EXTENDED ABSTRACT

Title: Green and digital transition: Assessing regional patterns of EU subsidies

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Abstract: *(minimum1500 words)*

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.

[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.

Our empirical methodology consists of three main steps. The first step is to identify, using text analysis techniques, whether research projects are devoted to digital and/or green transition. The second step deals with the estimation of a proper location indicator (the Location Quotient). Third, we integrate the results pertaining previous steps to estimate an empirical model, a probit econometric model.

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 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.

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.

Figures 1-3 display the regions with a greater concentration of ERDF green, digital and green-digital projects, respectively.

Figure 1. Concentration of ERDF green projects, 2014-2020, EU27

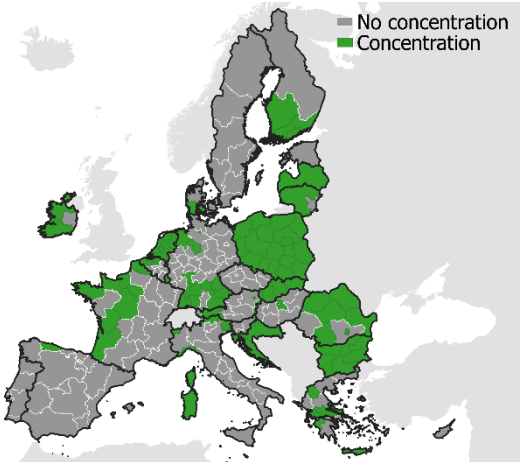


Figure 2. Concentration of ERDF digital projects, 2014-2020, EU27

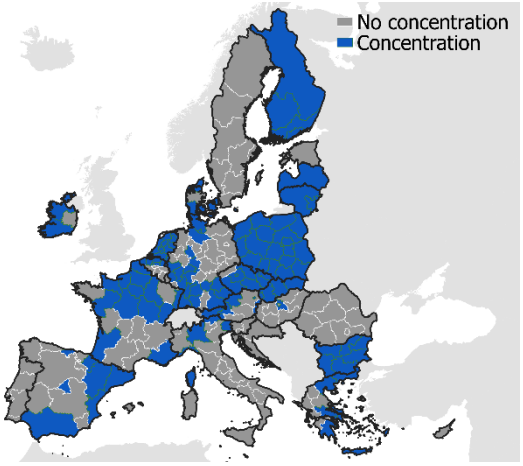


Figure 3. Concentration ERDF green-digital projects, 2014-2020, EU27

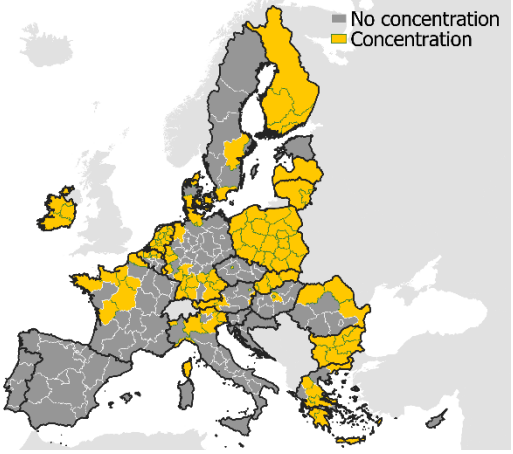
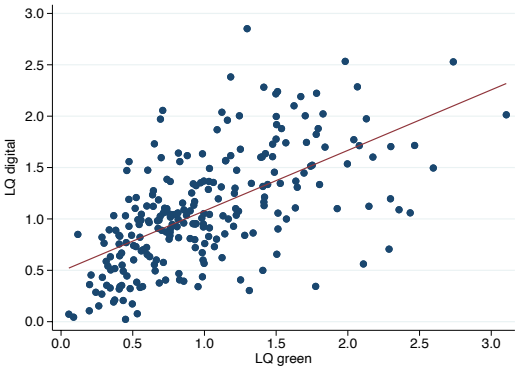


Figure 4. Scatterplot ERDF green versus digital projects, 2014-2020, EU27



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

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.

A binary choice model is estimated using a probit model and results are presented in Table 1. 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.

Table 1. Results Probit model: baseline model

Variables	(1) Green	(2) Digital	(3) Greene-Digital
Log of CO2 emissions intensity	0.311**	0.196	0.312**
	(0.152)	(0.139)	(0.138)
Log of GVA per capita	-0.382	-0.432	-0.084
	(0.304)	(0.277)	(0.279)
Log of Human Capital	0.496	0.750**	0.369
	(0.313)	(0.315)	(0.311)
Log of Employment Density	0.200**	0.186**	0.145*
	(0.084)	(0.080)	(0.080)
Quality of Government	0.102	0.305**	0.173
	(0.144)	(0.141)	(0.139)
Constant	2.770	4.544	-0.376
	(3.772)	(3.396)	(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

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.

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.

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.

Keywords: *Green transition; Digital transition; Twin transition; EU funds; Location*
JEL codes: R11, Q50