

RESEARCH ARTICLE



OPEN ACCESS



On the road to regional 'Competitive Environmental Sustainability': the role of the European structural funds

Anabela Santos^a, Javier Barbero^b, Simone Salotti^a, Olga Diukanova^a
and Dimitrios Pontikakis^a

^aEuropean Commission, Joint Research Centre, Seville, Spain; ^bDepartment of Economics, Universidad Autónoma de Madrid, Madrid, Spain

ABSTRACT

We construct a novel indicator of regional competitive sustainability based on the movements over time of employment sectoral shares across all the regions of the European Union. The indicator accounts for shifts in employment towards greener and more productive sectors over the 2008–2018 period. The mapping of the indicators shows considerable regional heterogeneity in terms of both competitiveness and environmental sustainability, as well as interesting dynamics over time. We also present an econometric analysis of the determinants of these sectoral shifts. It appears that the European structural funds are positively associated with the transition to a more competitive and sustainable economy at the regional level. This is particularly true for the competitive dimension of the transition, with the funds being positively associated with a regional employment restructuring towards more productive sectors.

KEYWORDS

Green transition; public support; sectoral employment; European regions; European Structural Funds

JEL


R11; L16; H25; O52

1. Introduction

The recent policy trends in the European Union (EU) advocate concentrating on growth and development strategies based on the so-called competitive sustainability paradigm: 'Competitive sustainability has always been at the heart of Europe's social market economy and should remain its guiding principle for the future' (European Commission 2019a, 3).¹ This paradigm is aligned with measures to fight climate change, as well as with the commitment to maintain welfare and innovative and competitive economic systems. Principles like these are reflected, for instance, in the recently launched Next Generation EU recovery package, which promotes green and digital activities so to permit to achieve the objective of a climate-neutral economy by 2050 (Pfeiffer, Varga, and In 't Veld 2021).

CONTACT Anabela Santos  anabela.MARQUES-SANTOS@ec.europa.eu  European Commission, Joint Research Centre, Edificio EXPO, c. Inca Garcilaso 3, Seville 41092, Spain

¹The concept of system innovation explored by the OECD (Diercks 2019) is similar to that of competitive sustainability used in the EU policy context.

 Supplemental data for this article can be accessed online at <https://doi.org/10.1080/13662716.2023.2236048>.

© 2023 European Union. Published by Informa UK Limited, trading as Taylor & Francis Group.

This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. The terms on which this article has been published allow the posting of the Accepted Manuscript in a repository by the author(s) or with their consent.

This is also in line with other ongoing policy efforts like the European Green Deal and the Fit for 55 package (European Commission 2019b).²

This so-called green transition, inevitably affects the way in which the factors of production are used, resulting in shifts of employment and other resources across sectors. These industrial transitions may be costly for certain regions due to the existence of barriers to investment activities, gaps in large infrastructure, lacking business innovation and unavailability of people with the right skills. All these factors may impede a smooth transition towards a more competitive and greener economy, with consequences on investment attractiveness and, ultimately, economic growth. Thus, the regions struggling with these long-term challenges are at risk of industrial decline, significant job losses in some sectors, and possibly even outflows of workers.

This paper proposes a new regional indicator to measure the transition towards a competitive and environmentally sustainable economy constructed using data from 2008 to 2018 on employment, productivity (to account for competitiveness), and greenhouse gas emissions (to account for sustainability), for a large number of economic sectors. The procedure, that we describe in detail in the paper, results in three indicators providing information on the sectoral changes in all the regional economies of the EU³ along the competitiveness and sustainability dimensions, both separately and jointly. In a nutshell, the indicators have higher values for the EU regions in which employment shares increased in the sectors categorised as either relatively more competitive than others, or greener, or both at the same time.

We first illustrate the territorial distribution of these indicators at the beginning of the period of analysis, as well as their evolution over time. Then, we use an econometric model to identify what affected the transition towards more competitive and environmentally sustainable systems. Among the potential determinants of this transition, we pay particular attention to the role played by macroeconomic conditions, innovation, and the European structural funds.

It appears important to understand how European policies such as the Cohesion policy funds have supported and influenced changes in employment across different sectors in the EU regions over the last decade. This policy in particular aims at strengthening the economic, social and territorial cohesion in the EU, with objectives related to support to competitiveness and improvement in the quality of the environment. We provide evidence on the role played by the investments made under this policy in relationship with these objectives. Besides its scientific value, this evidence would also be relevant for the design of policy instruments related to the green transition.

We first show that the Cohesion policy investments mainly targeted the regions lagging behind in terms of competitiveness according to the indicator we propose. Then, the econometric investigation suggests that the structural funds are positively related to a transition towards a more competitive and at the same time more environmentally sustainable economy, mainly due to the positive effect on the competitive dimension of the indicator.

²The European Green Deal in particular sees Europe's future economic competitiveness as passing through sustainability, aiming to transform the EU into 'a modern, resource-efficient and competitive economy where there are no net emissions of greenhouse gases in 2050 and where economic growth is decoupled from resource use' (European Commission 2019a, 2).

³From now onwards, EU stands for EU27, without the UK.

Our study innovates on the existing literature in several ways. First, we provide a novel indicator of competitive and sustainable transition using data for a high number of sectors, while most of the existing contributions have focused solely on productivity when studying industrial transitions, usually across highly aggregated sectors (agriculture, industry, and services – see, among others, Dabla-Norris et al. 2013; Duernecker, Herrendorf, and Valentinyi 2017; Herrendorf, Rogerson, and Valentinyi 2014; McMillan, Rodrik, and Verduzco-Gallo 2014).

Second, the majority of the existing evidence is based on country-level data, while in our analysis we use regional (NUTS-2) data. Third, we focus on the role of public policies and innovation investments in supporting the transition towards a greener and competitive economy, a dimension which has been overlooked so far due to the fact that the literature has mostly focused on secular shifts across macro-sectors, rather than medium-term changes as we do in our paper (one notable exception being Martins 2019).

Fourth, we provide evidence on the possibility for a policy such as the European regional one to be successful in achieving both economic and societal objectives such as competitive environmental sustainability (e.g. OECD 2021; Schot and Steinmueller 2018). This complements a vast literature on the returns of regional structural funds (Cerqua and Pellegrini 2018; Crescenzi and Giua 2020), a policy which has implications for territorial inequalities in Europe (Diemer et al. 2022; Rodríguez-Pose and Ketterer 2020).

The rest of the paper is organised as follows. Section 2 illustrates the framework of our analysis and briefly summarises the evidence on structural transformation across economic sectors. Section 3 describes the regional competitive sustainability indicators proposed here. Section 4 assesses the determinants of the transition towards competitive environmental sustainability. Finally, Section 5 concludes and provides policy recommendations.

2. Framework and related evidence

As briefly stated above, the indicators that we propose here are constructed by looking at the distribution of employment across economic sectors, which are classified depending on their productivity levels and greenhouse gas emissions. Some guidance on the investigation of what may drive the shifts in employment across sectors along those two dimensions is offered by the literature on economic growth and structural transformation, which is the reallocation of the economic activity across its sectors over time (Herrendorf, Rogerson, and Valentinyi 2014). Kuznets (1973) was the first to study the decreasing importance of agriculture in favour of manufacturing which characterises the development process of countries around the world. Building on that seminal article, several authors documented the reallocation of the economic activity across the three broad sectors of agriculture, manufacturing, and services, driven by both demand-side and supply-side mechanisms (Dabla-Norris et al. 2013). Multi-sector models are used to study the former determinants, which include preferences and income effects (Echevarria 2000; Kongsamut, Rebelo, and Xie 2001). An alternative group of models emphasise supply-side factors like relative price effects to explain the sectoral reallocation of resources, driven by different rates of productivity growth (Duarte and Restuccia 2010), or different sectoral capital intensity (Acemoglu and Guerrieri 2008).

In a review of the literature on the topic, Van Neuss (2019, 26) points out that ‘it is noteworthy that the recent literature on structural change has been exceptionally silent

on policy issues.’ This is the result of assuming that the transformation process leads to an efficient equilibrium by construction, thus eliminating any role for public policies. However, this view ignores that the process may be not linear due to the existence of rigidities such as, for example, imperfect mobility of the factors of production.

Our study aims at filling this gap in the literature by investigating the potential role played by industrial policies like those supported by the European structural funds. Moreover, we study the interlinked issues of competitiveness and productivity, on one hand, and environmental sustainability and greenhouse gas emissions, on the other.

Our investigation of the competitiveness dimension could contribute to the debate on the sluggish productivity performance of some European regions. Farole et al. (2018) suggest that European low-growth regions experienced almost no productivity growth in recent decades due to intersectoral employment shifts, suggesting no shift out of low-productivity agriculture and basic services.

The interest for environmental sustainability in this context is related to the ground-gaining concept of system innovation (Miedzinski et al. 2021; Pontikakis et al. 2020; Schot and Steinmueller 2018). While it is reasonable to expect trade-offs between economic prosperity and environmental sustainability, such trade-offs are not necessarily inevitable. A growing number of policy efforts intend to create synergetic development paths. These include, among others, transformative innovation policies (Haddad et al. 2022; Schot and Steinmueller 2018), mission-oriented innovation policies (OECD 2021), and partnerships for regional innovation (Pontikakis et al. 2022),⁴ all of which strive for system-level innovation using various combinations of public support for investment, regulation and demand-side interventions.

