silva et al., 2021). Consequently, there may be a strong incentive to agglomerate with other firms and reduce pollution via technological spillovers. However, evidence becomes unclear when introducing the digital transition

4. The list of keywords and taxonomies was build based on the keywords/taxonomies extracted from Horizon 2020 calls description in the field of digital innovation and from European Science Vocabulary (EuroSciVoc).

into the discussion, as academic scholars do not show consensus in the consideration of technological spillovers as a centripetal force, facilitating agglomeration, or a centrifugal one, spreading agglomeration (e.g., Ioannides et al., 2008).

The rest of the variables are described as follows. We use gross value added per capita and two variables related to employment, share of employment with high education, and employment density, to measure human capital and market size. Market size is considered as a key variable to determine location, as the probability of generating spillovers is greater in the case of larger markets (e.g., Klein and Crafts, 2012). We also acknowledge the impacts exerted by institutional quality, as it has been proved that better governmental quality increases innovative performance at subnational level (Rodríguez-Pose and Di Cataldo, 2015). Consequently, high-quality institutions may contribute to the projects´ location decision because of their capacity to generate spillovers. Finally, we introduce variables related to the characteristics of funds allocated to ERDF projects to identify the type of collaboration and the type of transition (green, digital or both). As argued before, collaboration generates technological spillovers that contribute to develop cleaner production techniques. Such spillovers are fundamental to address digital (De Propris and Bailey, 2021) and sustainability transition (Coenen et al., 2012; 2021).

3.2. Data and sources

Our sample contains 238 European regions. Due to the availability of data sources, we need to move to a cross sectional analysis. The stock of funds of ERDF projects used to calculate the location quotient indicator are from 2014 to 2020, while the explanatory variables refer to 2014. To perform our analysis, we combine data from different sources. In addition to Bachtrögler et al. (2021) data, the regions socio-economic indicators were extracted from EUROSTAT and the Annual Regional Database of the European Commission's Direcotrate General for Regional and Urban Policy (ARDECO). Regional CO2 emissions have been extracted from the JRC-EDGAR emission gridmaps (Crippa et al., 2021) by computing the sum of emissions of the raster cells that intersect the NUTS-2 polygons. NUTS-2 polygons are obtained from Eurostat GISCO. When a single region's polygon and the sea partially cover a cell, all the emissions in the cell were attributed to the region. Finally, the quality of government variable at subnational level is gathered from the indicators elaborated by the University of Gothemburg (Charron et al., 2015).

4. Results

4.1. Characteristics of ERDF green and/or digital projects in the European Union

In the period 2014-2020 in the EU27, ERDF projects in the areas of climate change and digital technologies represented respectively around 28% and 30% of the total ERDF budget allocation (Table 1). About 10% of the total ERDF budget was targeted for digital-green projects, i.e. digital technologies development or adoption for the green transition. Green, digital and digital-green projects are larger than the average, with green projects recording a higher average amount of EU funds per project than digital and digital-green ones. Therefore, due to their size, these typologies of projects report a lower likelihood to fall into the category of micro-subsidy (lower than €25.000) (Appendix A). Green (digital-green) projects have two (three) times more likelihood to be part of inter-regional partnership projects than the average. R&D projects are more likely associated with digital technologies and green-digital technologies than the average, whereas green projects are less likely to be R&D projects. In this case, non-R&D green projects are essentially related to energy and environmental infrastructures and business development to support climate change targets, which are also usually more capital-intensive, and can justify the higher average amount of green projects.

Table 1

ERDF green and/or digital projects, EU27, 2014-2020: EU funds and number of projects

	EU funds			
Category	Million €	% Total	N° projects	€/project
ERDF green projects	50,617 €	28%	90,972	556,399 €
ERDF digital projects	55,010 €	30%	165,267	332,857 €
ERDF green-digital projects	17,600 €	10%	36,949	476,333 €
Total ERDF projects	182,368 €	100%	587,699	310,309 €

Source: Own elaboration based on Bachtrögler et al. (2021).

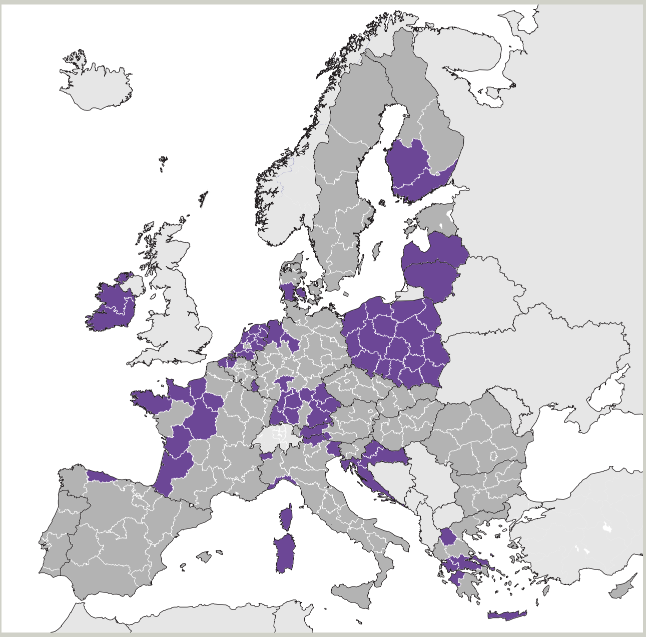
4.2 The geography of ERDF green and/or digital projects in the European Union

