Global Challenges & Regional Science 2 (2025) 100012

Contents lists available at ScienceDirect

Global Challenges & Regional Science

journal homepage: www.elsevier.com/locate/gcrs

Overlapping payoffs and policy synergies: The case of CAP and EU cohesiveness

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ARTICLE INFO

JEL classification:
O18
R11
R58

Keywords:
Cohesion policy
CAP
Rural policy
FADN

ABSTRACT

The use of Cohesion Policy and Common Agricultural Policy funds vary significantly between regions within the European Union. Each policy fund typically benefits different recipients within the same region. While conventional wisdom suggests that there are implications stemming from the overlap in these policy streams within the same region, this study explores the source and the extent to which a synergy or trade-off arises. Using multivariate statistical analysis, this paper models the associations in the allocation of specific EU Cohesion Policy and Common Agricultural Policy funds among spending sub-categories. Results show that this more granular measurement, whilst considering multiple preferences in aggregating structural place-based characteristics by employing the sigma-mu methodology, provides evidence of policy synergy and trade-offs arising within territories. Thus, we identify the specific sources of funding categories that work successfully in tandem and those that seemingly have a detrimental effect when applied simultaneously in the same region. This poses challenging questions about the choice of policy mix for generating positive synergies and whether such a framework can be extended to other policy realms and their interactions

1. Introduction

Regional policy evaluation attracts regular interest among scholars and economic agencies (Bachtler and Michie, 1995; Diez, 2002; Artobolevskiy, 2012; Becker et al., 2018; Garretsen et al., 2013). The evaluation process involves multidimensional aspects requiring a comprehensive methodology for evaluating a wide range of regional expenditures with potentially different principles and objectives in the three main phases of ex-ante, ongoing, and ex-post evaluation (Armstrong and Taylor, 2000). Given the very broad regional development responsibilities of the EU, a focus on EU regional policy is found in the extant literature (See, among others, Dall'erba et al., 2006; Hart, 2007; Gore and Wells, 2009; McCann and Ortega-Argilés, 2016; Hoerner and Stephenson, 2012). At the EU level of intervention, the two most important funding streams stimulating socio-economic development at the territorial level are Cohesion Policy (CP) and the Common Agricultural Policy.

CP addresses efforts to reduce economic, social, and territorial disparities across Member States (MS). Its core objectives include[1] (i) strengthening economic, social, and territorial cohesion for a more balanced development across the EU by reducing multidimensional gaps between regions, as well as (ii) actively supporting the green and digital transitions to build a more sustainable and technologically advanced Europe (EC, 2023). These objectives are pursued according to the main principles of solidarity between wealthier and less prosperous regions, partnership (or collaboration) between the European Commission, national and regional authorities, and other stakeholders in implementing CP, and subsidiarity implying that decisions on CP are made as close as possible to the citizens, at the appropriate regional and local levels. Furthermore, CP has a clear focus on results based on tangible results to demonstrate the impact of investments.

As for the CAP, it has the stated objectives[2] of supporting farmers, both ensuring income stability and supporting environmentally friendly investments, as well as improving agricultural productivity to promote the supply of affordable food. Moreover, it aims to achieve the sustainable management of natural resources and to maintain rural areas and landscapes across the EU by implementing rural development measures

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[1] For details on the objectives of the current 2012-27 programming period the reader is referred to https://www.fi-compass.eu/funds/erdf-cf and https://ec.europa.eu/regional_policy/2021-2027_en#:~:text=It%20aims%20to%20correct%20imbalances,the%20green%20and%20digital%20transition. Retrieved on 15/05/2025.

[2] For an overview of CAP the reader is referred to https://agriculture.ec.europa.eu/common-agricultural-policy/cap-overview/cap-glance_en. Retrieved on 15/03/2025

https://doi.org/10.1016/j.gcrs.2025.100012
Received 31 January 2025; Received in revised form 4 May 2025; Accepted 6 May 2025

addressing specific needs and keeping the rural economy alive by promoting jobs in farming, agri-food industries and associated sectors. According to the EU regulation, the CAP is implemented in line with the principles of market unity involving the free movement of agricultural products within the EU, community preference, that is, giving priority to EU agricultural products, and financial solidarity entailing common funding of the CAP (Pe'Er et al., 2019).

A recurring problem in the analysis of the impact of policy on regional development is determining the relationship between different policy instruments, which are of a sectoral nature in EU countries. Likewise, as for CP and CAP, when analysed separately, they show a number of positive correlations with the level of rural development, with a clear farm-oriented approach for agricultural policy, and a territorial approach for cohesion policy (Pike et al., 2006). Nonetheless, in the evaluation exercise, it is not possible to easily separate the effects of one policy from the other, especially as the territorial character of agricultural policy is related to both the physical and geographical characteristics of the production space in a given region (Daniel and Kilkenny, 2009; World Bank, 2009). Agricultural use of land resources is also linked to the valuation process, which is largely influenced by the flow of CAP direct payments (Ciaian et al., 2018; Mittenzwei and Britz, 2018; Camaioni et al., 2013; Rizov et al., 2013). Moreover, research shows that public policy intervention has a positive impact on development, spillovers in knowledge, as well as in financial terms (Zubek and Henning, 2016; Barca et al., 2012).

Put differently, the shared focus on territorial development of CP and CAP is a potential source of overlap between them, especially in rural areas. Indeed, both CP and CAP play a significant role in supporting rural areas. The former focuses on infrastructure development, job creation, and the diversification of rural economies. The latter provides funding for various initiatives aimed to improve rural communities' economic, social, and environmental conditions, especially through its rural development pillar. On a more general premise, a core objective of the CP is to reduce disparities between regions. Hence, once applied to rural areas, this objective overlaps with CAP's objectives to the extent that both contribute to territorial cohesion by supporting farmers.

Moreover, both policies are increasingly committed to environmental sustainability. In this regard, the CAP focuses on environmentally friendly farming practices and supports measures to protect natural resources. Similarly, CP increasingly invests in projects aiming to contribute to climate change mitigation and adaptation as well as the protection of biodiversity. Many of those projects are implemented in rural areas and, again, as a consequence, CAP and CP have substantial touching points in this field.

On a related note, both policies work toward the goal of diversifying rural economies. Indeed, both CAP's rural development funding and Cohesion policy funds help to support non-farm-related rural businesses. This, in turn, entails another area of potential overlap.

To summarise, while the CAP primarily focuses on agricultural production and farmers' incomes and the CP focuses on broader regional development, they are both designed and implemented in a way that has a significant focus on rural areas. Shared goals concern rural development by improving the quality of life in rural areas, territorial cohesion through balanced territorial development across the EU, environmental sustainability, and economic diversification. More generally, since the CP promotes integrated territorial development (i.e. coordinating investments across different sectors to maximize their impact), it potentially interacts with other policies addressing economic, social, and environmental challenges such as the CAP. Therefore, this policy framework leads to a potential overlap in their activities. This overlap, in turn, makes it difficult to disentangle and assess the effect of each policy separately.