In the econometric part of our analysis, in which we investigate the potential determinants of the transition towards more competitive and sustainable regional economic systems in the EU, we take advantage of the empirical literature on structural change. For example, Martins (2019) finds that both human and physical capital play a key role in shaping structural transformation based on data for 169 countries between 1991 and 2013. Therefore, after presenting the construction and properties of the regional indicators that we propose, we use them as dependent variables in a model close in spirit to those used to study the determinants of structural change, enriched with variables capturing the role of public policies.

3. The regional competitive environmental sustainability indicator

3.1. Constructing the indicator

An indicator of progress towards competitive sustainability should account for both economic performance and environmental sustainability. Economies achieving competitive sustainability, and thus aligning with the vision of the European Green Deal (European Commission 2019a), are expected to succeed in identifying synergic investments to achieve both productivity growth and declining carbon emissions. Therefore, our indicators are based on information on these two variables.

⁴The potential role played by innovation for the regional sectoral shifts considered here is also linked to the Schumpeterian theories put forward by Perez (2010) and, for Europe in particular, by Mazzucato and Martin (2015).

We construct the Regional Competitive Environmental Sustainability (*RCES*) indicator using NUTS-2 level data from 2008 to 2018 for 56 NACE economic activities (see list in Table A1 in Appendix A).⁵ In each year, each economy sector is classified according to its relative positioning in terms of i) competitiveness and ii) environmental sustainability, as follows:

- (i) ‘High (Low) productivity’ if the economic sector shows an above- (below-) EU27 average productivity level in 2008-2018.⁶ Productivity is proxied by wages and salaries per employee, since information on gross value added (GVA) or other output measures are not available with the required degree of NUTS-2 and NACE 2-digits granularity.⁷ Regional values are transformed in constant prices (base 2015) using country GDP deflators, and expressed at Purchasing Power Standard (PPS) to allow comparison with the EU27 average.
- (ii) ‘Low (High) emissions intensity’ if the economic sector is characterised by a below- (above-) average air emissions intensity (greenhouse gases emissions – GHG – per employee) in comparison with the EU27 level in 2008-2018.⁸

The classification of economic activities is made relatively to the whole EU27 to allow comparability between the different regions, no matter the country they are in. The existence of a European single market in which goods and persons can move freely suggests that a EU comparison is more meaningful than an alternative one based, for instance, on country-specific classifications of sectors. Also, from a policy point of view, the European Structural funds, which we study in the econometric part of the analysis, are allocated to the regions and countries based on criteria using data at the EU level. Therefore, it seems natural to refer to the whole EU when classifying economic sectors in terms of their competitiveness and environmental sustainability.⁹

The data refer to 56 economic activities in 237 NUTS-2 level (2016 version) EU regions.¹⁰ In each year, a sector is assigned a value of 1 if productivity is above and emissions intensity is below the EU27 benchmark; 0 otherwise. Then, we compute the sum of employment in these activities that are simultaneously classified as ‘High

⁵The choice of the time period is due to data availability for air emissions. At the time of the study (first quarter of 2022), the last year available for JRC-EDGAR on emissions is 2018.

⁶The average refers to the sum of wages and salaries (constant price and PPS) in all the EU countries divided by total population. Then, an average for the period under analysis is estimated to be used as threshold for tracking changes over time. An alternative strategy would have been to compare the values to the 2008 average, to avoid a comparison with data referring to future years.

⁷Using data by industry and by country, we analysed the relationship between wage per employee and gross value added per employee. The correlation between the two is high (see Figure C1 in Appendix C), suggesting that using wage per employee as a proxy for productivity is a viable strategy for the present analysis. Using wages rather than GVA also eliminates the problem of dealing with the negative values of GVA, which could exist when intermediate consumption is higher than the value of output.

⁸We express emissions intensity using employment instead of GVA due to the lack of adequate regional data, and because employment is less sensitive to economic shocks than other economic indicators. Moreover, using employment avoids having to deal with negative air emissions intensity when GVA is negative. As in the case of productivity, average EU emissions intensity is calculated as total greenhouse gas emissions in the EU divided by the number of EU employees.

⁹An alternative strategy would be to classify sectors separately within each country. The drawback is that, for instance, a sector can be simultaneously categorised as highly competitive in a country, and not competitive in another one, despite having the same numerical value of the indicator.

¹⁰The regions of Mayotte (FRY5), Ciudad Autónoma de Ceuta (ES63) and Ciudad Autónoma de Melilla (ES64) are not included in the analysis due to missing data.

productivity' and 'Low emissions', which corresponds to the regional employment in competitive and environmental sustainable activities ($Empl_{i,t}^{CompSust}$). Every year, the *RCES* indicator proposed here measures the proportion of employees working in those competitive and environmental sustainable NACE 2-digits sectors with respect to total employment in every region of the sample ($Empl_{i,t}^{Total}$), as per equation (1):

$$RCES_{i,t} = \frac{Empl_{i,t}^{CompSust}}{Empl_{i,t}^{Total}}, \quad (1)$$

where i refers to NUTS-2 regions, and t refers to years (from 2008 to 2018). The two dimensions, competitiveness and environmental sustainability, have the same weight in the indicator.

Besides its regional distribution, the evolution over time of the *RCES* indicator is of interest. An increase over time for a certain region would mean that more of the workers located there would find themselves in sectors which are simultaneously above average in terms of productivity, and below average in terms of air emission intensity (this can happen both due to productivity and sustainability improvements in the sectors, and to the changes in sectoral specialisation of regions over time). Section 3.3 presents an analysis of the territorial distribution of the indicator and of its evolution over time. In our analysis we use the *RCES* indicator as well as two alternative ones based on each of its two components. Thus, the *RC* indicator refers to the indicator constructed using the information on competitiveness/productivity only, and the *RES* indicator refers to the environmental sustainable dimension and it is constructed using solely the information on emissions intensity.

3.2. Data sources

We construct the three indicators using data from Eurostat's 'Regional Structural Business Statistics' and 'Regional economic accounts', and JRC-EDGAR (Crippa et al., 2021) for air emissions, as described below.

3.2.1. Regional data on employment and wages and salaries

Regional data on employment and wages and salaries are extracted from the Regional structural business statistics (NACE B-S) and the Regional economic accounts (NACE A) of Eurostat. Data on wages and salary are not available at the NUTS-2 level for the NACE code A sector (Agriculture, forestry and fishing), thus we converted the value of compensation of employees into wages and salaries based on the country-industry relationship between the two variables (compensation of employees is the sum of wages and salaries and employers' social contributions). Missing values in the time series for some variables (employment and wages and salaries) were interpolated.

3.2.2. Region-sector data on GHG emissions

The JRC-EDGAR database (<https://edgar.jrc.ec.europa.eu/>) contains the annual sector-specific gridmaps with the emissions values for the three main greenhouse gases (CO₂, CH₄ and N₂O) for the period 1970–2018. Emission gridmaps are expressed in tonnes and classified by sectors using the IPCC 1996 and 2006 codes. Those sectors are different

Table 1. Correspondence between NACE activities and IPCC sector (main polluters).

NACE Classification		GHG	IPCC Sector
A	Agriculture, forestry and fishing	15.1%	Enteric fermentation, manure management, agricultural waste burning and agricultural soils
C19	Manufacture of coke and refined petroleum products	4.1%	Oil refineries and transformation industry
C20	Manufacture of chemicals and chemical products	4.7%	Chemical processes and solvents and products use
C23	Manufacture of other non-metallic mineral products	5.9%	Non-metallic minerals production
C24	Manufacture of basic metals	5.0%	Steel production + non-ferrous metals production
D	Electricity, gas, steam and air conditioning supply	29.0%	Power industry, energy for buildings and fuel exploitation gas
E	Water supply; sewerage, waste management and remediation activities	4.7%	Solid waste landfills, solid waste incineration and waste water handling
H49_53	Land transport and transport via pipelines (H49) + Postal and courier activities (H53)	5.6%	Road transportation no resuspension, railways, pipelines and off-road transport
H50	Water transport	4.2%	Shipping
H51	Air transport	4.2%	Aviation (climbing, descent, cruise, landing and takeoff)
TOTAL		82.6%	

Source: Own elaboration.

Values of GHG refer to the contribution of each NACE activities to the total GHG in E27 for the year 2018. Data extracted from EUROSTAT.

from the NACE classification. Therefore, we used the mapping reported in [Table 1](#) to attribute the emissions data to the NACE sectors. The 10 NACE activities in [Table 1](#) account for more than 80% of the GHG in EU27. For the remaining NACE activities associated with manufacturing and services, we used the JRC-EDGAR data for GHG emissions of combustion for manufacturing and energy for buildings, respectively.

To estimate the region-year GHG emissions for all the 56 NACE activities in [Table A1](#), we combined country-industry-year data on the air emissions accounts from EUROSTAT by NACE Rev. 2 activity [*env_ac_ainah_r2*] and the estimated regional shares of these emissions from JRC-EDGAR. The CH₄ and N₂O were also transformed in CO₂ equivalent, considering that 1 kg of nitrous oxide (N₂O) emissions are equivalent to 298 kg of CO₂, and 1 kg of methane (CH₄) is equivalent to 25 kg of CO₂.

Regional emissions are calculated by computing the sum of emissions of the raster cells from the JRC-EDGAR emission gridmaps that intersect the NUTS-2 polygons, weighting each cell by the coverage fraction of the polygons. NUTS-2 polygons are obtained from Eurostat GISCO. When an emission cell contains both land and water, all the emissions are attributed to the region. The extraction has been performed using the *exactextractr* package for the R programming language.