Figures 1-3 display the regions with a greater concentration of ERDF green, digital and green-digital projects, respectively. A higher concentration of ERDF green projects is observed in some regions of Eastern and Western countries, as well as in some regions of Ireland, Finland and France. The concentration of ERDF digital projects is observed in a higher number of regions than green ones. Most of the EU countries have at least one region with a substantial concentration of ERDF digital projects (excluding Cyprus, Estonia, Croatia, Luxembourg, Malta, Portugal, Romania, Sweden and Slovenia). The location of green and digital projects is also positively correlated (Figure 4), pointing to the existence of potential complementarities between both.

Figure 1

Concentration of ERDF green projects, 2014-2020, EU27

No concentration
Concentration

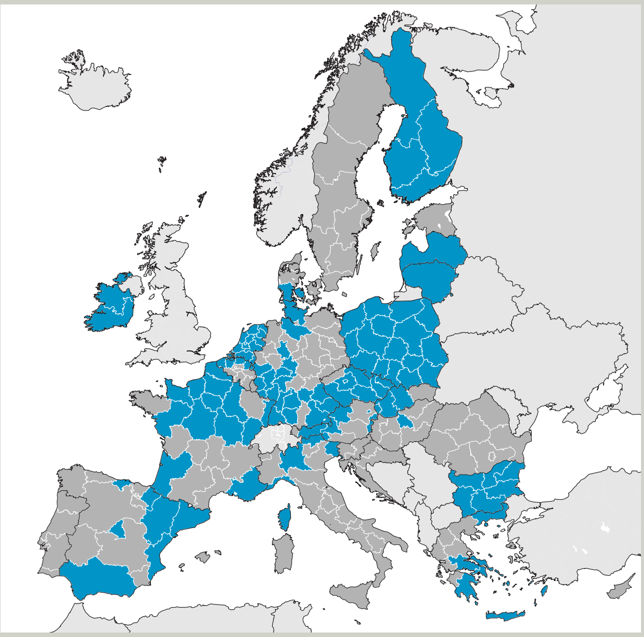


Source: Own estimation based on Bachtrögler et al. (2021) database.

Figure 2

Concentration of ERDF digital projects, 2014-2020, EU27

No concentration
Concentration

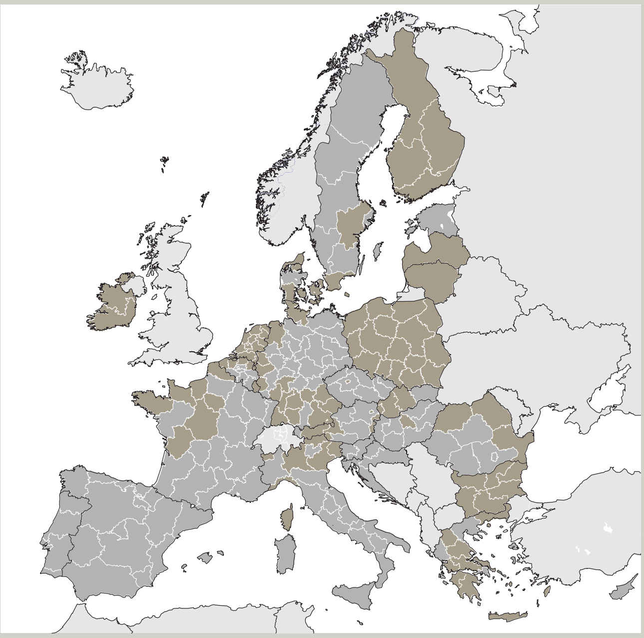


Source: Own estimation based on Bachtrögler et al. (2021) database.