On more quantitative grounds, assessing and disentangling the effects of a specific policy instrument relates to the issue of identification and the linked methodological approaches to analysing them (Lewbel, 2019). Furthermore, there are issues related to the availability or quality of relevant regional data and, also, not all regional data conveniently maps to the data sourced from the European Union (EU) administration. Yet, this type of data has been considered essential to robustly analyse the key questions surrounding the impact of CAP across EU regions, in a spatial research setting (Védrine, 2018; Boysen et al., 2016; Esposti, 2015).

Despite the underlying methodological challenges, the consideration of the interaction between CP and CAP has important policy implications. It has been argued that a deeper and more nuanced consideration of the policy interactions may contribute to *"…establishing a common strategy for more coordination and less overlap between the European Structural and Investment Funds (ERDF, Cohesion Fund and ESF as the three funds under Cohesion Policy as well as the Rural Development and Fisheries funds)"* (EC, 2013) and to *"…ensuring that Cohesion Policy is better linked to wider EU economic governance making programmes more consistent with National Reform Programmes"* (EC, 2013). This has long been a feature of analytical concern (See, for example, Norman, 1979; Bateman and Williams, 1966).

As already noted, in principle, an explicit intended link between the two policies is set out in EU objectives. CAP and CP share the objectives to help by improving competitiveness, achieving sustainable management of natural resources and climate action, maintaining rural areas and landscapes, and promoting jobs. Focusing on policy instruments at the EU level, the European Regional Development Fund (ERDF) and the European Social Fund (ESF) are intended to explicitly complement the European Agricultural Fund for Rural Development (EAFRD). In terms of policy evaluation, the lessons learnt on territorial coordination and the interaction between financial allocations are potentially able to offer insights into prioritising investment for enhancing regional cohesion (Védrine, 2018). Specifically, empirical analysis can potentially inform EU decisions aimed at enhancing 'overall effects' in terms of job creation, economic growth and competitiveness (Crescenzi et al., 2015). This arises by exploring and leveraging any potential synergies among financial allocations from CP and CAP.

Nonetheless, despite the political and policy discourse on the subject (European Commission, 2010, 2018), empirical policy evaluation focussing on the synergy and trade-offs of CP and CAP remains limited (see, for example, Crescenzi et al., 2015; Calegari et al., 2021; Wasilewski et al., 2021). The empirical examination undertaken in this study of the territorial allocation of CP and CAP funds alongside scrutiny of their policy interactions addresses three key research questions: i) Are the funds able to target the most structurally disadvantaged regions of the EU?; ii) Is there a significant synergy (or trade-off) between cohesion and rural policies?; iii) to what extent do synergies coincide with the most rural regions?

Hence, while conventional wisdom suggests that there are implications stemming from the overlap in policy streams, this paper offers an insight into where and to what extent these occur. Departing from previous research work, we focus on identifying the synergy and trade-offs within the disaggregated policy streams.

An additional contribution to the extant literature in this field concerns the measurement of regional structural characteristics according to the recent $\sigma-\mu$ approach (Greco et al., 2019b). This approach builds upon the mounting criticism about GDP and other one-dimensional measures of economic performance that has paved the way for the use of Composite Indices (CIs) (Greco et al., 2018). While sharing the overarching framework of CIs, the $\sigma-\mu$ approach represents an attempt to overcome the limitation of CIs of regional socioeconomic performance related to the impossibility of explicitly considering differences in the weighting system used to aggregate the different dimensions (i.e. characteristics) of places such as social and economic indicators. Indeed, the $\sigma-\mu$ approach challenges the equal weighting assumption common to other CIs in order to explicitly value the potential differences in local preferences concerning the relative importance of the different spatial characteristics. Since the allocation of funds also entails a variety of perspectives from agents acting from different standpoints, the consid-

eration of multiple views regarding the multidimensional evaluation of structural characteristics is a crucial issue. In other words, the $\sigma-\mu$ - at the same time as being able to provide also a final single measure - stands "by the principle that a meaningful composite indicator should ideally reflect a multiplicity of viewpoints" (Greco et al., 2019b, p. 945), therefore, rejecting the idea of the allegedly representative agent in favour of the consideration of multiple preferences among economic agents (e.g. practitioners, experts, households).

The adoption of the $\sigma-\mu$ approach to the measurement of place-based characteristics, jointly with the more granular measurement of policies, provides evidence of policy synergies and trade-offs arising within territories. Thus, we identify which funding sub-categories are subject to such interactions. This poses challenging questions about the choice of policy mix for generating positive synergies and whether such a framework can be extended to other policy realms and their interactions.

The remainder of the paper is as follows. Section 2 presents a brief retrospect on CAP and CP focusing on the different positions between space-neutral and place-based policy approaches which backgrounds the empirical analysis. Section 3 introduces the methodological framework along with the data used for the empirical analysis. Sections 4 and 5 present the results and set out concluding remarks.

2. Rural development and EU cohesiveness in retrospect

The fundamental approach to regional policy has remained almost unchanged over the last few decades (Lagendijk and Cornford, 2000; Pike et al., 2006) using a paradigm based on 1950s growth and development theories. Debate about the link between place characteristics and policy design has emerged under pressure for more realism prompted by the onset of the process of globalization (Roberts, 1993). A key concern is the extent to which the policy design should reflect the uneven spatial distribution of people, infrastructure, and resources. A different spatial approach would call for a shift in the decision-making process, moving away from the "mainly top down, with mixed, integrated, and/or bottom-up approaches virtually ignored" (Barca et al., 2012).

Advocacy for a new approach based on spatial characteristics is founded on many arguments (see, for a more extensive discussion, Barca, 2009). First, different spatial endowments, such as social, cultural, and institutional factors, shape the trajectory of development potential (Bolton, 1992). Neglecting to consider these different characteristics (i.e. being 'space-neutral') provides an uncontrolled space effect that may undermine the intended effect of the policy. Second, in order to increase policy effectiveness, the (knowledge-based) intervention ought to consider the causes, extent, and channels of relative underdevelopment for a given region. Further, there is a recognised complexity to the interaction between geography, policy structure, and interaction between regional governments. A more decentralised policy structure causes greater interaction between neighbouring regional governments (Vedrine, 2018).

Nonetheless, the appeal of 'spatially blind' policies has found renewed momentum. The narrative is theoretically based on agglomeration effects (World Bank, 2009) for which spatially-blind policies (or rather 'people-based' policies) can promote equal opportunities and improve productivity via spatial adjustment. These in turn, are contended to promote economic convergence across geographical areas. Within this theoretical framework, the EU's approach has been inspired by several different positions. The 2004 Sapir Report 'An Agenda for a Growing Europe' came to conclusions that were more along the lines of the 'spatial-blind' policies. It argued that the EU Cohesion Policy should primarily target member states rather than subnational regions (Barca et al., 2012). However, the Barca (2009) report An Agenda for a Reformed Cohesion Policy pointed out that "there is a strong case, rooted in economic theory and in a political interpretation of the present state of the European Union, for the Union to allocate a large share of its budget to the provision of European public goods through a place-based development strategy aimed at both core economic and social objectives (p. VII)".