3.3. Analysis of the RCES, RC, and RES indicators

[Table 2](#) displays the median values over all the EU regions of the RCES, the RC and the RES indicators in 2008 and 2018, as well as for four groups of regions divided according to their location. The ‘Change’ column displays the difference of medians between 2008 and 2018.

Overall, it appears that, in the median region in 2018, 16.7% of the employees were working in sectors which were at the same time more competitive and sustainable than

Table 2. Values of the *RCES*, *RC*, and *RES* indicators in the regions of the EU27.

Region	<i>RCES</i>			<i>RC</i>			<i>RES</i>		
	2008	2018	Change	2008	2018	Change	2008	2018	Change
EU	0.134	0.167	+0.033	0.185	0.212	+0.027	0.472	0.507	+0.035
East	0.009	0.048	+0.039	0.016	0.063	+0.047	0.541	0.522	−0.019
North	0.269	0.273	+0.004	0.347	0.328	−0.019	0.494	0.532	+0.038
South	0.083	0.093	+0.010	0.119	0.125	+0.006	0.502	0.524	+0.022
West	0.199	0.250	+0.051	0.276	0.318	+0.042	0.410	0.482	+0.072

Source: own elaborations based on Eurostat and JRC-EDGAR data.

Note: *RCES* = Regional Competitive Environmental Sustainability indicator; *RC* = Regional Competitive indicator; *RES* = Regional Environmental Sustainability indicator. North includes the regions of Denmark, Estonia, Finland, Ireland, Latvia, Lithuania and Sweden; South includes the regions of Croatia, Cyprus, Greece, Italy, Malta, Portugal, Slovenia, and Spain; West includes the regions of Austria, Belgium, France, Germany, Luxembourg, and the Netherlands; and East includes the regions of Bulgaria, Czech Republic, Hungary, Poland, Romania, and Slovakia.

the EU average, representing an improvement of + 3.3 with respect to 2008. As for competitiveness, in the median region in 2018, 21.2% of the employees were working in sectors characterised by above-average productivity levels. On the sustainability side, 50.7% of the employees of the median region were working in sectors with below-average air emissions intensity levels in 2018. These numbers referring to the middle of the distributions mask considerable regional heterogeneity, with the Northern and West regions being characterised by relatively higher values of the indicators for *RCES* and *RC*. A more comprehensive depiction of the geographical distribution of the indicators is offered by the following figures. Figure 1 shows the mapping of the *RCES* in the EU regions at the beginning of the period under analysis (2008). Figures 2 and Figure 3 and Figures 2 and Figure 3 display the same information for the competitiveness (*RC*) and the environmental sustainability (*RES*) components of the indicator, respectively. Figures 4 to 6 show the territorial distribution of the percentage changes between 2008 and 2018 for the *RCES*, *RC* and *RES* indicators, respectively.

Figures 1-3 suggest that, at the beginning of the period under analysis, the regions in Eastern Europe were better positioned according to the *RES* indicator, but they were weaker from the competitiveness point of view (*RC*), with the composite indicator *RCES* reflecting more the latter situation than the strength from an environmental point of view. Figure 4 shows considerable regional heterogeneity in terms of the 2008–2018 changes in the *RCES* values in most of the EU countries. It appears that most regions of the EU improved in terms of their *RCES* levels during the sample period. The information contained in Figures 5 and 6 suggests that, for instance, regions in Slovenia and Germany mostly improved over time in their green dimension (*RES* indicator - Figure 6), while most regions of Croatia, Romania, Hungary, Latvia, Estonia and some Polish regions improved along the competitiveness dimension (*RC* indicator - Figure 5).

One final piece of evidence we offer is a map showing the regions divided into four categories: those which improved both in terms of competitiveness and sustainability, those which improved in one dimension but got worse in the other, and those which saw a deterioration in the two.

The territorial distribution of Figure 7 differs from the one in Figure 4 because the combined indicator *RCES* may improve even when only one of its components improves, but the other one does not. On the other hand, in Figure 7 there must be improvements in both dimensions in order for a region to be included in the

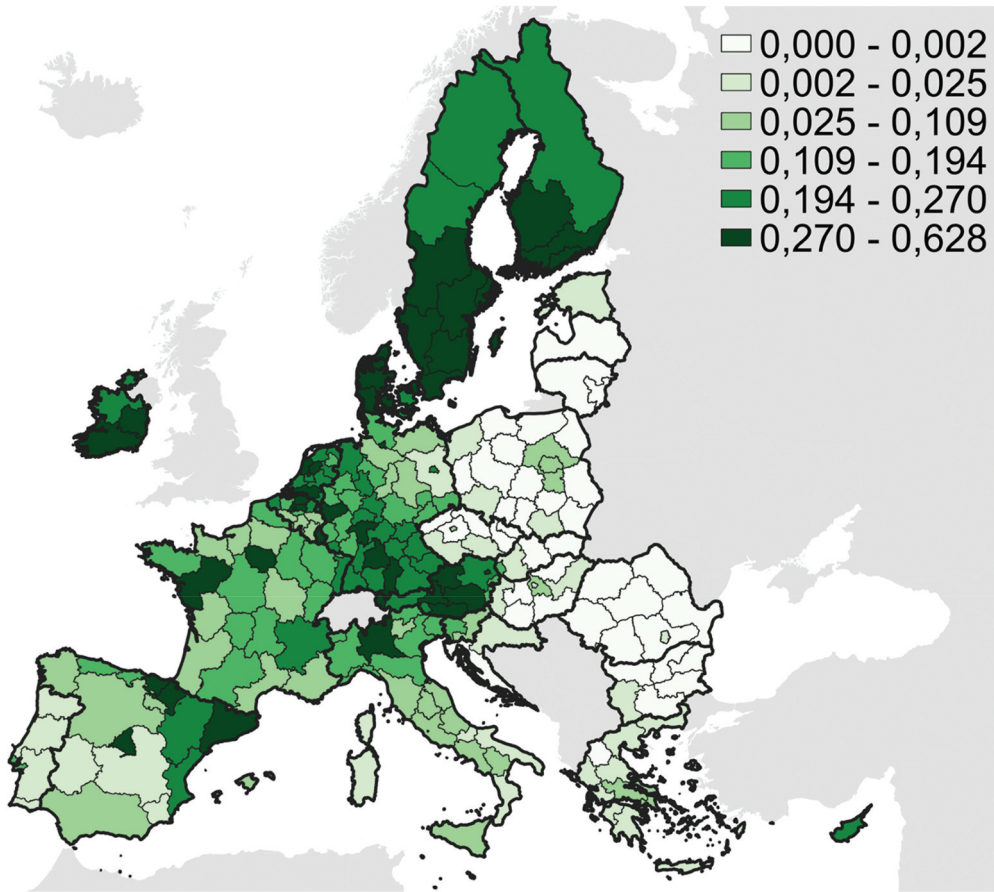


Figure 1. RCES indicator at the NUTS 2 level in 2008. Source: Own elaborations based on Eurostat and JRC-EDGAR data. EuroGeographics for the administrative boundaries. Note: RCES = Regional Competitive Environmental Sustainability indicator. Regions are classified into six equal count intervals.

category marked by the colour green, and this seems to happen mostly, but not only, in Central Europe. It seems that the level of development may influence the dynamics of the three indicators proposed here, with a number of Eastern European regions where competitiveness improved between 2008 and 2018, but environmental sustainability deteriorated. One shortcoming of [Figure 7](#) is that it is silent about the magnitude of the improvements, so that a tiny increase in the value of the indicators is qualitatively equivalent to a bigger increase. That is why we believe that there is value in presenting this alternative way of looking at the evolution over time of the data summarised by the indicators proposed here.

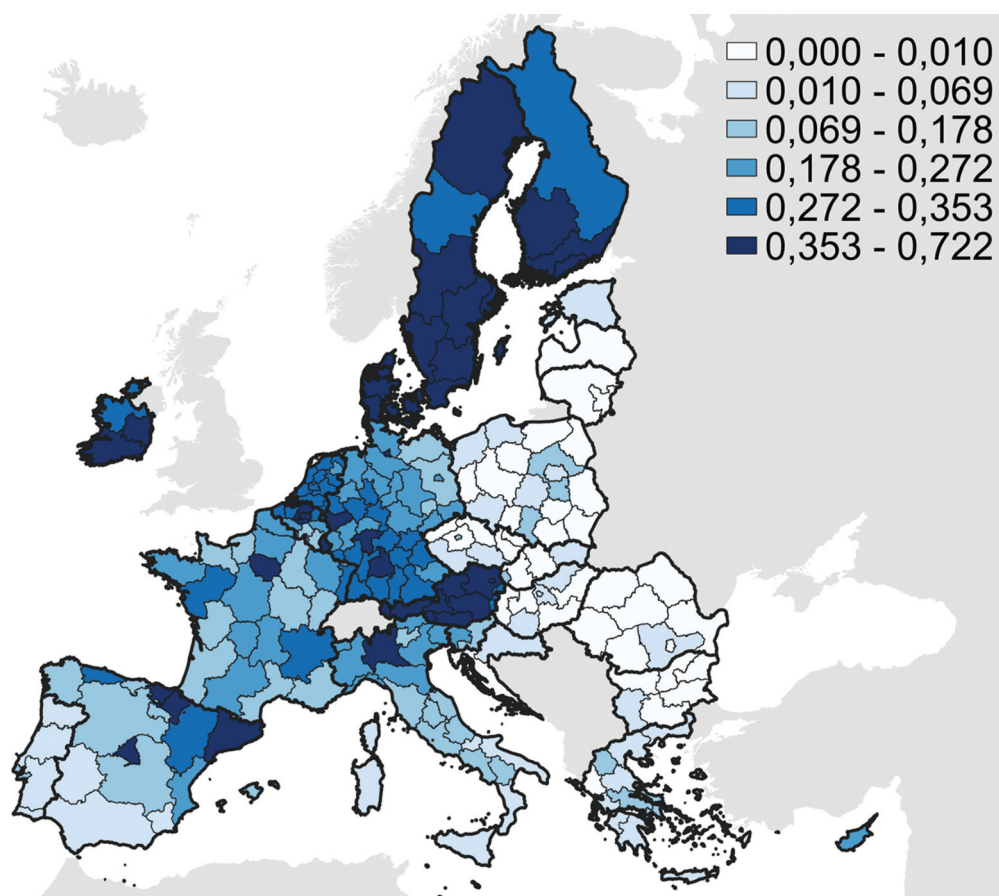


Figure 2. RC indicator at the NUTS 2 level in 2008. Source: Own elaborations based on Eurostat and JRC-EDGAR data. EuroGeographics for the administrative boundaries. Note: RC = Regional Competitive indicator. Regions are classified into six equal count intervals.