Figure 3

Concentration ERDF green-digital projects, 2014-2020, EU27

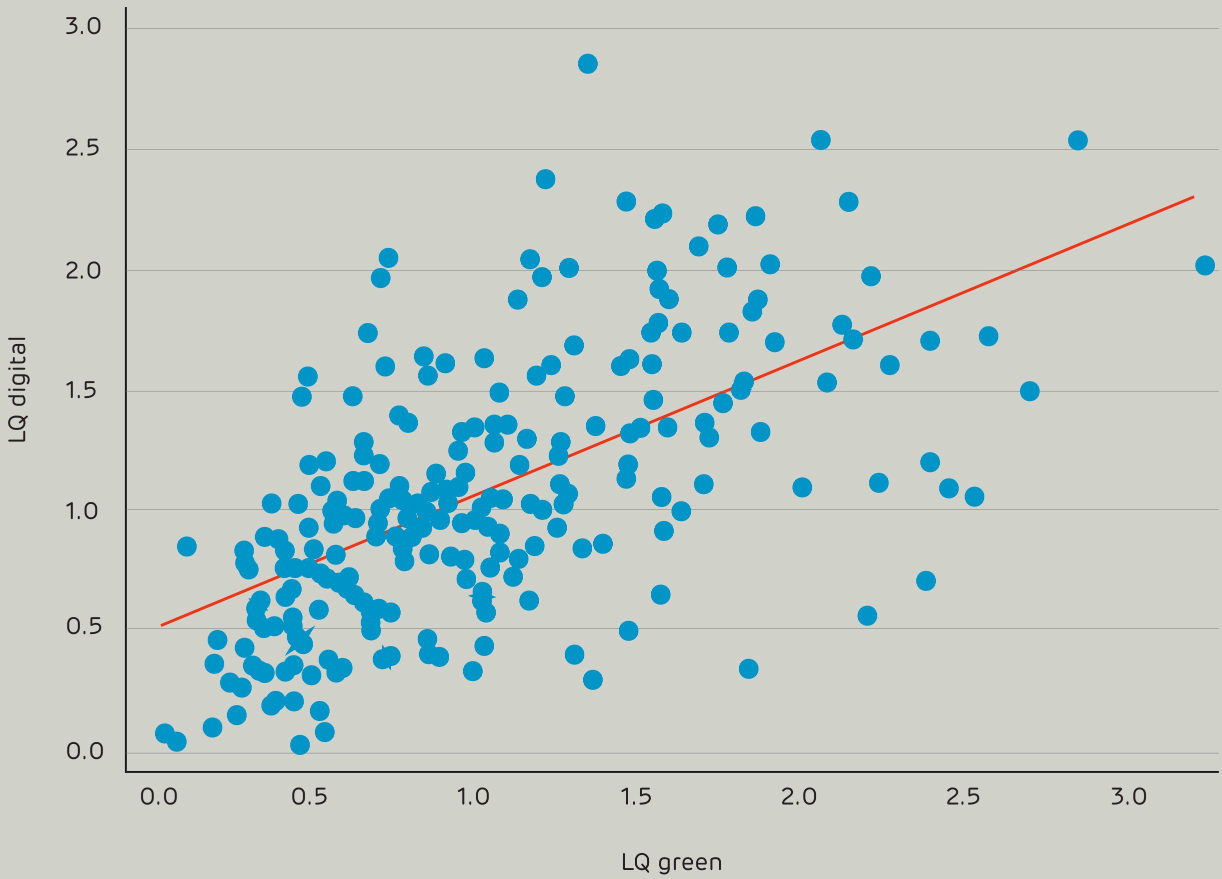
No concentration
Concentration



Source: Own estimation based on Bachtrögler et al. (2021) database.

Figure 4

Scatterplot ERDF green versus digital projects, 2014-2020, EU27



Source: Own estimation based on Bachtrögler et al. (2021) database.

4.3. Understanding regional patterns of ERDF green and/or digital projects

The binary choice model (2) is estimated using a probit model and results are presented in Table 2. Column (1) shows the results for the concentration probability of EU funds in green projects, column (2) for digital technologies projects and column (3) for green-digital technologies projects. At the bottom of the Table 2, the result of the Ramsey regression specification-error test (RESET), for omitted variables, and of the Goodness-of-fit test illustrate that the model is correctly specified, and also that the functional form is correct. No problems of multicollinearity were detected based on the results of VIF and on different model specifications reported in Table B1 in Appendix B. The models don't include country fixed-effects due to multi-collinearity issues (results available upon request). However, since the Ramsey test don't rejected the null hypothesis of no omitted variables, the model fits well the data without fixed effects.

The interpretation of the coefficients shows that the probabilities of green (column 1) and green-digital projects concentration (column 3) are positively correlated with CO2 emissions intensity at the beginning of the period; suggesting that ERDF was able to enhance the development of investment projects in the most polluting regions. The employment density, proxy used for agglomeration, reveals to be positively associated with the three probabilities of concentration. As highlighted previously, agglomeration may be a strong incentive of projects´ concentration in a similar topic because they can benefit from the existence of local spillovers.

The qualification of human resources seems to be only a determinant explaining the concentration of digital projects in EU regions, probably because this typology of project is more related to R&D investments than ERDF green ones (see Table A4 in Appendix). The quality of governance index is also only significant for explaining the concentration of digital projects. This fact is not surprising, as the joint consideration of institutional quality with other variables at subnational level may override impacts´ (Ketterer and Rodríguez-Pose, 2018).

As a complementary analysis, we include separately in our baseline model the intensity (measured by per capita) of ERDF network projects[5] in the three investment areas under analysis (Table C1 - Appendix) and the intensity of ERDF micro-subsidy (Table C2 – Appendix). Results of a probit regression model are reported in Table 3, and confirm our previous findings obtained in section 4.1: the concentrations of green and green-digital technologies projects are positively associated with the existence of a network collaboration in these areas; findings in line with scientific literature of knowledge spillovers (see e.g. Feldman, 1994; Asheim and Gertler, 2005; Miguélez and Moreno, 2015; Scherngell, 2021). For digital projects, it seems that network collaboration is not a significant factor explaining the concentration of funds in this area in a region, maybe because of the incentive of agents to deagglomerate under certain factors, such as size or sector (Liang and Goetz, 2018). Indeed, climate change has not only an impact on a specific region but affects all the regions over the world. Therefore, because of its more global concern, regional entities may be more willing to collaborate than for digital projects only, which may be more region-specific.

Concerning the relationship between the intensity of ERDF micro-subsidy and the probability of ERDF projects concentration, Table C2 (Appendix) shows a negative correlation between them for green and green-digital areas. Since, in section 4.1 we showed that green and green-digital projects are bigger in terms of fund amount than the average, this fact may explain why the probability of concentrating on these specific areas is negatively associated with the intensity of micro-subsidy (lower than €25,000).