In the case at hand, it is worth mentioning both the CAP and the CP in the EU have increasingly called for a "place-based" approach, recognising the diversity of agricultural and rural realities across the EU, in the CAP realm, and that development challenges and opportunities vary significantly across regions for CP. For example, the CAP 2023-2027 emphasises national CAP Strategic Plans. These plans are developed by each EU MS considering their specific national and regional needs. Hence, this allows for greater flexibility in adapting CAP measures to local conditions. Furthermore, the CAP aims to provide more targeted support to farmers and rural communities diversified by challenge. This includes support for farmers in mountainous or remote areas, small-scale farmers, and those operating in areas facing specific environmental challenges. To ensures that policies are relevant and effective in addressing local needs, the CAP also increasingly recognises the importance of involving local stakeholders in the design and implementation of policies[3]. Similarly, for the CP a core principle is to involve local and regional authorities, as well as other stakeholders, in the design and implementation of CP programs to ensure that a Community-Led Local Development (CLLD) approach promotes investments aligned with local priorities and needs, which, indeed, show variation across EU regions. More specifically, under the 'Policy Objective 5: A Europe closer to citizens'[4] the place-based approach is further reinforced as emphasis is placed on the importance of local communities and local involvement in the development of projects. This echoes the concept of 'smart specialization' to the extent it encourages regions to focus investments on their unique strengths and competitive advantages in order to foster innovation and sustainable growth.

Despite the narrative used in developing the discourse about CAP and CP, which paradigm actually prevails in the implementation of CAP and CP is still questioned and only a limited amount of research has currently been specifically developed on this issue. Building upon Crescenzi et al. (2015) and Calegari et al. (2021), this empirical analysis explores the role of structural factors - i.e. the empirical relevance of place-based characteristics - in shaping CAP and CP policy in the EU. The analysis considers the shape of policy in terms of: the association between structural spatial disadvantage and the allocation of funds; the associations between allocations; and, more specifically, the interaction between cohesion and agricultural policy.

The econometric analysis of the link between structural characteristics and the policy interventions reported in the next section aims to shed light on the guiding principles which actually prevailed in the allocation of funds for CP and CAP policies. Moreover, especially in consideration of the aforementioned potential overlapping between the two, the lessons learnt from analysing the synergies and complementarities between different realms of EU policy could potentially lead to more efficient use of funding alongside better focussed intervention to address inequality. Furthermore, it may be beneficial in terms of better coordination and coherence among national and regional development programmes.

3. Methodological framework

This section describes the dataset used, sets out the specific research questions addressed, and unfolds the empirical strategy for identifying and analysing the synergy between CAP and CP. Preliminarily, it is worth noticing that the empirical exercise focuses on CAP's Pillar 1. Indeed, since Pillar 1 unfolds around direct payments directly to farmers and market measures designed to address specific market situations

[3] Details about these aspects can be found at https://agriculture.ec.europa.eu/common-agricultural-policy/cap-overview/cap-2023-27_en. Retrieved on 19/03/2025.

[4] https://ec.europa.eu/regional_policy/policy/what/territorial-cohesion_en. Retrieved on 20/03/2025

and support the agri-food sector, it is deemed more appropriate to focus on it; therefore, excluding Pillar 2 as its broader scope on rural development aims to serve only a complementary function with respect to Pillar 1 by addressing the wider economic, environmental, and social challenges facing rural areas. Put differently, potential overlaps involving expenditure under Pillar 2 are more likely to occur and, in turn, less meaningful to the case at hand. Hence, for the sake of our analysis, we prefer focusing on the core Pillar 1[5] for the ease of interpretation and in order to enhance the explicative strength of our results. Section 3.3 provides additional details on the dataset.

3.1. The model

The empirical strategy employed in this paper builds on the work of Crescenzi et al. (2015) with some key departures, which are discussed in this section. The link between structural factors, i.e. *place-based* characteristics as measured by the $\sigma-\mu$ methodology, and EU cohesion and agricultural policy is explored both in terms of allocation of funds and interactions between policies. The analysis builds upon cross section data in an ordinary least squares regression framework. The principal model framework is as follows:

$$\boldsymbol{CP\_exp_i = \alpha + \mu_i + \beta_1 X\_char_i + \beta_2 gdp_i + \gamma CAP\_exp_i + \varepsilon_i} \quad (1)$$

where i is each of the NUTS 2 level regions across Europe that have received both Cohesion Policy (CP) and Common Agricultural Policy (CAP) expenditure. *CP_exp* is regional level EU cohesion policy expenditures per capita, this is presented as the total expenditure and the subcategories of cohesion policy expenditure. *X_char* is the structural characteristics composite index described in the following Section 3.2. *Gdp* is the GDP per capita at PPS. *CAP_exp* is the EU CAP Pillar 1 expenditures per capita, this is presented as the total expenditure and as the subcategories of CAP expenditure. $\boldsymbol{\mu_i}$ is country fixed effects, to capture unobserved country specific variations, and e is the remaining error.

Consequently, β_1 in Eq. (1) estimates the association between the structural characteristics index on the total cohesion policy expenditures and the subcategories, β_2 estimates the correlation between GDP and the same. Although a strict causality cannot be stablished due to the lack of temporal sequencing, if these coefficient estimates are negative and statistically significant, this somehow supports the argument that cohesion policy funding is flooding to the regions that are most in need of support. We then estimate the association of the regional structural characteristics index to total CAP expenditures and the subcategories in the same manner, using *CAP_exp* as the dependent variable.

γ in Eq. (1) estimates the correlation of CAP (CP) expenditures on CP (CAP) expenditures. Again, a positive and statistically significant coefficient estimate will provide evidence in favour of synergies between policy areas, suggesting that the policies are targeting the same regions with an additional (or cumulative) impact. If the estimate is negative, this will show the presence of a trade-off between policies, where one policy is compensating for the absence of another.

Adding an interaction term between policy expenditures and regional characteristics, such that:

$$\boldsymbol{CP\_exp_i = \alpha + \mu + \beta_1 X_{char\,i} + \beta_2 gdp_i + \gamma CAP\_exp_i}$$

$$+\delta_1\left(\boldsymbol{X_{char\,i}} \,.\, \boldsymbol{CAP\_exp_i}\right) + \delta_2\left(\boldsymbol{gdp_i} \,.\, \boldsymbol{CAP\_exp_i}\right) + \boldsymbol{\varepsilon_i} \quad (2)$$

provides an estimate, δ_1, for the specific correlation of the interaction between CP (CAP) expenditure and structural characteristics on CAP (CP) policies. The term δ_2 performs a similar role in relation to estimates of the interaction between CP (CAP) expenditure and GDP on CAP (CP) policies. When combined with $\boldsymbol{\beta}$ and $\boldsymbol{\gamma}$, negative and statistically significant estimates will show that regions suffering from the worst structural characteristics attract the cumulative effect (synergies) of policy expenditures, in other words, there is presence of 'pro-cohesion' synergies. A positive and significant coefficient estimate (when combined with $\boldsymbol{\beta}$ and $\boldsymbol{\gamma}$) will show that stronger regions are better placed to attract policy funds.