4. The European structural funds and the transition towards a more competitive and sustainable economy

4.1. The econometric model

To assess the relationship between the European structural funds and the transition to a more competitive and environmental sustainable economy, we consider a fixed effects econometric model as expressed in equation (3) in which the dependent variable measures industrial transition, and refer to the growth rate of our indicator, expressed as the first difference of the log of *RCES* ($\Delta \ln RCES_{i,t}$).

$$\Delta \ln RCES_{i,t} = \alpha + \beta \ln RCES_{i,t-1} + \gamma \ln FundPC_{i,t-1} + \delta \mathbf{X}_{i,t} + \mu_i + \tau_t + u_{i,t} \quad (2)$$

The model includes as explanatory variables the lagged level of the indicator in log ($\ln RCES_{i,t-1}$), as we expect it to be easier (harder) for a region to improve over time when starting from lower (higher) values of the indicator. Therefore, the expected sign of the coefficient of the lagged level of the indicator is negative.

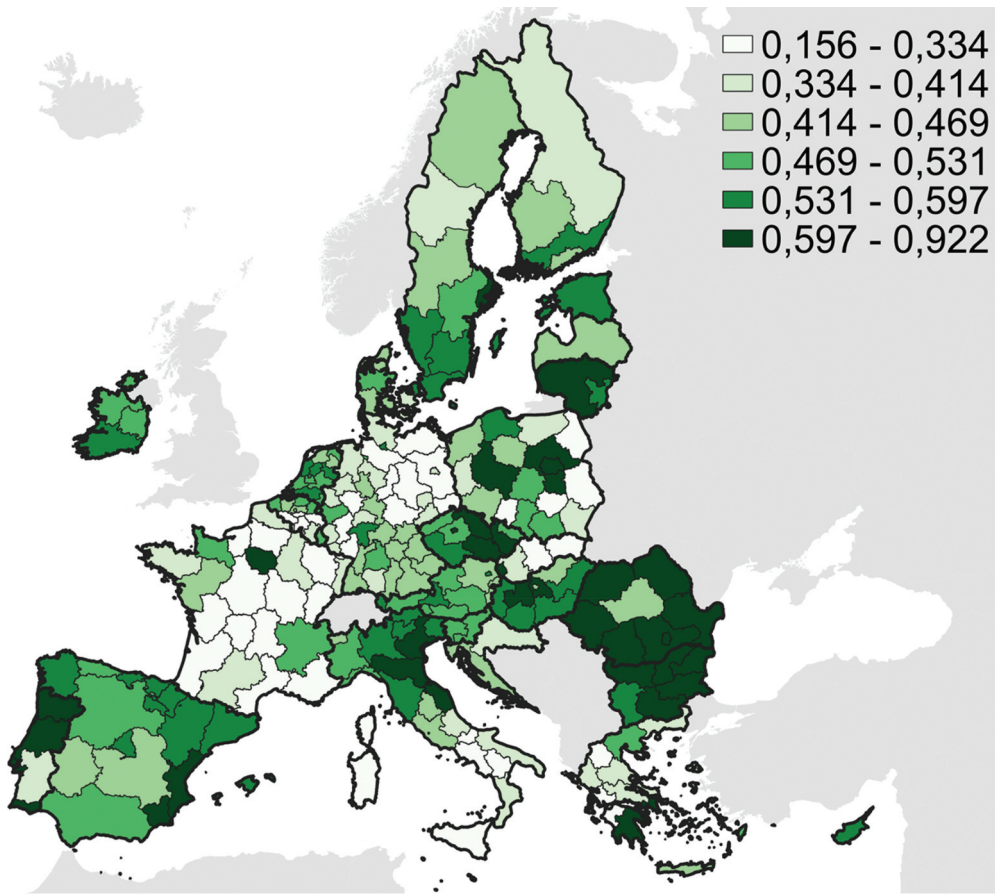


Figure 3. RES indicator at the NUTS 2 level in 2008. Source: Own elaborations based on Eurostat and JRC-EDGAR data. EuroGeographics for the administrative boundaries. Note: RES = Regional Environmental Sustainability indicator. Regions are classified into six equal count intervals.

Our main variable of interest in model (2) is the lagged stock of EU structural funds per capita in log ($\ln FundPC_{i,t-1}$), that we use to explore the potential role played by policy interventions in the transition towards more competitive and sustainable regional economies in the EU. The stocks of the EU structural funds are estimated using the Perpetual Inventory method (PIM) assuming a depreciation rate of 8% (Hall and Mairesse 1995). Data on EU funds payments at the NUTS-2 level refer to the European Regional Development Fund (ERDF), the European Social Fund (ESF), and the Cohesion Fund (CF), and come from the Cohesion data Portal.¹¹ Since the transformation of economic systems along the competitive and sustainable dimensions happens over several years, we prefer to use the accumulated stock of funds in a region rather than the year-specific investments due to the significant legacy effects entailed by this type of interventions.

The European Funds variable is lagged one period in order to account for potential reverse causality issues, as the funds may affect industrial transition, but at the same time they mostly

¹¹<https://cohesiondata.ec.europa.eu/> (accessed on 13 October 2021).

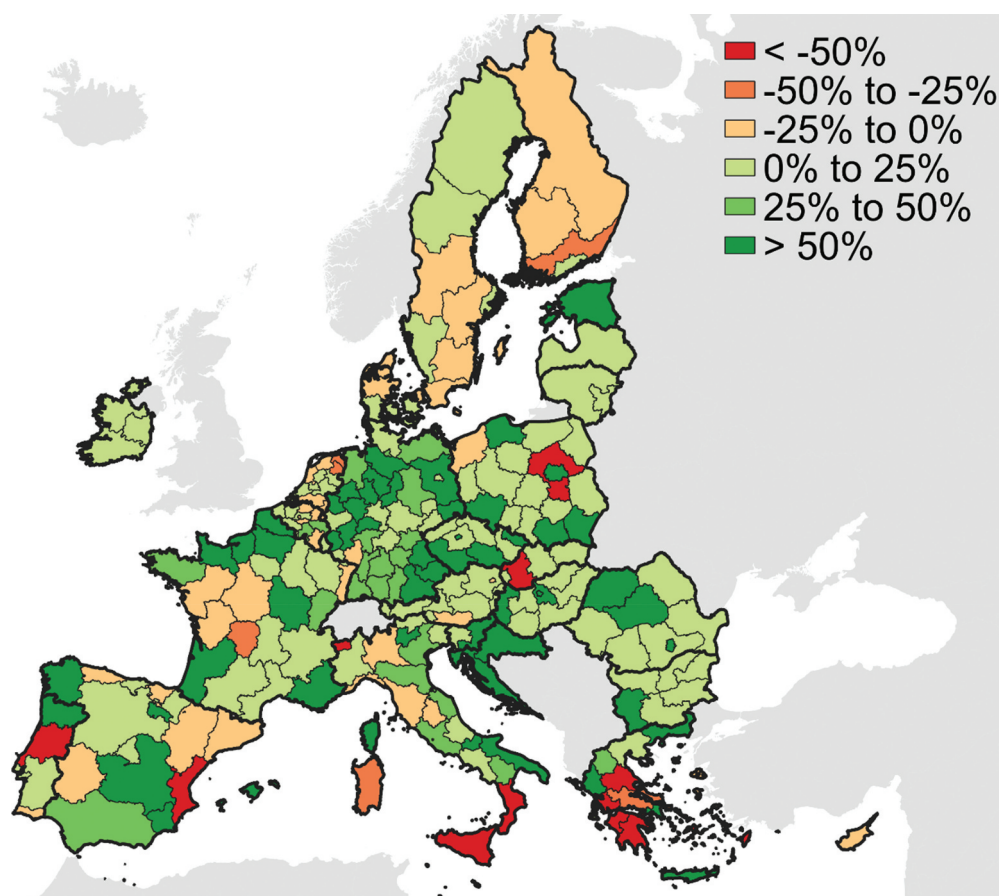


Figure 4. 2008–2018 percentage change of the RCES indicator at the NUTS 2 level, EU. Source: Own elaborations based on Eurostat and JRC-EDGAR data. Note: RCES = Regional Competitive Environmental Sustainability indicator. The six intervals are specified so to ensure comparability across Figures 4–6.

target regions lagging behind in terms of competitiveness. We are aware that this procedure may not be sufficient for a causal interpretation, as there could be correlation in trends, and/or other concerns from serially correlated omitted variables biasing our estimates. However, a quasi-experimental analysis would be beyond the scope of this paper. Therefore, the results of our analysis should not be interpreted as a causal inference analysis.