5. They corresponds to projects under Interreg programme, funded by the ERDF, and created to stimulate cooperation between regions in and out of the EU.

Table 2

Results Probit model: baseline model

Variables	(1) Green	(2) Digital	(3) Greene-Digital
Log of CO2 emissions intensity	0.311** (0.152)	0.196 (0.139)	0.312** (0.138)
Log of GVA per capita	-0.382 (0.304)	-0.432 (0.277)	-0.084 (0.279)
Log of Human Capital	0.496 (0.313)	0.750** (0.315)	0.369 (0.311)
Log of Employment Density	0.200** (0.084)	0.186** (0.080)	0.145* (0.080)
Quality of Government	0.102 (0.144)	0.305** (0.141)	0.173 (0.139)
Constant	2.770 (3.772)	4.544 (3.396)	-0.376 (3.409)
Observations	238	238	238
Log pseudolikelihood	-152.41	-155.19	-158.48
Pseudo R2	0.0568	0.0576	0.0353
Ramsey RESET test (p-value)	0.060	0.479	0.684
Godness-of-fit test (p-value)	0.319	0.362	0.374

Note: Robust standard errors in parentheses. Significance level: *** $p<0.01$, ** $p<0.05$, * $p<0.1$

5. Conclusions

In this study, our aim is to shed light on sustainability and/or digital transition at subnational level by identifying the underlying factors that contribute to enhance these transitions. By means of a novel dataset of ERDF projects, our methodology combines (i) text analysis techniques to identify the type of transition associated to the ERDF projects, (ii) construction of a location quotient indicator to identify the degree of concentration and (iii) a binary choice model to identify the exact factors underlying the location decision. Using a sample of 238 European regions, our results suggest that ERDF green and green-digital projects follow a similar spatial pattern. They are concentrated in the most polluting regions and associated to network collaboration in these areas. The qualification of human resources and the quality of governance in a region seem to be more relevant explaining the location of digital technologies projects than for green (green-digital) projects. Green and green-digital projects are bigger (amount of funds) than the average and show a lower likelihood to be supported by micro-subsidy (lower than €25,000).

These results lead to important policy features. Digital and sustainability transition can be considered as pillars for the future green growth strategy because of implementing clean production techniques. However, it is required not only to distinguish the type of transition, but also the financial amount devoted to such transitions. In this context, the geography of regions emerges as a fundamental component, given the existence of pronounced spatial differences for European regions, which lead to the importance of promoting specific place-based policies. As a consequence, such differences need to be taken into account to achieve a more inclusive and efficient transition. In addition to that, the amount of funds seems to play a key role, as efforts devoted to microfinance could result in substantial gains for all the agents involved in the process. However, such gains are strongly determined by the geographical concentration, which impacts on the allocation of funds.

Our study suggests important avenues for future research. First, this study presents a cross-sectional nature that impedes to evaluate whether regions can improve their transition commitments over time. For this reason, an analysis incorporating panel data would be desirable to complement our findings. Second, it would be important to introduce variables contingent on international economics, given the strong existence of incentives to locate in areas with laxer environmental regulations. However, this trade and foreign direct investment data is not available at subnational level for European regions.

Appendix A - Characteristics of ERDF green, digital and green-digital investment projects, 2014-2020, EU27

Table A1

T-test for equality of means: ERDF maximum co-funding by typology of projects (green, digital and green-digital projects)

Group	Obs	Mean (EU funds)	Std. err.	Std. dev.	[95% conf. interval]	
Green project (N)	505,936	301,739	7,019	4,992,453	287,982	315,496
Green project (Y)	93,335	578,581	15,439	4,716,866	548,320	608,842
Combined	599,271	344,856	6,396	4,951,554	332,320	357,393
diff		-276,842	17,636		-311,408	-242,277
P-value		0.0000				
Digital project (N)	430,912	338,392	8,316	5,458,911	322,093	354,691
Digital project (Y)	168,359	361,402	8,083	3,316,455	345,560	377,244
Combined	599,271	344,856	6,396	4,951,554	332,320	357,393
diff		-23,010	14,231		-50,903	4,882
P-value		0.1059				
Green-digital project (N)	561,301	333,894	6,674	4,999,869	320,814	346,975
Green-digital project (Y)	37,970	506,904	21,396	4,169,253	464,967	548,841
Combined	599,271	344,856	6,396	4,951,554	332,320	357,393
diff		-173,010	26,255		-224,470	-121,550
P-value		0.0000				

Source: Own estimation based on Bachtrögler et al. (2021). Note: Values refer to project-beneficiaries characteristics.