Although the cross-section approach can identify associations between policies and structural characteristics without properly establishing causal relationships, it is deemed methodologically appropriate in consideration of the main intended contribution of this paper. The rationale is as follows. One of the main contributions involves the consideration of structural characteristics in the analysis of funds allocation; to this end, we use the novel regional structural index obtained from the $\sigma-\mu$ methodology which is rather time-invariant, as those characteristics generally show substantial inertia. Therefore, a cross-section approach is to be preferred to the alternative panel data approach. On a more general premise, the primary interest of our analysis is in understanding differences *between* regions in the implementation of EU policy, mainly based on their structural characteristics, rather than changes *within* them over time; hence, also under this respect, we deem the cross-sectional approach more appropriate. Furthermore, due to the potentially significant time lag in EU regional policy (especially when large-scale projects are involved), the year-by-year variation in EU expenditure for different policies might have a rather weak link with the underlying intervention. Instead, considering the programming period as a whole is potentially able to provide a more comprehensive measure of the policy implemented under its time framework. This conjecture is somehow in line with Crescenzi et al. (2015) to the extent the spatial panel data results confirm the results obtained adopting cross-section models.

In addition to the above consideration about the cross-section model, it is worth noting that, to the best of our knowledge, detailed yearly data on CP policy for the sample under consideration are not available. Therefore, a re-consideration of the research questions addressed in the current analysis according to a proper panel approach is left for future research.

A related issue involving our model(s) concerns the multicollinearity between the different policy measures. Indeed, the different expenditures are correlated to each other as they belong to the same realm of policy intervention[6]. Undeniably, this might have well-known detrimental effects on the efficiency of estimates (Wooldridge, 2016). Nonetheless, even with this caveat, we deem that the main points of our analysis hold. Indeed, the potential collinearity lies in the richness and depth of our data, and, in turn, this is a structural aspect of the EU complex policy intervention with multiple objectives and instruments, which translate into a somewhat unavoidable econometric issue (Kennedy, 1998). In this respect, Blanchard (1987, p.449) cogently argued that on occasions "[m]ulticollinearity is God's will, not a problem with OLS or statistical techniques in general" and it "is likely to prevent the data from speaking loudly on some issues, even when all of the resources of economic theory have been exhausted".

Having said that, as a robustness check, the regressions reported in the following Table 4 and 5, which include a large set of covariates, have been estimated adopting a Minimax Adaptive Generalised Ridge Regression (MAGRR) model (Strawderman, 1978). Overall, the results substantially confirm the patterns of OLS estimates. Focusing on the main variable of interest of our exercise, i.e. the structural characteristics index, although with differences involving the statistical significance[7], the signs of OLS coefficients agree with the signs of MAGRR co-

[5] Also, Pillar 1 represents the core of total CAP expenditure. For the current 2021-27 period, as of January 2021, it represents about 76% of the multiannual financial framework compared to about 23% of Pillar 2 expenditure. Details at https://www.europarl.europa.eu/factsheets/en/sheet/106/financing-of-the-cap#:~:text=The%20EAGF%20 (1st%20pillar%20of,3). Retrieved on 22/03/2025.

[6] Tables 2 and 3 report the pairwise correlations for CAP and CP, respectively.

[7] For example, in the case of Table 4, the same level of statistical significance for the coefficient of the structural characteristics index is achieved for

efficients without exception[8]. Theoretically, no method dominates the other in terms of econometric properties in our setting. Given the aforementioned consistency and the interpretational advantages of OLS coefficients as compared to MAGRR shrinkage, which can make the interpretation of individual coefficients more difficult, we will proceed by discussing the OLS estimates.

On a more general premise, as mentioned, the focus of our empirical scrutiny is not on the *exact* magnitude of coefficients, but, rather, on the direction of associations between the set of considered variables; as a consequence, despite the potential issue of multicollinearity, the models presented in this section are still able to provide meaningful insights into the overall pattern of associations among place-specific structural factors, CP, and CAP expenditures, especially with respect to cases in which the *t* statistics are significant (Johnston, 1984).

3.2. The structural characteristics index: the $\sigma-\mu$ methodology

The paper uses a composite measure of the structural performance of the region, with larger values denoting a better performing region and *vice versa*. A major issue in the construction of composite indicators concerns the weights chosen to be applied to the indicators. There are several approaches in the literature offering guidance as to how to resolve this issue. One can use participatory approaches (i.e. involving individuals - often called 'experts'- to decide) or deploying data-driven techniques (i.e. relying solely on the underlying data at hand to elicit the importance of the criteria). Each approach is associated with a different set of advantages and limitations (see Greco et al., 2019a; Greyling and Tregenna, 2017). Perhaps, a more profound issue that is often overlooked is that a selected weight vector is supposed to be representative of all parties embodied in the composite measure. Towards a solution to this problem, Greco et al. (2019b) proposed a method called 'Sigma-Mu efficiency analysis'. This approach takes into account the entire space of weight vectors in order to synthesise for each unit (hereby regions) a distribution via two components. These are the average evaluation, μ, and the standard deviation, σ, in the whole space of preferences taken into account within the evaluation.

The former comprises a measure of overall performance, whilst the latter is conceived of as a measure of inequality of satisfaction (or inverse measure of robustness) should a different participant want to express their own preferences (weights)[9]. The two components are then synthesised to form the most rewarding trade-off for each region that maximises its performance and which acts as the final structural index[10].

On more technical grounds, the paper departs from the extant literature by operationalising the structural characteristics index (i.e. the variable *X_char* reported in models (1) and (2)) through this $\sigma-\mu$ methodology. This methodology, differently from other common data-reduction techniques such as the Principal Component Analysis used in a similar exercise by Crescenzi et al. (2015), allows for the consideration of multiple weighting schemes in assessing the socioeconomic characteristics of places.

Put differently, it offers a multidimensional measure of structural characteristics able to consider not only the different dimensions, but also the different views about the relative importance of each dimension of places. While the reader is referred to Greco et al. (2019b) for the technicalities of the procedure, we report the intuition behind the methodology with precise regard to the goal of constructing a CI of spatial characteristics.