The set of control variables ($X_{i,t}$) are related to the macroeconomic and political conditions capable of affecting the growth rates of the RCES indicator, and they are those normally used in empirical investigation of structural change (see [section 2](#)). They are the following: i) a measure of regional quality of government (*QoG*) – the expected sign is positive, as better institutions should favour improvements in competitiveness and environmental sustainability (Rodríguez-Pose and Di Cataldo 2015; Rodríguez-Pose and Ganau 2022); ii) the real growth of GDP per capita (constant price base 2005) – the expected sign is ambiguous, as economic growth should be positively related to competitiveness, but not necessarily to better

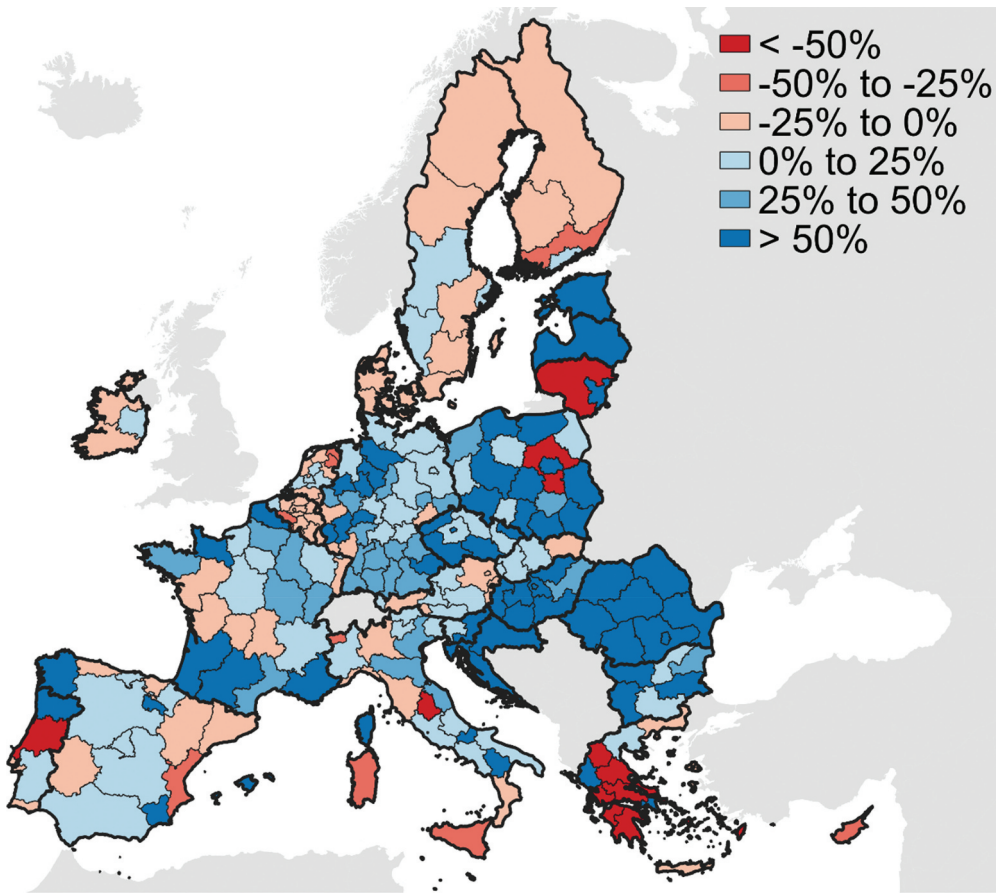


Figure 5. 2008–2018 percentage change of the RC indicator at the NUTS 2 level, EU. Source: Own elaborations based on Eurostat and JRC-EDGAR data. EuroGeographics for the administrative boundaries. Note: RC = Regional Competitive indicator. The six intervals are specified so to ensure comparability across Figures 4–6.

sustainability (Sanyé-Mengual et al. 2019); iii) the R&D stock¹² per capita – the expected sign is positive, as innovation is believed to be associated with higher competitiveness and also to environmental improvements (Camagni and Capello 2013); iv) the share of employment with higher education – the expected sign is positive, as human capital plays a key role for competitiveness and innovation (Martins 2019); and v) employment density (persons employed per squared kilometre) – the expected sign is positive for competitiveness (although recent evidence on spatial agglomeration is mixed, see Gardiner, Martin, and Tyler 2011) and ambiguous for sustainability. Table 3 below provides information on the model variables and the data sources.

Finally, model (2) also includes fixed regional effects (μ_i) and annual time fixed effects (τ_t), and $u_{i,t}$ is the error term. We also present the results of estimating model (2) with the growth rates of either $RC_{i,t}$ or $RES_{i,t}$ as alternative dependent variables in order to investigate the two

¹²Estimated using PIM and a depreciation rate of 15% following Hall and Mairesse (1995).

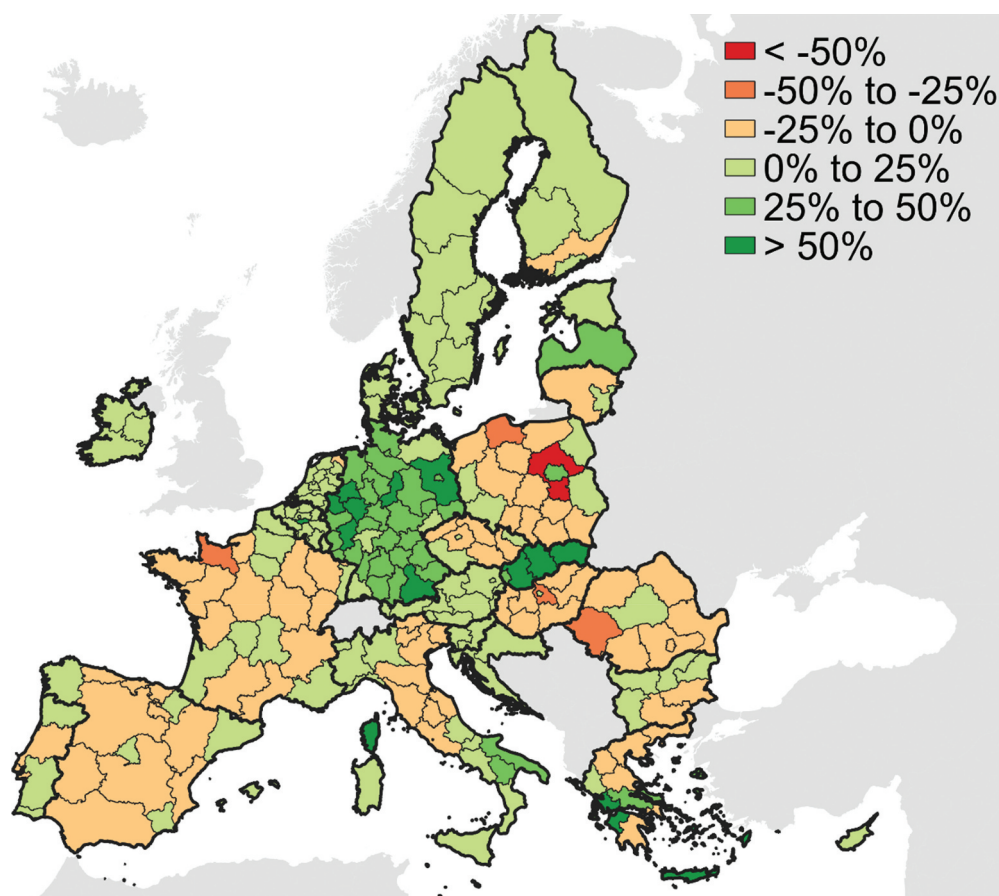


Figure 6. 2008–2018 percentage change of the RES indicator at the NUTS 2 level, EU. Source: Own elaborations based on Eurostat and JRC-EDGAR data. EuroGeographics for the administrative boundaries. Note: RES = Regional Environmental Sustainability indicator. The six intervals are specified so to ensure comparability across [Figures 4–6](#).

components of the *RCES* indicator separately. The descriptive statistics of these variables can be found in Table B1 in Appendix B.