Table A2

T-test for equality of means: likelihood of having of micro-subsidy by typology of projects (green, digital and green-digital projects)

Group	Obs	Mean (EU funds)	Std. err.	Std. dev.	[95% conf. interval]	
Green project (N)	505,975	0.517	0.001	0.500	0.516	0.519
Green project (Y)	93,339	0.207	0.001	0.405	0.204	0.209
Combined	599,314	0.469	0.001	0.499	0.468	0.470
diff		0.311	0.002		0.307	0.314
P-value		0.0000				
Digital project (N)	430,940	0.524	0.001	0.499	0.522	0.525
Digital project (Y)	168,374	0.329	0.001	0.470	0.327	0.332
Combined	599,314	0.469	0.001	0.499	0.468	0.470
diff		0.194	0.001		0.191	0.197
P-value		0.0000				
Green-digital project (N)	561,341	0.492	0.001	0.500	0.491	0.494
Green-digital project (Y)	37,973	0.125	0.002	0.331	0.122	0.129
Combined	599,314	0.469	0.001	0.499	0.468	0.470
diff		0.367	0.003		0.362	0.372
P-value		0.0000				

Source: Own estimation based on Bachtrögler et al. (2021). Note: Values refer to project-beneficiaries characteristics.

Table A3

T-test for equality of means: likelihood of having of interregional collaboration project by typology of projects (green, digital and green-digital projects)

Group	Obs	Mean (EU funds)	Std. err.	Std. dev.	[95% conf. interval]	
Green project (N)	505,975	0.030	0.000	0.170	0.029	0.030
Green project (Y)	93,339	0.153	0.001	0.360	0.151	0.155
Combined	599,314	0.049	0.000	0.216	0.048	0.049
diff		-0.123	0.001		-0.125	-0.122
P-value		0.0000				
Digital project (N)	430,940	0.034	0.000	0.182	0.034	0.035
Digital project (Y)	168,374	0.087	0.001	0.281	0.085	0.088
Combined	599,314	0.049	0.000	0.216	0.048	0.049
diff		-0.052	0.001		-0.054	-0.051
P-value		0.0000				
Green-digital project (N)	561,341	0.039	0.000	0.194	0.039	0.040
Green-digital project (Y)	37,973	0.194	0.002	0.395	0.190	0.198
Combined	599,314	0.049	0.000	0.216	0.048	0.049
diff		-0.155	0.001		-0.157	-0.153
P-value		0.0000				

Source: Own estimation based on Bachtrögler et al. (2021). Note: Values refer to project-beneficiaries characteristics.

Table A4

T-test for equality of means: likelihood of having of an R&D project by typology of projects (green, digital and green-digital projects)

Group	Obs	Mean (EU funds)	Std. err.	Std. dev.	[95% conf. interval]	
Green project (N)	504,036	0.361	0.001	0.480	0.360	0.362
Green project (Y)	92,717	0.304	0.002	0.460	0.301	0.307
Combined	596,753	0.352	0.001	0.478	0.351	0.353
diff		0.057	0.002		0.054	0.060
P-value		0.0000				
Digital project (N)	429,199	0.340	0.001	0.474	0.339	0.342
Digital project (Y)	167,554	0.383	0.001	0.486	0.381	0.385
Combined	596,753	0.352	0.001	0.478	0.351	0.353
diff		-0.043	0.001		-0.045	-0.040
P-value		0.0000				
Green-digital project (N)	558,949	0.348	0.001	0.476	0.346	0.349
Green-digital project (Y)	37,804	0.421	0.003	0.494	0.416	0.426
Combined	596,753	0.352	0.001	0.478	0.351	0.353
diff		-0.073	0.003		-0.078	-0.068
P-value		0.0000				

Source: Own estimation based on Bachtrögler et al. (2021). Note: Values refer to project-beneficiaries characteristics.

Appendix B - Testing multi-collinearity and descriptive statistics

Table B1

Collinearity Diagnostics and descriptive statistics

Variable	VIF	Mean	Std. Dev.	Min	Max
Log of CO2 emissions intensity	2.02	5.788	0.838	2.946	8.665
Log of GVA per capita	4.25	9.874	0.622	8.091	11.299
Log of Human Capital	1.23	-1.243	0.305	-2.115	-0.569
Log of Employment Density	1.28	-2.886	1.174	-7.177	0.975
Quality of Government	2.70	0.002	1.002	-2.313	2.197
Mean VIF	2.30				

Source: Own elaboration.
Note: N° of observations = 238

Appendix C - Complementarity analysis

Table C1

Results probit model: Concentration and interregional collaboration projects

Variable	(1) Green	(2) Digital	(3) Greene-Digital
Control variables	Yes	Yes	Yes
Log of Green collaboration projects	0.196***	-	-
per capita	(0.074)	-	-
Log of Digital collaboration projects	-	0.052	-
per capita	-	(0.068)	-
Log of Green-Digital collaboration projects	-	-	0.205***
per capita	-	-	(0.070)
Constant	1.435 (3.577)	5.530 (3.589)	1.485 (3.534)
Observations	236	233	232
Log pseudolikelihood	-146.34	-152.02	-150.92
Pseudo R2	0.0864	0.0566	0.0590

Source: Own estimation
Note: Robust standard errors in parentheses. Significance level: *** p<0.01, ** p<0.05, * p<0.1

Table C2

Results probit model: Concentration and micro-subsidy projects

Variable	(1) Green	(2) Digital	(3) Greene-Digital
Control variables	Yes	Yes	Yes
Log of Micro-subsidy per capita	-0.141*** (0.053)	-0.029 (0.038)	-0.070* (0.041)
Constant	2.422 (3.674)	4.598 (3.409)	-0.363 (3.448)
Observations	238	238	238
Log pseudolikelihood	-143.97	-154.80	-156.29
Pseudo R2	0.1091	0.0599	0.0487