The starting point of the $\sigma-\mu$ is the outcome of a Stochastic Multiobjective Acceptability Analysis (SMAA) (Lahdelma et al., 1998) exercise applied to the normalised dimensions of structural characteristics considered in the analysis (e.g. employment, unemployment, population conditions. See Table 1 for details). Therefore, within the SMAA framework a random sampling of q vectors of weights $w_h = [\, w_{1h}, \ldots, w_{mh} \,]$, with $h = 1, \ldots, q$, such that w_{ih} is non-negative for all i and for all h, and $w_{1h} + \ldots + w_{mh} = 1$ for all h is used to aggregate m dimensions. The q random extracted weight vectors w_h, $h = 1, \ldots, q$, constitute a representative sample of the whole set of feasible weight vectors. Then, using the weight matrix, a composite indicator

$$CI(\mathbf{x}_i, \mathbf{w}_h) = w_{1h}x_1 + w_{2h}x_2 + \ldots + w_{mh}x_m$$

can be computed for each local economy (e.g. region) i and each weight vector w_h. Hence, the results can be ordered in a $n \times q$ matrix **CI.** The following step consists in using the values collected in **CI**, for each region i to compute the approximated values $\widetilde{\mu_i}$ and $\widetilde{\sigma_i}$ for the mean μ_i and the standard deviation σ_i of the composite indicator $CI(x_i, w)$ in the whole set of feasible weight vectors.

$$\tilde{\mu}_i = \frac{1}{q}\sum_{h=1}^{q} CI(x_i w_h), \tilde{\sigma}_i = \sqrt{\frac{1}{q}\sum_{h=1}^{q}\left(CI(x_i, w_h) - \tilde{\mu}_i\right)^2}.$$

These two - μ and σ- are the parameters of interest; μ_i is intended to be maximized, because it represents the average evaluation of the level of regional structural development taking into account the variability of the weight vectors **w**. By contrast, σ_i has to be minimized, as it captures the variability in the overall evaluations due to the different weights[11].

The $\sigma-\mu$ framework allows defining both a concept of Pareto-Koopmans dominance between regions based on the uneven spatial characteristics and a set of local and global efficiency scores. Those scores, in turn, can be easily interpreted as a holistic score of structural characteristics.

As for the former, the $\sigma-\mu$ Pareto-Koopmans dominance relation on the set of regions is as follows: a region $i \in I$ (the set of all units, local economies in case at hand) is $\sigma-\mu$ Pareto –Koopmans efficient if there is no convex combination of $\mu_{i'}$ and $\sigma_{i'}$ of the remaining units, $i' \neq i$, with a mean value μ that is not smaller, and a standard deviation σ that is not greater, with at least one of these inequalities being strict. Then, the set of all Pareto efficient units constitutes the Pareto frontier and, similarly, the set of all $\sigma-\mu$ Pareto–Koopmans efficient units constitutes the $\sigma-\mu$ Pareto–Koopmans Frontier (PKF). Removing the first PKF from the set of units to be evaluated and re-computing the PKF efficiency frontier (for the remaining units), generates a second $\sigma-\mu$ PKF (PKF_2). This exercise can be repeated until all PKFs have been computed.

Hence, by considering the whole set of PKF(s), a [local] global measure of efficiency ($\delta_{i[k]}^*$) can be obtained (see Greco et al. (2019b) for methodological details). In terms of socioeconomic spatial characteristics, δ_i^* can be interpreted as a measure of overall regional performance for region *i*.

The local multidimensional measure of structural factors (δ_{ik},) represents the socio-economic performance of each region compared to its peers, where the *peer regions* are determined according to a data-driven process. As a result, *k* subsets of *comparable* regions are detected in order to assess the relative development between regions sharing a similar performance, i.e. less dependent on outliers (both development poles and regions in a condition of relative underdevelopment).

the following expenditure categories: 'Total cohesion policy', 'Business support', 'Energy', 'Environment and natural resources', 'Human resources', 'IT infrastructure and services', 'Research and Technology, 'Social infrastructure', 'Technical assistance', 'Tourism and Culture', 'Transport infrastructure', 'Urban and rural regeneration', and 'Other'.

[8] Full results available as supplementary material in TableS1, Table S2i, and TableS2ii.

[9] In a complementary interpretation, one might think of these weights as potential preferences of different experts, policy-makers, or even citizens intended to benefit from the policies.

[10] For more details, we refer the interested reader to the original study of Greco *et al.* (2019b).

[11] Again, for a detailed discussion on this point including the economic rationale the reader is referred to Greco et al. (2019b, p. 946). In short, the rationale for minimising σ_i stems from considering it as a measure of inequality.

Table 1
Descriptive statistics.

Variable (all per capita, except Rural Dev. Index)	Mean	SD	Min	Max
GDP PPS per inhabitant	28459.81	25198.65	7300.00	228000.00
Structural characteristics index	0.58	0.22	0.00	1.00
% territory in predominantly rural regions	46.01	33.31	0	100
% population in predominantly rural regions	35.1	32.3	0	100
% employment in predominantly rural regions	33.69	32	0	100.03
Population density hab/km2	202.12	339.86	23.4	2373.9
% people aged 15-64	66.23	2.57	61.45	72.66
Old-age dependency ratio (pop 65+ y.o. / pop 15-64 y.o.) per 100 (-)	28.04	5.46	17.42	43.93
Long-term unemployment (% total unemployment) (-)	44.77	9.29	17.67	67.07
Share of employment in primary sector (Branch A) % of total employment	8.25	9.45	0.17	51.39
Share of employment in food industry (% total employment)	2.84	1.21	0.55	7.29
% Famers (holders) with other gainful activity	36.77	16.86	13.22	83.72
Net migration (Total pop change-Natural pop change/Average annual pop) per 1000	1.29	3.9	-4.9	21.6
% adults (25-64) with medium or high educational attainment	66.77	15.2	24.49	93.99
Total Cohesion Policy expenditure per capita	427.05	546.88	1.18	3500.61
Business support	51.22	77.47	0.00	459.99
Energy	17.55	34.94	0.00	274.90
Environment and natural resources	61.52	96.06	0.00	640.42
Human resources	1.45	3.50	0.00	26.15
IT infrastructure and services	15.96	24.30	0.00	221.29
Research and Technology	54.63	65.96	0.06	414.25
Social infrastructure	38.06	85.18	0.00	837.56
Technical assistance	12.30	28.46	0.00	308.04
Tourism & Culture	18.24	29.94	0.00	240.06
Transport infrastructure	135.87	226.66	0.00	1463.33
Urban and rural regeneration	17.17	27.92	0.00	220.18
Other	3.07	20.50	0.00	199.57
Total Common Agricultural Policy expenditure per capita	81.70	156.86	0.00	1179.81
Subsidies on investments (SE406)	5.61	21.34	0.00	209.09
Total subsidies (not investments) (SE605)	76.09	140.82	0.00	1078.91
(=SE610+SE615+SE624+SE625+SE626+SE630+SE699)	3.33	8.93	0.00	70.51
Subsidies on crops (SE610)				
Compensatory payments/area payments (SE611)	0.63	1.91	0.00	12.40
Set aside premiums (SE612)	0.01	0.04	0.00	0.32
Other crops subsidies (SE613)	2.58	8.67	0.00	70.51
Subsidies on livestock (SE615)	6.83	25.08	-1.79	240.82
Subsidies dairying (SE616)	1.32	9.32	-2.76	110.63
Subsidies other cattle (SE617)	2.96	10.72	0.00	96.95
Subsidies sheep & goats (SE618)	0.37	1.09	0.00	9.87
Variable (all per capita, except Rural Dev. Index)	**Mean**	**SD**	**Min**	**Max**
Other livestock subsidies (SE619)	2.18	16.43	0.00	243.15
Total support for rural development (SE624)	17.13	50.40	0.00	533.14
Environmental subsidies (SE621)	8.47	21.66	0.00	232.95
LFA subsidies (SE622)	8.01	28.65	0.00	284.16
Other rural development payments (SE623)	0.65	1.53	0.00	16.02
Subsidies on intermediate consumption (SE625)	1.61	5.32	0.00	41.91
Subsidies on external factors (SE626)	0.53	1.62	0.00	9.32
Decoupled payments (SE630)	42.23	76.48	0.00	562.52
Single Farm payment (SE631)	32.58	66.93	0.00	562.32
Single Area payment (SE632)	9.55	44.55	0.00	521.12
Additional aid (SE640)	0.10	0.17	0.00	1.36
Support Art.68 (SE650)	0.89	2.06	0.00	18.56
Other subsidies (SE699)	4.42	11.37	0.00	86.61

Note: (-) refers to variables with negative polarity whose values have been inversely scaled in calculating the $\sigma-\mu$ index. Source: Authors' elaboration.