4.2. Results and discussion

4.2.1. Understanding the geographical concentration of the EU structural funds

The EU structural funds mainly target the less developed regions of the EU with the objective of favouring convergence and cohesion. Thus, we expect the regions characterised by relatively lower values of the *RCES* indicator to be among the main beneficiaries of the funds. This intuition is confirmed by a simple correlation between the level of our three indicators in 2008 and the stock of EU Funds used in model (3) averaged over the 2008–2018 period, as shown in [Figure 8](#). In particular, there is a negative and statistically significant correlation between the initial level of the *RCES* indicator and the amount of funds targeting the regions, driven by the competitive

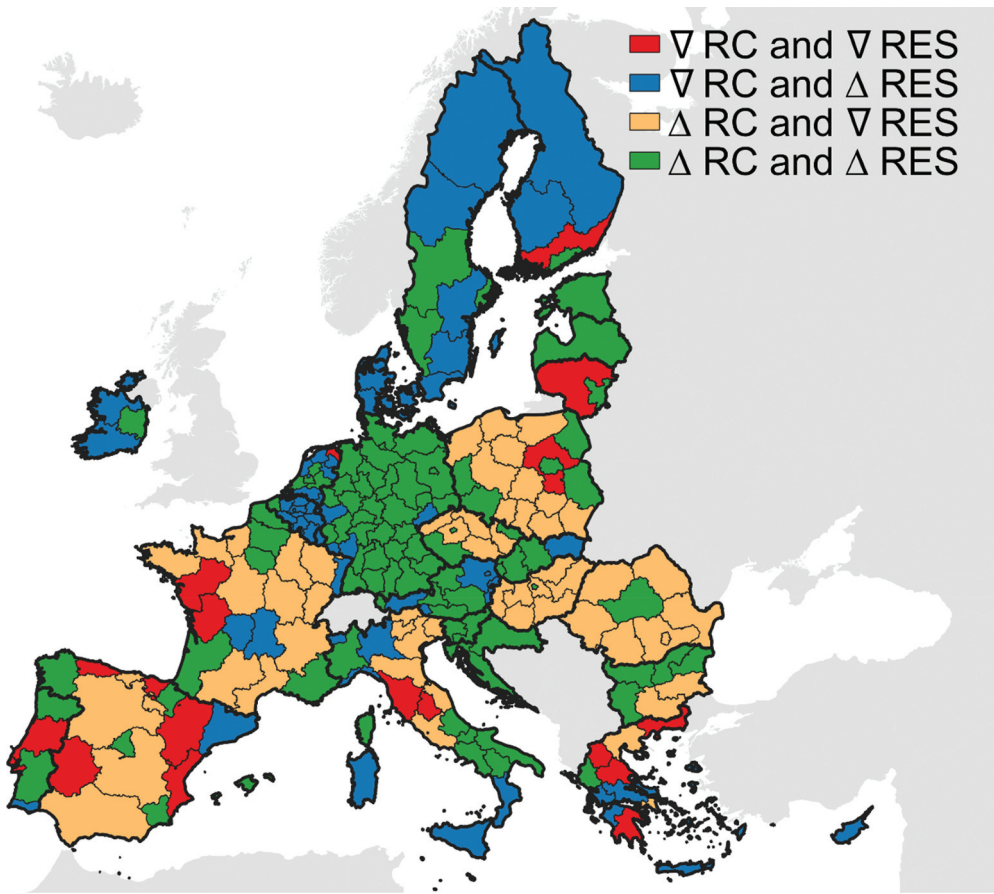


Figure 7. 2008–2018 changes in the RC and RES indicators at the NUTS 2 level, EU. Source: Own elaborations based on Eurostat and JRC-EDGAR data. EuroGeographics for the administrative boundaries. Note: RC = Regional Competitive indicator; RES = Regional Environmental Sustainability indicator. Green (red) indicates positive (negative) changes in both indicators during the 2008–2018 period. Blue (yellow) indicates positive changes in RES (RC), and negative in RC (RES).

dimension (RC). This suggests that the policy is designed so to target the regions which are actually lagging behind in terms of economic performance (in this case measured by the share of employees in sectors with high productivity within each country).

4.2.2. Assessing the relationship between EU structural funds and industrial transition

Table 4 shows the results of three specifications of equation (3) using the fixed effects estimator, depending on the indicator used (either RCES, or RC, or RES).

The coefficient associated with the lagged level of the indicator – from which the dependent variable is calculated as per equation (2) – is in all cases negative and statistically significant. This suggests that the lower (higher) the shares of employees in competitive and/or sustainable sectors in a region, the more probable it is for that region

Table 3. Model variables and data sources.

Variables	Source	Description
<i>RCES</i>	Own estimation based on Eurostat	Regional Competitive Environmental Sustainability Index
<i>RC</i>	Own estimation based on Eurostat and JRC-EDGAR data	Regional Competitive Index
<i>RES</i>	Own estimation based on Eurostat	Regional Environmental Sustainability Index
Employment density	Own estimation based on Eurostat	Total persons employed per squared kilometre
Stock EU funds per capita	Own estimation based on Cohesion data Portal and Eurostat	Stock of EU funds payments (estimated using PIM and a depreciation rate of 8%) expressed per capita at constant price base 2005
GDP per capita	Eurostat	Gross domestic product per capita at constant price base 2005
Percentage High Education	Eurostat	Share of employment with higher education
Quality of Government	Charron, Lapuente, and Bauhr (2021)	European Quality of Government Index. The index is available only for 2010, 2013, 2017, and 2021. Following Rodríguez-Pose and Ketterer (2020), we build a time series by interpolating the middle years. For the years before 2010, we assume that the regional quality of governments difference with respect to the national quality of government is kept constant. For the national quality of government index, we use an unweighted average of the Control of Corruption (CC), Government Effectiveness (GE), Rule of Law (RL), and Voice and Accountability (VA) indicators of the Worldwide Governance Indicators.
R&D stock per capita	Own estimation based on Eurostat	Stock of Gross Expenditure on R&D (estimated using PIM and a depreciation rate of 15%) expressed per capita and at constant price base 2005

Source: Own elaboration.

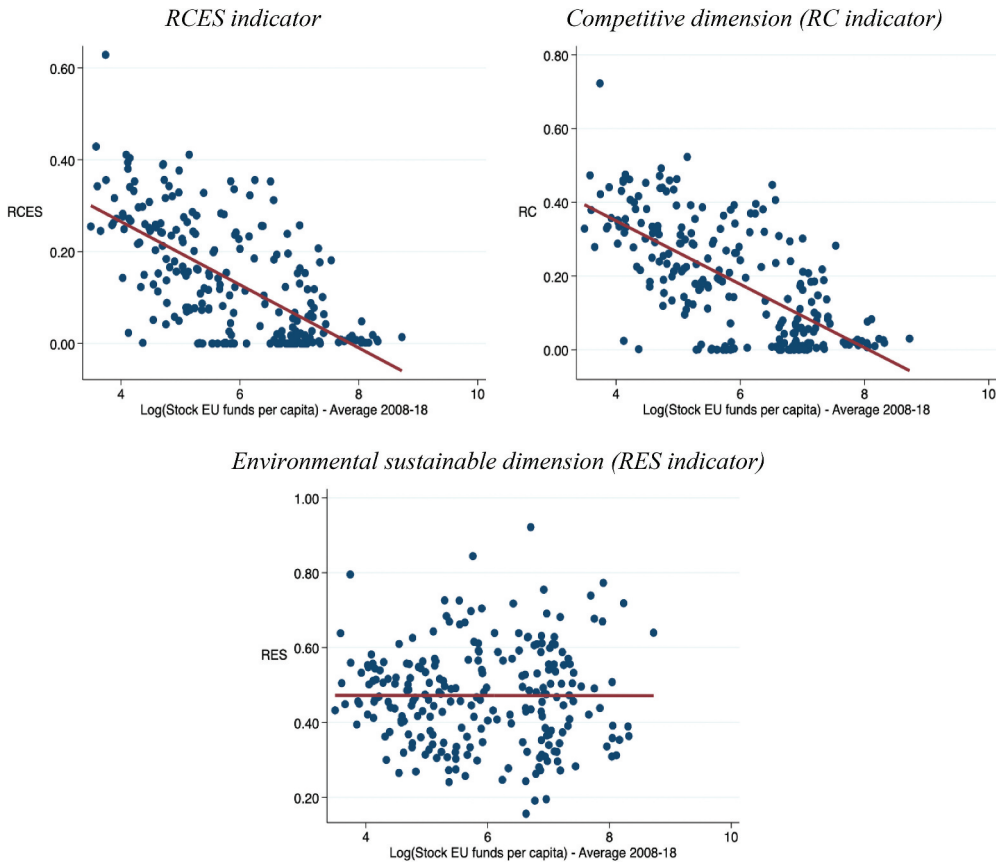


Figure 8. Two-way Scatterplots: *RCES*, *RC* and *RES* indicators (vertical axis) versus stock of EU funds per capita (in logs). stock of EU funds per capita (in logs) Source: Own elaborations.

to experience a higher (lower) growth rate in the value of the indicator. This is intuitive, as it would be easier to improve an initially relatively bad performance rather than a good one.

The coefficient of the log of the stock of EU structural funds per capita is positive and statistically significant for the growth rates of *RCES* and *RC* (columns (1) and (2) of Table 4), but negative for *RES* (column (3) of Table 4). These results suggest that the injection of EU funds accompanies a restructuring of employment towards more competitive and environmentally sustainable sectors, with the first dimension dominating the second one, given the negative coefficient of column (3). One possible explanation for the latter results is that the EU structural funds mainly targeted the reduction of socio-economic inequalities and promoted economic cohesion, rather than focusing on environmental sustainability.¹³

On the other hand, the less developed regions of the EU (mainly in Eastern countries) are the ones receiving a higher amount of EU funds (see Table B2 in Appendix B), and

¹³Only a small percentage of the 2014–2020 ESIF budget was allocated to Thematic Objective 4 – Low Carbon Economy (Table C1 – Appendix C).

Table 4. Fixed Effects estimates, dependent variables: growth rates of the indicators *RCES* (1), *RC* (2), and *RES* (3).