Source: Own estimation
Note: Robust standard errors in parentheses. Significance level: *** p<0.01, ** p<0.05, * p<0.1

References

- Antràs, P., & Chor, D. (2013). Organizing the global value chain. Econometrica, 81(6), 2127-2204.
- Arbolino, R., Carlucci, F., Cirà, A., Yigitcanlar, T., & Ioppolo, G. (2018). Mitigating regional disparities through microfinancing: An analysis of microcredit as a sustainability tool for territorial development in Italy. Land Use Policy, 70, 281-288.
- Asheim, B. T., & Gertler, M. S. (2005). The geography of innovation: regional innovation systems. In The Oxford handbook of innovation.
- Bachtrögler et al (2021). UPDATE: Dataset of projects co-funded by the ERDF during the multi-annual financial framework 2014-2020, JRC125008.
- Baldwin, R., & Forslid, R. (2020). Globotics and development: When manufacturing is jobless and services are tradable (No. w26731). National Bureau of Economic Research.
- Balland, P. A. (2012). Proximity and the evolution of collaboration networks: evidence from research and development projects within the global navigation satellite system (GNSS) industry. Regional studies, 46(6), 741-756.
- Banerjee, A., Duflo, E., Glennerster, R., & Kinnan, C. (2015). The miracle of microfinance? Evidence from a randomized evaluation. American economic journal: Applied economics, 7(1), 22-53.
- Brauer, B.; Ebermann, C.; Hildebrandt, B.; Remané, G.; and Kolbe, Lutz M. (2016). "Green by App:: The contribution of mobile applications to environmental sustainability". PACIS 2016 Proceedings. Paper 220
- Bresnahan, T. F., & Trajtenberg, M. (1995). General purpose technologies 'Engines of growth'?. Journal of econometrics, 65(1), 83-108.
- Bresnahan, T. F., Brynjolfsson, E., & Hitt, L. M. (2002). Information technology, workplace organization, and the demand for skilled labor: Firm-level evidence. The Quarterly Journal of Economics, 117(1), 339-376.
- Bruneel, J., d'Este, P., & Salter, A. (2010). Investigating the factors that diminish the barriers to university–industry collaboration. Research policy, 39(7), 858-868.
- Charron, N., Dijkstra, L., & Lapuente, V. (2015). Mapping the regional divide in Europe: A measure for assessing quality of government in 206 European regions. Social Indicators Research, 122(2), 315-346.
- Chen, Z., Kahn, M. E., Liu, Y., & Wang, Z. (2018). The consequences of spatially differentiated water pollution regulation in China. Journal of Environmental Economics and Management, 88, 468-485.
- Cheng, Z. (2016). The spatial correlation and interaction between manufacturing agglomeration and environmental pollution. Ecological indicators, 61, 1024-1032.
- Coenen, L., & Truffer, B. (2012). Places and spaces of sustainability transitions: geographical contributions to an emerging research and policy field. European Planning Studies, 20(3), 367-374.
- Coenen, L., Benneworth, P., & Truffer, B. (2012). Toward a spatial perspective on sustainability transitions. Research policy, 41(6), 968-979.
- Coenen, L., Hansen, T., Glasmeier, A., & Hassink, R. (2021). Regional foundations of energy transitions. Cambridge Journal of Regions, Economy and Society, 14(2), 219-233.
- Cowling, M. and Liu, W. (2021). "Access to Finance for Cleantech Innovation and Investment: Evidence from U.K. Small- and Medium-Sized Enterprises," in IEEE Transactions on Engineering Management, doi: 10.1109/TEM.2021.3066685.
- Crépon, B., Devoto, F., Duflo, E., & Parienté, W. (2015). Estimating the impact of microcredit on those who take it up: Evidence from a randomized experiment in Morocco. American Economic Journal: Applied Economics, 7(1), 123-150.
- Crippa, M; Guizzardi, D; Muntean, M; Schaaf, E; Lo Vullo, E; Solazzo, E; Monforti-Ferrario, F; Olivier, J; Vignati, E (2021): EDGAR v6.0 Greenhouse Gas Emissions. European Commission, Joint Research Centre (JRC) [Dataset] PID: http://data.europa.eu/89h/97a67d67-c62e-4826-b873-9d972c4f670b
- de Lucio, J., & Mora-Sanguinetti, J. S. (2022). Drafting "better regulation": The economic cost of regulatory complexity. Journal of Policy Modeling, 44(1), 163-183.
- De Propris, L., & Bailey, D. (2021). Pathways of regional transformation and Industry 4.0. Regional Studies, 55(10-11), 1617-1629.
- Dekle, R. (2002). Industrial concentration and regional growth: evidence from the prefectures. Review of Economics and Statistics, 84(2), 310-315.
- Devereux, M. P., Griffith, R., & Simpson, H. (2004). The geographic distribution of production activity in the UK. Regional science and urban economics, 34(5), 533-564.
- Dingel, J. I., & Neiman, B. (2020). How many jobs can be done at home?. Journal of Public Economics, 189, 104235.
- Dong, F., Wang, Y., Zheng, L., Li, J., & Xie, S. (2020). Can industrial agglomeration promote pollution agglomeration? Evidence from China. Journal of Cleaner Production, 246, 118960.
- Doussineau, M. and Bachtrögler-Unger, J. (2021). Exploring synergies between the EU Cohesion policy and Horizon 2020 fund-ing across European Regions, Publications Office of the European Union, Luxembourg.