As a final step, one aiming to explicitly consider the multiplicity of PKFs, a 'global' development score, denoted by sm_i, reflecting the level of development of each local economy with respect to all frontiers can be defined as follows:

$$sm_i = \sum_{k=1}^{p} \delta_{ik}.$$

In other words, sm_i represents a measure of structural characteristics - *X_char* - encapsulating the multidimensional nature of the evaluation exercise by taking into account both (i) the potential different weights assigned to each considered dimension and (ii) the resulting different rankings.

This, in turn, makes the $\sigma-\mu$ substantially different from the aforementioned PCA and alike techniques, which, instead, does not entail any valuation on the (variations in the) relative importance of the single dimensions (i.e. variables) included in the analysis. In light of the political dimension (among others) of the process of funds allocation, we deem that considering the different relative evaluations represents a considerable improvement. Moreover, on a more technical note, the $\sigma-\mu$ approach is *ranking-oriented* in its nature. Therefore, we deem it is conceptually more appropriate than *data-reduction* measures, such as PCA, in evaluating to what extent the underlying dimensions relate to the allocation of a limited amount of resources (EU funds across policies) over a set of potential recipients (EU regions). Put differently, we argue the $\sigma-\mu$ approach better aligns with the Multiple Criteria Decision Making (MCDM) setting of EU CAP and CP intervention. Hence, the application of the $\sigma-\mu$ approach to the case at hand represents a significant departure from the extant literature: an original methodological contribution potentially able to provide additional insights into the extent to which a place-based approach applies to EU policy, eventually.

3.3. The dataset

As mentioned, the analysis uses data on CP and CAP Pillar 1 expenditure along with socio-economic indicators used for policy evaluation. The data on CP expenditure are retrieved from 'Integrated database of allocations and expenditure for 2007–2013' from the European Commission data for research[12]. We use NUTS 2 expenditure from the end of the programming period, 2013, for the ERDF and Cohesion Fund, the policy categories are described in Table 1. This dataset is based on Eurostat's 2006 definition of NUTS 2[13] with some exceptions that are based on the 2003 definition[14]. Region names are adjusted to meet the 2010 NUTS 2 definition, to allow alignment with social and economic variables obtained from Eurostat.

The data on CAP Pillar 1 expenditure are retrieved from the Farm Accountancy Data Network (FADN). This covers subsidies on crops (SE610), livestock (SE615), rural development support (SE624), decoupled payments (SE630), and corresponding subcategories of funding. The authors note that FADN does not include non-commercial and very small farms and that there are other sources of total expenditure data such as CATS (Clearance Audit Trail System). However, the FADN database is the only data source for analysing the impact of agricultural policy instruments on the economic situation of farms and the desire is to compliment the existing analysis on the interaction between EU policies using FADN data as found in Crescenzi et al. (2015) and Calegari et al. (2021).

The regional breakdown of FADN data in some countries does not correspond to the NUTS2 breakdown for which cohesion policy is defined. Therefore, this analysis makes use of the dataset generated by Chmielinski et al. (2019) offering FADN data on the support under the CAP in 2007-2013 delimited for LAU2 and grouped at the NUTS2 level regions in the EU Member States. More specifically, in the dataset, each FADN region has been assigned a corresponding NUTS2 region (or regions) according to the classification in 2010, in which the full census of the farm structure survey was carried out. The delimitation of FADN data to NUTS2 regions is based on weights constructed on the basis of Eurostat data on utilised agricultural area and number of holdings in 2010. In each economic size class, each FADN region consisted of the sum of the NUTS2 regions weighted by the utilised agricultural area. The result of each FADN variable is the sum of its values in each economic size class, weighted by the total number of holdings in each class.

Policy expenditure data are used in a per capita form using regional population information from Eurostat[15]. We use the average of the population over the period 2007-2013 for each NUTS 2 area. All regions are NUTS 2, with the exception of a number of areas in Germany where rural policy expenditure is available at NUTS 1 level only (DE1, DE2, DE7, DE9, DEA, DEB, DED). The ZZ extra-regio areas are not used.

Then, the above expenditure measures are matched with placed-based indicators. We make use of a GDP purchasing power per capita to capture variation in economic strength across regions. GDP data is taken from the Eurostat database. Secondly, as explained in the above Section 3.2, an index of structural performance attributes is generated. Variables that help to describe a region's structural disadvantage are retrieved from 'Rural Development in the EU – Statistical and Economic Information Report – 2013' [16] and listed in Table 1 alongside summary statistics. Tables 2 and 3 complement the descriptive statistics with the pairwise correlations between CAP and CP expenditures by sector of intervention.

There are four categories of variables relating in turn to: The importance of rural areas; Socio-economic indicators; Sectoral economic indicators; and Diversification and Quality of Life. Whilst rural industry characteristics are included, despite the different methodological approach based on $\sigma-\mu$, the analysis follows Crescenzi et al. (2015) in attempting to capture accumulation of human capital (by % adults (25-64) with high educational attainment) and the productive use of human capital (by long-term unemployment as % of unemployment, and % employment in primary sector). This dataset includes information for matching all regions from the other data sources gathered with the exception of Croatia HR01 and HR02. As such, the complete dataset spans across 242 regions.

Hence, the above variables in each category contribute to constructing a structural characteristics composite index (X_char) adopting the $\sigma-\mu$ methodology[17] describe in Section 3.2. Following the suggestion of Greco et al. (2019b), 10,000 simulations are used to elicit weights (potential preferences) through a uniform distribution, whilst in order to address the existence of potential outliers in the 'sigma-mu' plane, m-robust frontiers (Cazals et al., 2002; Daraio and Simar, 2005) are employed.

4. Results

This section reports results from estimating equations arising from models (1) and (2). More in detail, there are 12 subcategories of cohesion policy expenditure and 18 subcategories of CAP expenditure, where the corresponding descriptive statistics are presented in Table 1, in per capita form. Cohesion policies provide far larger funding than Pillar 1 policies. The total policy expenditure is 158,865 million Euros and 78 million Euros, respectively. Transport Infrastructure is the policy area that has seen the largest amount of funding, on average 136 Euros per person. Whereas, subsidies that are decoupled from output size, single farm payments, are 33 Euros per capita on average.