Explanatory variables	$\Delta \ln RCES_{i,t}$ (1)	$\Delta \ln RC_{i,t}$ (2)	$\Delta \ln RES_{i,t}$ (3)
Lag <i>RCES/RC/RES</i> Indicator	−0.777*** (0.0674)	−0.778*** (0.0642)	−0.634*** (0.0360)
Log Stock EU funds per capita	0.572*** (0.117)	0.273*** (0.103)	−0.0346*** (0.00801)
Quality of Government	−0.156 (0.138)	−0.144 (0.109)	0.0227* (0.0117)
Growth of GDP per capita	0.536 (0.877)	0.604 (0.564)	0.346*** (0.0825)
Log R&D stock per capita	0.891*** (0.320)	0.802*** (0.306)	0.0374 (0.0239)
Log Percentage High Education	0.166 (0.217)	−0.240 (0.167)	0.0408* (0.0246)
Log Employment density	0.690 (0.538)	0.577 (0.391)	0.147*** (0.0546)
Constant	2.774 (3.167)	3.604 (2.689)	0.463* (0.271)
Year dummies	Yes	Yes	Yes
Observations	2,360	2,360	2,360
Regions	237	237	237
R ²	0.398	0.497	0.395
Wald test for joint significance	14.82	23.97	30.29

Source: Own elaborations.

Note: Robust standard errors in parentheses. Significance level: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All the explanatory variables are in lag, except GDP per capita growth.

they show mostly positive improvements along the competitiveness dimension of our indicator between 2008 and 2018 (see [Figure 5](#)), and negative ones for sustainability (see [Figure 6](#)). This suggests that, on the road to a competitive sustainability economy, less developed regions initially improve in terms of competitiveness, rather than environmental sustainability. This could be also interpreted as a trade-off between competitive and sustainability convergence for less developed regions during the initial phase of the transition. Furthermore, transition to low-carbon economy requires more effort (not only related to socio-economic conditions, but also to the legal and institutional framework) than transition to a more competitive economy. Thus, any progress on the environmental side could take longer to materialise than mere economic and competitive improvements. It is also important to highlight that even if the performance of Eastern regions in terms of environmental sustainable convergence is not as impressive as their competitiveness one, it does not mean that they are not using EU structural funds to promote low-carbon technologies¹⁴ it may simply means that the effects are not visible in the period of this analysis and according to the indicator we constructed.

As for the other control variables of the model, it appears that the R&D stock per capita is positively associated with the growth rates of *RCES* and *RC* (column 1 and 2), in line with previous literature highlighting the importance of innovation to support regional sectoral shifts (see e.g. Mazzucato and Martin 2015; Perez 2010). The quality of government appears to be significantly and positively correlated with the growth of the *RES* indicator. The same is true for GDP per capita growth, employment density, used to

¹⁴Actually, Marques Santos et al. (2022) showed that for the period 2014–2020 central and eastern European regions are the ones with a higher share of low-carbon projects funded by the ERDF.:

capture agglomeration effects, and the qualification of labour forces. Previous studies (see e.Duranton and Puga 2004), already pointed out that agglomeration of firms and workers constitutes a source of knowledge generation, diffusion and accumulation.

The results presented so far are robust to changes in the specification of the model. Table C2 in Appendix C shows that the estimated coefficients for the policy variable are robust to the exclusion of the time dummies and the control variables of model (2) – results are reported for the *RCES* case only, but they are similar for the other two indicators. Table C3 reports the results of an alternative specification of model (2) in which the stock of R&D funds is replaced with the stock of capital per capita (since the indicators are constructed using employment data, there could be spurious correlation with capital intensity): the results discussed above hold for all the three indicators.

Table 5. Fixed Effects estimates, dependent variables: changes in the indicators as per equations (2) and (3) - RCEST (1), RCT (2), and REST (3), sub-sample ‘Less developed regions’.

Explanatory variables	$\Delta \ln RCES_{i,t}$ (1)	$\Delta \ln RCT_{i,t}$ (2)	$\Delta \ln RES_{i,t}$ (3)
Lag <i>RCES/RC/RES</i> Indicator	−0.797*** (0.0709)	−0.789*** (0.0657)	−0.635*** (0.0413)
Log Stock EU funds per capita	0.680*** (0.178)	0.344** (0.163)	−0.0414*** (0.0107)
Control variables	Yes	Yes	Yes
Constant	3.077 (5.498)	4.551 (4.578)	0.826** (0.409)
Observations	1,080	1,080	1,080
Regions	108	108	108
R-squared	0.413	0.511	0.430
Wald test for joint significance	14.37	26.99	28.56

Source: Own elaborations.

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

Note that the dependent variable is calculated as $\ln(RCES_{i,t}) - \ln(RCES_{i,t-1})$ in order to interpret the coefficient of the EU funds variable as an elasticity. All the explanatory variables are in lag, except GDP per capita growth.

Table 6. Fixed Effects estimates, dependent variables: changes in the indicators as per equations (2) and (3) - RCEST (1), RCT (2), and REST (3), sub-sample ‘More developed regions’.

Explanatory variables	$\Delta \ln RCES_{i,t}$ (1)	$\Delta \ln RCT_{i,t}$ (2)	$\Delta \ln RES_{i,t}$ (3)
Lag <i>RCES/RC/RES</i> Indicator	−0.580*** (0.0786)	−0.540*** (0.0667)	−0.640*** (0.0745)
Log Stock EU funds per capita	0.0645 (0.0634)	0.0601 (0.0498)	−0.00788 (0.0183)
Control variables	Yes	Yes	Yes
Constant	−1.178* (0.706)	−0.549 (0.572)	0.241 (0.521)
Observations	1,280	1,280	1,280
Regions	129	129	129
R-squared	0.362	0.326	0.377
Wald test for joint significance	10.44	9.97	41.6

Source: Own elaborations.

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

Note that the dependent variable is calculated as $\ln(RCES_{i,t}) - \ln(RCES_{i,t-1})$ in order to interpret the coefficient of the EU funds variable as an elasticity. All the explanatory variables are in lag, except GDP per capita growth.

4.2.3. Assessing differences between less developed and more developed regions

There is substantial economic inequality among EU regions (Iammarino, Rodríguez-Pose, and Storper 2019), with potential consequences on the phenomena captured by the three indicators proposed here. For instance, according to the literature on the environmental Kuznets curve, there is an inverted U-shaped relationship between development and pollution, which may result in different dynamics related to the *RCES* and *RES* indicators in the regions of our sample (Figure 7 above suggests that this could be the case, with a number of Eastern European regions in which competitiveness improved between 2008 and 2018, but sustainability did not). Thus, we investigate the robustness of our findings by applying separately model (2) to two sub-sets of regions differing in their level of economic development. Namely, we separate the ‘less developed or transitions regions’ (according to the Cohesion policy criteria in 2014–2020) from the ‘more developed regions’. Tables 5 and 6 report the results of model (2) using the fixed effects estimator for the 108 less developed and transition regions on the one hand, and the 129 more developed regions on the other, respectively.

According to these additional estimates, the European funds are significantly and positively associated with the growth rates of the *RCES* and *RC* indicators only in the less developed and transition regions, and negatively to the *RES* growth rate. Thus, the European Cohesion policy makes a difference in the regions targeted by the policy, accelerating the transition towards a more competitive economic systems.

5. Conclusions

In this paper, we presented a novel indicator of regional competitive sustainability based on the sectoral employment shares across all the regions of the EU. We show the mapping and the main statistical properties of the indicator accounting for competitiveness (in terms of productivity) and environmental sustainability (in terms of air emissions intensity), both when considered jointly and separately. There appears to be substantial regional heterogeneity in the EU for all the three versions of the indicator, as well as interesting dynamics over the 2008–2018 period.

The EU regions are faced with two big challenges for the next coming years: recovery from the COVID-19 crisis, and the transition to a climate neutral economy by 2050. Under the programming period 2021–2027, the EU has mobilised €750 billion to support the EU recovery, in addition to the €1,074 billion of the EU’s Multiannual Financial Framework (MFF). The results of our study can be particularly useful for policymakers to better understand what can enhance the transitions and in which circumstances public support is proving effective.

Our findings show that the EU funds, which mostly target the less developed regions of the EU, target regions characterised by relatively worse values of the competitiveness indicators, in line with the objectives of Cohesion policy. At the same time, our econometric analysis suggests that the funds are positively associated with a transition towards a competitive and environmentally sustainable economy, especially due to their influence on the competitiveness dimension. We also uncover a positive role played by both the quality of government and the stock of investments in R&D.

We believe that quantitative economic indicators of the type we propose here could be used in the context of policy making besides being useful for in-depth economic analyses.

For instance, these indicators could be used as targets for the regions in the process of transitioning to a competitive and sustainable economy by setting a minimum share of employment in high productivity and low emission sectors that regions must achieve.

Future research could explore techniques to deal with the potential endogeneity issues of the econometric model used here, since the European funds are not randomly assigned to regions, but rather target specific territories in light of the policy objectives, which now include environmental considerations, in addition to purely economic ones. Also, further research going beyond reduced form estimates could explore the mechanisms through which the European funds affect both competitiveness and sustainability to propose more substantial policy recommendations.

Disclaimer

The views expressed are purely those of the authors and may not in any circumstances be regarded as stating an official position of the European Commission.

Disclosure statement

No potential conflict of interest was reported by the author(s).