doi:10.2760/218779, JRC123485.
- Duranton, G., & Overman, H. G. (2005). Testing for localization using micro-geographic data. The Review of Economic Studies, 72(4), 1077-1106.
- Duranton, G., & Puga, D. (2004). Micro-foundations of urban agglomeration economies. In Handbook of regional and urban economics (Vol. 4, pp. 2063-2117). Elsevier.
- Evans, S., Vladimirova, D., Holgado, M., Van Fossen, K., Yang, M., Silva, E. A., & Barlow, C. Y. (2017). Business model innovation for sustainability: Towards a unified perspective for creation of sustainable business models. Business Strategy and the Environment, 26(5), 597-608.
- Feldman, M. P. (1994). The geography of innovation (Vol. 2). Springer Science & Business Media.
- Fernández, Y. F., López, M. F., & Blanco, B. O. (2018). Innovation for sustainability: the impact of R&D spending on CO2 emissions. Journal of cleaner production, 172, 3459-3467.
- Fujita, M., Krugman, P. R., & Venables, A. (1999). The spatial economy: Cities, regions, and international trade. MIT press.
- Gal, P., Nicoletti, G., von Rüden, C., Sorbe, S., & Renault, T. (2019). Digitalization and productivity: In search of the holy grail-firm-level empirical evidence from European countries. International Productivity Monitor, (37), 39-71.
- García-Muñiz, A. S., Vicente, M. R., & Billon, M. (2021). ICT Research networks and regional competitiveness: an analysis of the 7th Framework Program. European Planning Studies, 1-21.
- Ghisetti, C., Marzucchi, A., & Montresor, S. (2015). The open eco-innovation mode. An empirical investigation of eleven European countries. Research Policy, 44(5), 1080-1093.
- Hervás-Oliver, J. L., Parrilli, M. D., Rodríguez-Pose, A., & Sempere-Ripoll, F. (2021). The drivers of SME innovation in the regions of the EU. Research Policy, 50(9), 104316.
- Ioannides, Y. M., Overman, H. G., Rossi-Hansberg, E., & Schmidheiny, K. (2008). The effect of information and communication technologies on urban structure. Economic Policy, 23(54), 202-242.
- Ketterer, T. D., & Rodríguez-Pose, A. (2018). Institutions vs.'first-nature'geography: What drives economic growth in Europe's regions?. Papers in Regional Science, 97, S25-S62.
- Kheder, S. B., & Zugravu, N. (2012). Environmental regulation and French firms location abroad: An economic geography model in an international comparative study. Ecological Economics, 77, 48-61.
- Klein, A., & Crafts, N. (2012). Making sense of the manufacturing belt: determinants of US industrial location, 1880–1920. Journal of Economic Geography, 12(4), 775-807.
- Krugman, P. (1991). Increasing returns and economic geography. Journal of political economy, 99(3), 483-499.
- Lange, A., & Quaas, M. F. (2007). Economic geography and the effect of environmental pollution on agglomeration. The BE Journal of Economic Analysis & Policy, 7(1).
- Liang, J., & Goetz, S. J. (2018). Technology intensity and agglomeration economies. Research Policy, 47(10), 1990-1995.
- Liu, J.; Zhao, M.; Wang, Y. (2020). "Impacts of government subsidies and environmental regulations on green process innovation: A nonlinear approach", Technology in Society, 63. https://doi.org/10.1016/j.techsoc.2020.101417.
- Llano-Verduras, C., Pérez-Balsalobre, S., & Rincón-Aznar, A. (2021). Market fragmentation and the rise of sub-national regulation. The Annals of Regional Science, 67(3), 765-797.
- Luederitz, C., Schäpke, N., Wiek, A., Lang, D. J., Bergmann, M., Bos, J. J., ... & Westley, F. R. (2017). Learning through evaluation–A tentative evaluative scheme for sustainability transition experiments. Journal of Cleaner Production, 169, 61-76.
- McAfee, A. (2019). More from less: The surprising story of how we learned to prosper using fewer resources—and what happens next. Scribner.
- Melville, N. P. (2010). Information systems innovation for environmental sustainability. MIS quarterly, 1-21.
- Miguélez, E., & Moreno, R. (2015). Knowledge flows and the absorptive capacity of regions. Research Policy, 44(4), 833-848.
- OECD/European Commission (2021). "Designing effective microfinance schemes for inclusive entrepreneurship". In: The Missing Entrepreneurs 2021:Policies for Inclusive Entrepreneurship and Self-Employment, OECD Edition, Paris, https://doi.org/10.1787/5adabec3-en.
- Owen, R.; Brennan, G.; Lyon, F. (2018). ''Enabling investment for the transition to a low carbon economy: government policy to finance early stage green innovation", Current Opinion in Environmental Sustainability, 31:137-145. https://doi.org/10.1016/j.cosust.2018.03.004.
- Parviainen, P., Tihinen, M., Kääriäinen, J., & Teppola, S. (2017). Tackling the digitalization challenge: how to benefit from digitalization in practice. International journal of information systems and project management, 5(1), 63-77.
- Polzin, F. and Sanders, M. (2020). "How to finance the transition to low-carbon energy in Europe?", Energy Policy, 147. https://doi.org/10.1016/j.enpol.2020.111863.
- Pontikakis, D.; Fernandez, T.; Janssen, M.; Guy, K.; Santos, A., Boden, M. and Moncada-Paterno-Castello, P. (2020). "Projecting Opportunities for INdustrial Transitions (POINT): Concepts, rationales and methodological considerations for territorial reviews of industrial transition", JRC technical report, EUR 30375 EN, Publications Office of the