Results from estimating Eq. (1) are shown in Tables 4 to 6, while results from Eq. (2) are shown in an Appendix. Robust standard errors are shown in parentheses. Statistical significance is reported as *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Country-specific fixed effects are included, and statistically significant with respect to Belgium and the base county, in all estimations but not reported.

(i) Are the funds able to target the most structurally disadvantaged regions of the EU?

Table 4 shows the estimation of Eq. (1) using data of total CAP Pilar 1 expenditures, GDP, and the structural characteristics index. Both the index and GDP have a significant coefficient on CP, showing that CP is positively related to areas most in need of support. Notably, the Transport infrastructure and services expenditure category shows the strongest link towards regions weakest in rural development. However, we find no evidence to support a similar argument for Human resources, IT infrastructure and services, Technical assistance, and Other expenditures.

Results from the reverse estimation are shown in Table 5. Here, estimations show that Subsidies on cattle (SE617) is the most sensitive to being related to regions that are weaker. Other funding policy streams that also tend to flow to areas in need of support are SE610 SE618, SE630, SE640, SE650, and SE699. Weaker areas, measured by GDP, seem to attract a number of CAP Pilar 1 expenditure policies of which, Single farm payments (SE631) are the most likely to flooding to weaker areas Table 5ii.

(ii) Is there a significant synergy (or trade-off) between cohesion and CAP Pilar 1 policies?

To the end of the current empirical exercise, 'synergy' is defined as the interaction of elements that, when combined, produce a total effect that is greater than the sum of the individual elements and contribu-

[12] https://ec.europa.eu/regional_policy/en/policy/evaluations/data-for-research/

[13] https://ec.europa.eu/eurostat/web/nuts/history

[14] DK00 = DK01~DK05; FI18 = FI1B + FI1C; SI00 = SI01 + SI02.

[15] https://ec.europa.eu/eurostat/web/regions/data/database

[16] https://ec.europa.eu/agriculture/statistics/rural-development/2013_en

[17] Variables with a negative polarity, such as 'long-term unemployment', have been inversely scaled in applying the $\sigma-\mu$ methodology. See Table 1 for details.

Table 2
CAP expenditure - pairwise correlations.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
(1) SE406	1.000																
(2) SE611	0.019	1.000															
(3) SE612	-0.020	0.829*	1.000														
(4) SE613	0.342*	-0.001	-0.036	1.000													
(5) SE616	0.120	0.030	-0.033	0.295*	1.000												
(6) SE617	0.106	0.396*	0.263*	0.142*	0.461*	1.000											
(7) SE618	0.166*	0.302*	0.307*	0.190*	0.187*	0.654*	1.000										
(8) SE619	0.732*	0.000	-0.022	0.190*	0.068	0.031	0.058	1.000									
(9) SE621	0.840*	0.016	-0.052	0.295*	0.328*	0.188*	0.145*	0.792*	1.000								
(10) SE622	0.876*	0.018	-0.040	0.406*	0.367*	0.286*	0.274*	0.795*	0.931*	1.000							
(11) SE623	0.501*	-0.081	-0.093	0.108	0.379*	0.136*	0.048	0.639*	0.623*	0.583*	1.000						
(12) SE625	0.175*	-0.005	-0.047	0.003	0.000	-0.065	-0.060	0.009	0.292*	0.121	0.008	1.000					
(13) SE626	0.112	-0.053	-0.083	-0.026	-0.025	0.040	-0.098	-0.016	0.189*	0.048	0.037	0.698*	1.000				
(14) SE630	0.396*	0.283*	0.141*	0.279*	0.101	0.191*	0.186*	0.214*	0.563*	0.468*	0.113	0.684*	0.554*	1.000			
(15) SE640	0.573*	0.335*	0.263*	0.079	0.093	0.452*	0.454*	0.478*	0.546*	0.568*	0.468*	0.049	0.078	0.346*	1.000		
(16) SE650	0.347*	0.200*	0.098	0.436*	0.359*	0.439*	0.440*	0.216*	0.462*	0.582*	0.144*	0.169*	0.022	0.483*	0.298*	1.000	
(17) SE699	0.584*	0.020	-0.036	0.371*	0.158*	0.160*	0.223*	0.290*	0.528*	0.595*	0.142*	0.434*	0.248*	0.498*	0.198*	0.700*	1.000

Note: *** p < 0.01, ** p < 0.05, * p < 0.1. SE406, SE605, SE610, SE611, SE612, SE613, SE615, SE616, SE617, SE618, SE619, SE621, SE622, SE623, SE624, SE625, SE626, SE630, SE631, SE632, SE640, SE650, and SE699 refer to 'Subsidies on investments', 'Total subsidies - excluding on investments', 'Total subsidies on crops', 'Compensatory payments/area payments', 'Set aside premiums', 'Other crops subsidies', 'Total subsidies on livestock', 'Subsidies dairying', 'Subsidies other cattle', 'Subsidies sheep & goats', 'Other livestock subsidies', 'Environmental subsidies', 'LFA subsidies', 'Other rural development payments', 'Total support for rural development', 'Subsidies on intermediate consumption', 'Subsidies on external factors', 'Decoupled payments', 'Single Farm payment', 'Single Area payment', 'Additional aid', 'Support under Art68', and 'Other subsidies', respectively. Source: Authors' elaboration.

Table 3
CP expenditure - pairwise correlations.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1) Business support	1.000											
(2) Energy	0.501*	1.000										
(3) Environment and natural resources	0.556*	0.390*	1.000									
(4) Human resources	-0.054	0.069	0.005	1.000								
(5) IT infrastructure	0.422*	0.373*	0.407*	-0.009	1.000							
(6) Research and Technology	0.363*	0.339*	0.532*	0.121	0.571*	1.000						
(7) Social infrastructure	0.597*	0.275*	0.826*	-0.009	0.345*	0.525*	1.000					
(8) Technical assistance	0.486*	0.298*	0.353*	-0.032	0.785*	0.399*	0.328*	1.000				
(9) Tourism & Culture	0.535*	0.467*	0.677*	0.104	0.339*	0.469*	0.640*	0.304*	1.000			
(10) Transport infrastructure	0.528*	0.608*	0.653*	0.011	0.489*	0.483*	0.570*	0.371*	0.504*	1.000		
(11) Urban and rural regeneration	0.377*	0.395*	0.568*	0.082	0.324*	0.448*	0.453*	0.274*	0.346*	0.452*	1.000	
(12) Other	0.255*	-0.035	0.333*	-0.041	0.092	0.042	0.433*	0.090	0.267*	0.161*	0.036	1.000

Note: *** *p < 0.01,* ** *p < 0.05,* * *p < 0.1.* Source: Authors' elaboration.

tions: i.e., funds of different policies targeting the same areas having a 'cumulative' and/or 'knock-on' process among the policies.