References

- Acemoglu, D., and V. Guerrieri. 2008. "Capital Deepening and Non-Balanced Economic Growth." *Journal of Political Economy* 116 (3): 467–498. <https://doi.org/10.1086/589523>.
- Camagni, R., and R. Capello. 2013. "Regional Innovation Patterns and the EU Regional Policy Reform: Toward Smart Innovation Policies." *Growth and Change – A Journal of Urban and Regional Policy* 44 (2): 355–389. <https://doi.org/10.1111/grow.12012>.
- Cerqua, A., and G. Pellegrini. 2018. "Are We Spending Too Much to Grow? The Case of Structural Funds." *Journal of Regional Science* 58 (3): 535–563. <https://doi.org/10.1111/jors.12365>.
- Charron, N., V. Lapuente, and M. Bauhr. 2021. Sub-National Quality of Government in EU Member States: Presenting the 2021 European Quality of Government Index and Its Relationship with COVID-19 Indicators. University of Gothenburg: The QoG Working Paper Series 2021:4.
- Crescenzi, R., and M. Giua. 2020. "One or Many Cohesion Policies of the European Union? On the Differential Economic Impacts of Cohesion Policy Across Member States." *Regional Studies* 54 (1): 10–20. <https://doi.org/10.1080/00343404.2019.1665174>.
- Crippa, M., D. Guizzardi, E. Solazzo, M. Muntean, E. Schaaf, F. Monforti-Ferrario, M. Banja et al, 2021. *GHG Emissions of All World Countries*, EUR 30831 EN, Publications Office of the European Union, Luxembourg, ISBN 978-92-76-41546-6, doi:10.2760/173513.
- Dabla-Norris, E., A. H. Thomas, R. Garcia-Verdu, and Y. Chen. 2013. "Benchmarking Structural Transformation Across the World." *IMF Working Papers* 2013 13 (176): 1. <https://doi.org/10.5089/9781484359662.001>.
- Diemer, A., S. Iammarino, A. Rodríguez-Pose, and M. Storper. 2022. "The Regional Development Trap in Europe." *Economic Geography* 98 (5): 487–509. <https://doi.org/10.1080/00130095.2022.2080655>.
- Diercks, G. 2019. "Lost in Translation: How Legacy Limits the OECD in Promoting New Policy Mixes for Sustainability Transitions." *Research Policy* 48 (10): 103667. <https://doi.org/10.1016/j.respol.2018.09.002>.

- Duarte, M., and D. Restuccia. 2010. "The Role of the Structural Transformation in Aggregate Productivity." *Quarterly Journal of Economics* 125 (1): 129–173. <https://doi.org/10.1162/qjec.2010.125.1.129>.
- Duernecker, G., B. Herrendorf, and A. Valentinyi. 2017. "Structural Change within the Service Sector and the Future of Baumol's Disease." *Report*. <https://www.atlantafed.org/~media/Documents/research/seminars/2017/herrendorf-081417.pdf>.
- Duranton, G., and D. Puga. 2004. "Micro-Foundations of Urban Agglomeration Economies." In *Handbook of Regional and Urban Economics*, J. V. Henderson and J. F. Thisse, edited by 2063–2117. [https://doi.org/10.1016/S1574-0080\(04\)80005-1](https://doi.org/10.1016/S1574-0080(04)80005-1).
- Echevarria, C. 2000. "Non-Homothetic Preferences and Growth." *The Journal of International Trade & Economic Development* 9 (2): 151–171. <https://doi.org/10.1080/09638190050028153>.
- European Commission 2019a. Annual Sustainable Growth Strategy 2020. SWD(2019) 650 Final, Brussels, 17.12.2019.
- European Commission 2019b. The European Green Deal. COM(2019) 640 Final. Brussels, 11.12.2019.
- Farole, T., S. Goga, and M. Ionescu-Heroiu. 2018. Rethinking Lagging Regions - Using Cohesion Policy to Deliver on the Potential of Europe's Regions, World Bank Report on the European Union, World Bank Group.
- Gardiner, B., R. Martin, and P. Tyler. 2011. "Does Spatial Agglomeration Increase National Growth? Some Evidence from Europe." *Journal of Economic Geography* 11 (6): 979–1006. <https://doi.org/10.1093/jeg/lbq047>.
- Haddad, C., V. Nakic, A. Bergek, and H. Hellsmark. 2022. "Transformative Innovation Policy: A Systematic Review." *Environmental Innovation and Societal Transitions* 43:14–40. June 2022. <https://doi.org/10.1016/j.eist.2022.03.002>.
- Hall, B. H., and J. Mairesse. 1995. "Exploring the Relationship Between R&D and Productivity in French Manufacturing Firms." *Journal of Econometrics* 65 (1): 263–293. <https://doi.org/10.1016/0304-40769401604-X>.
- Herrendorf, B., R. Rogerson, and A. Valentinyi. 2014. "Growth and Structural Transformation." In *Handbook of Economic Growth*, 855–941. Vol. 2. Elsevier. <https://doi.org/10.1016/B978-0-444-53540-5.00006-9>.
- Iammarino, S., A. Rodríguez-Pose, and M. Storper. 2019. "Regional Inequality in Europe: Evidence, Theory and Policy Implications." *Journal of Economic Geography* 19 (2): 273–298. <https://doi.org/10.1093/jeg/lby021>.
- Kongsamut, P., S. Rebelo, and D. Xie. 2001. "Beyond Balanced Growth." *The Review of Economic Studies* 68 (4): 869–882. <https://doi.org/10.1111/1467-937X.00193>.
- Kuznets, S. 1973. "Modern Economic Growth: Findings and Reflections. Nobel Lecture." *American Economic Review* 63 (3): 247–258.
- Marques Santos, A., P. Reschenhofer, J. Bachtrögler-Unger, A. Conte, and N. Meyer. 2022. Mapping Low-Carbon Industrial Technologies Projects Funded by ERDF in 2014–2020, European Commission, JRC128452.
- Martins, P. M. G. 2019. "Structural Change: Pace, Patterns and Determinants." *Review of Development Economics* 23 (1): 1–32. <https://doi.org/10.1111/rode.12555>.
- Mazzucato, L., and C. Martin. 2015. "Innovation as Growth Policy. The Challenge for Europe." In *The Triple Challenge for Europe: Economic Development, Climate Change, and Governance*, edited by Fagerberg, J., Laestadius, Laestadius, S., and Martin, B. R., 229–264. Oxford: Oxford University Press. <https://doi.org/10.1093/acprof:oso/9780198747413.003.0009>.
- McMillan, M. S., D. Rodrik, and Í. Verduzco-Gallo. 2014. "Globalization, Structural Change and Productivity Growth, with an Update on Africa." *World Development* 63:11–32. <https://doi.org/10.1016/j.worlddev.2013.10.012>.
- Miedzinski, M., K. Ciampi Stancova, M. Matusiak, and L. Coenen. 2021. *Addressing Sustainability Challenges and Sustainable Development Goals via Smart Specialisation. Towards a Theoretical and Conceptual Framework*. Luxembourg: EUR 30864 EN, Publications Office of the European Union. 2021, ISBN 978-92-76-42380-5, JRC126448. <https://doi.org/10.2760/410983>.

- OECD. 2021. *The Design and Implementation of Mission-Oriented Innovation Policies*. OECD STI Policy Papers. <https://doi.org/10.1787/23074957>.
- Perez, C. 2010. "Technological Revolutions and Techno-Economic Paradigms." *Cambridge Journal of Economics* 34 (1): 185–202. <https://doi.org/10.1093/cje/bep051>.
- Pfeiffer, P., J. Varga, and J. In 't Veld. 2021. Quantifying Spillovers of Next Generation EU Investment. European Economy discussion paper no. 144.
- Pontikakis, D., T. Fernandez Sirera, M. Janssen, K. Guy, A. M. Santos, J. Boden, and P. Moncada Paternó Castello. 2020. Projecting Opportunities for INDUSTRIAL Transitions (POINT): Concepts, Rationales and Methodological Guidelines for Territorial Reviews of Industrial Transition. *JRC Working Papers* no. JRC121439.
- Pontikakis, D., I. Gonzalez Vazquez, G. Bianchi, L. Ranga, A. Marques Santos, R. Reimeris, S. Mifsud, K. Morgan, C. Madrid Gonzalez, and J. Stierna. 2022. *Partnerships for Regional Innovation Playbook*. Luxembourg: EUR 31064 EN, Publications Office of the European Union. <https://doi.org/10.2760/775610>.
- Rodríguez-Pose, A., and M. Di Cataldo. 2015. "Quality of Government and Innovative Performance in the Regions of Europe." *Journal of Economic Geography* 15 (4): 673–706. <https://doi.org/10.1093/jeg/lbu023>.
- Rodríguez-Pose, A., and R. Ganau. 2022. "Institutions and the Productivity Challenge for European Regions." *Journal of Economic Geography* 22 (1): 1–25. <https://doi.org/10.1093/jeg/lbab003>.
- Rodríguez-Pose, A., and T. Ketterer. 2020. "Institutional Change and the Development of Lagging Regions in Europe." *Regional Studies* 54 (7): 974–986. <https://doi.org/10.1080/00343404.2019.1608356>.
- Sanyé-Mengual, E., M. Secchi, S. Corrado, A. Beylot, and S. Sala. 2019. "Assessing the Decoupling of Economic Growth from Environmental Impacts in the European Union: A Consumption-Based Approach." *Journal of Cleaner Production* 236:117535. <https://doi.org/10.1016/j.jclepro.2019.07.010>.
- Schot, J., and E. Steinmueller. 2018. "Three Frames for Innovation Policy: R&D, Systems of Innovation and Transformative Change." *Research Policy* 47 (9): 1554–1567. <https://doi.org/10.1016/j.respol.2018.08.011>.
- Van Neuss, L. 2019. "The Drivers of Structural Change." *Journal of Economic Surveys* 33 (1): 309–349. <https://doi.org/10.1111/joes.12266>.