European Union, Luxembourg, doi:10.2760/59038.
- Porter, M. E., & Van der Linde, C. (1995). Toward a new conception of the environment-competitiveness relationship. Journal of economic perspectives, 9(4), 97-118.
- Puga, D. (2010). The magnitude and causes of agglomeration economies. Journal of regional science, 50(1), 203-219.
- Raptou, E., Manolas, E. (2022). Consumption Patterns and Public Attitudes Toward Organic Foods: The Role of Climate Change Awareness. In: Leal Filho, W., Manolas, E. (eds) Climate Change in the Mediterranean and Middle Eastern Region. Climate Change Management. Springer, Cham. https://doi.org/10.1007/978-3-030-78566-6_18
- Rodríguez-Pose, A., & Di Cataldo, M. (2015). Quality of government and innovative performance in the regions of Europe. Journal of Economic Geography, 15(4), 673-706.
- Santos, A. and Cincera, M. (2022). "Determinants of financing constraints", Small Business Economics, 58:1427–1439. https://doi.org/10.1007/s11187-021-00449-w
- Sarc, R., Curtis, A., Kandlbauer, L., Khodier, K., Lorber, K. E., & Pomberger, R. (2019). Digitalisation and intelligent robotics in value chain of circular economy oriented waste management–A review. Waste Management, 95, 476-492.
- Scherngell, T. (2021). The geography of R&D collaboration networks. Handbook of Regional Science, 869-887.
- Sharma, R., Lopes de Sousa Jabbour, A.B., Jain, V. and Shishodia, A. (2022), "The role of digital technologies to unleash a green recovery: pathways and pitfalls to achieve the European Green Deal", Journal of Enterprise Information Management, Vol. 35 No. 1, pp. 266-294. https://doi.org/10.1108/JEIM-07-2021-0293
- Siegel, D. S., Waldman, D. A., Atwater, L. E., & Link, A. N. (2003). Commercial knowledge transfers from universities to firms: improving the effectiveness of university–industry collaboration. The Journal of High Technology Management Research, 14(1), 111-133.
- Silva, P., Madaleno, M., Robaina, M., Meireles, M. (2021). Eco-Innovation and Emissions Trading: a sector analysis for European countries. International Journal of Sustainable Energy Planning and Management, 32, 5–18.
- Testa, F., Pretner, G., Iovino, R. et al. Drivers to green consumption: a systematic review. Environ Dev Sustain 23, 4826–4880 (2021). https://doi.org/10.1007/s10668-020-00844-5
- Vicente, M. R., García-Muñiz, A. S., & Billón, M. (2020). Exploring European-funded project-based networks in ICT and their links with regional total factor productivity: The FP7 and the CIP. Research Evaluation, 29(4), 441-455.
- Vinuesa, R., Azizpour, H., Leite, I., Balaam, M., Dignum, V., Domisch, S., Felländer, A., Langhans, S. D., Tegmark, M. & Fuso Nerini, F. (2020). The role of artificial intelligence in achieving the Sustainable Development Goals. Nature Communications, 11(1), 1-10.
- Wang, X., & Zhou, D. (2021). Spatial agglomeration and driving factors of environmental pollution: A spatial analysis. Journal of Cleaner Production, 279, 123839.
- Williams, S., & Robinson, J. (2020). Measuring sustainability: An evaluation framework for sustainability transition experiments. Environmental Science & Policy, 103, 58-66.
- Xiang, X.; Liu, C.; Yang, M. (2022). "Who is financing corporate green innovation?", International Review of Economics & Finance, 78:321-337.https://doi.org/10.1016/j.iref.2021.12.011
- Zeng, D. Z., & Zhao, L. (2009). Pollution havens and industrial agglomeration. Journal of Environmental Economics and Management, 58(2), 141-153.
- Zolas, N., Kroff, Z., Brynjolfsson, E., McElheran, K., Beede, D. N., Buffington, C., Goldschlag, N., Foster, L & Dinlersoz, E. (2021). Advanced technologies adoption and use by US firms: Evidence from the annual business survey (No. w28290). National Bureau of Economic Research.

EUROPEAN MICROFINANCE NETWORK

European Microfinance Network (EMN) aisbl
Avenue des Arts 7-8, 1210 Brussels - Belgium
emn@european-microfinance.org
www.european-microfinance.org

With contribution by EIF

#Believe InSmall

This publication has received financial support from the European Union Programme for Employment and Social Innovation "EaSI" (2014-2020). For further information please consult: http://ec.europa.eu/social/easi
The information contained in this publication does not necessarily reflect the official position of the European Commission.