When considering the disaggregated policy streams, there are a number of observed relationships. In some cases, a significant relationship between policy subcategories is seen when the estimation is run in one direction but not the other. We focus only on the policy relationships that are statistically significant in both regression estimations. These relationships between policy streams are shown in Table 6.

These results show a connection between 'Subsidies on dairying' measure of the CAP with Business support, and Support to social and transport infrastructure. The evidence that, among all the considered policy dimensions, such a connection is found with particular reference to 'subsidies on dairying' calls for further scrutiny of the underlying economic mechanism. Undeniably, the development stage of regions might involve patterns of policy intervention such that while less developed regions tend to invest more in infrastructure, more developed regions focus their cohesion funds on supporting innovation activities and this, in turn, might affect the whole pattern of policy expenditure. Nonetheless, we conjecture that our result might reflect the fact that milk production concentration naturally implies processing industry concentration. Thus, because milk processing is one of the most modern and competitive sectors of the food economy, a strongly interrelated production and processing system is an important branch of the economy at the regional level potentially able to attract other categories of EU expenditure. Once more, we acknowledge that our empirical framework does not allow for a deeper analysis in this respect and, more generally, individually exploring the underlying economic mechanism of the detected associations is beyond the scope of the current paper.

The findings also point to clear trade-offs between the cohesion policy measure 'Human resources' and the 'Single farm payment' measure under CAP. Previous studies provide some evidence that area payments hamper efficiency-oriented changes in the social and economic structures of farms. These payments are an important component of household income (see, for example, Karwat-Woźniak and Chmieliński, 2007; Keeney, 2000) and this includes employment on agricultural holdings (Brady et al., 2017). Therefore, it may be contended that these payments slow down the process of optimizing employment in the sector with respect to labour force movements between agriculture and other sectors of the economy.

Quite paradoxically, pro-development measures towards rural areas (Urban and rural regeneration) under the cohesion policy seem to generate trade-offs with typical development measures of the agricultural sector (i.e. Subsidies on investments) and also with some elements of subsidy policy for animal and crop production. Clearly, the CAP is dominated by measures to support the agricultural sector (agricultural holdings, farmers' household budgets, the agricultural environment and industry), so in regions where this sector is particularly important, more intensive use of agricultural support can be observed. Where it is less

Table 4
Cohesion policy and sub categories of common agricultural policy.

Variables	(1) Total cohesion policy	(2) Business support	(3) Energy	(4) Environment and natural resources	(5) Human resources	(6) IT infrastructure and services	(7) Research and Technology	(8) Social infrastructure	(9) Technical assistance	(10) Tourism and Culture	(11) Transport infrastructure	(12) Urban and rural regeneration	(13) Other
Structural characteristics index	-576.6***	-81.60***	-30.08**	-112.6***	-1.759	-8.013	-77.66**	-82.38***	-4.523	-12.69	-132.3*	-35.55**	2.600
	(130.2)	(19.30)	(12.44)	(39.89)	(1.845)	(6.128)	(30.52)	(26.21)	(7.299)	(8.958)	(68.13)	(16.69)	(8.585)
GDP PPS per inhabitant	-0.00181***	-0.000327***	-8.13e-05***	-0.000253**	-2.16e-05*	-2.76e-06	-0.000293***	-0.000223**	5.06e-05	-0.000111**	-0.000372*	-0.000163***	-1.64e-05
	(0.000594)	(0.000107)	(2.86e-05)	(0.000121)	(1.20e-05)	(4.17e-05)	(9.52e-05)	(0.000105)	(6.05e-05)	(4.35e-05)	(0.000206)	(5.02e-05)	(1.81e-05)
Subsidies on investments	9.891	2.723***	-0.377	2.071	-0.155***	0.292	-0.0491	3.765**	1.151**	0.000452	0.425	-0.602	0.647
	(6.268)	(0.736)	(0.239)	(1.535)	(0.0372)	(0.366)	(1.033)	(1.672)	(0.576)	(0.318)	(3.243)	(0.371)	(0.543)
Compensatory payments/area payments	-2.562	-1.061	0.129	2.479	0.238*	-2.495**	-2.733	1.649	-3.335**	2.252**	-0.780	-0.420	1.516
	(23.76)	(3.244)	(0.578)	(5.687)	(0.142)	(1.146)	(2.793)	(4.223)	(1.523)	(1.040)	(11.38)	(1.515)	(1.595)
Set aside premiums	-937.9	-74.95	-6.634	-306.6	-1.977	36.62*	-63.51	-159.9	23.29	-31.21	-253.7	-78.67	-20.67
	(920.2)	(79.80)	(13.95)	(232.8)	(2.934)	(21.24)	(88.81)	(164.2)	(22.29)	(33.73)	(482.1)	(49.69)	(33.47)
Other crops subsidies	2.393	-0.202	0.145	0.449	0.0575*	0.137	-0.265	-0.552	-0.317	0.480*	1.022	0.106	1.335**
	(2.699)	(0.426)	(0.164)	(0.923)	(0.0318)	(0.159)	(0.401)	(0.702)	(0.259)	(0.249)	(1.507)	(0.231)	(0.668)
Subsidies dairying	12.42**	1.812***	-0.116	1.466	-0.0357	0.0605	0.612	3.116**	0.385	-0.0607	5.252*	-0.445*	0.370
	(5.016)	(0.645)	(0.158)	(1.031)	(0.0269)	(0.211)	(0.792)	(1.464)	(0.282)	(0.245)	(2.677)	(0.263)	(0.460)
Subsidies other cattle	3.389	1.065***	-0.164	0.422	0.0605**	0.283	-0.961	0.726	0.406	0.383**	0.929	-0.487*	0.726***
	(3.747)	(0.388)	(0.121)	(0.927)	(0.0258)	(0.214)	(0.820)	(0.886)	(0.327)	(0.160)	(1.668)	(0.284)	(0.274)
Subsidies sheep & goats	-1.950	-3.314	-0.338	2.296	0.166	-2.699**	11.04	6.052	-1.517	-0.246	-14.04	2.978	-2.331
	(40.99)	(2.834)	(1.134)	(11.20)	(0.235)	(1.358)	(9.069)	(8.367)	(1.497)	(1.343)	(14.68)	(3.574)	(2.131)
Other livestock subsidies	0.175	-0.834	0.155	-0.852	0.0824***	-0.0567	-0.128	0.0384	0.104	-0.351	2.045	-0.0110	-0.0178
	(3.069)	(0.795)	(0.149)	(0.653)	(0.0305)	(0.252)	(0.748)	(0.640)	(0.351)	(0.221)	(1.905)	(0.204)	(0.249)
Environmental subsidies	3.312	0.300	-0.206	1.624***	0.0117	-0.128	-0.254	1.226*	-0.535*	0.538***	0.401	-0.0655	0.401**
	(2.788)	(0.740)	(0.140)	(0.564)	(0.0280)	(0.235)	(0.455)	(0.670)	(0.292)	(0.180)	(1.459)	(0.209)	(0.164)
LFA subsidies	-9.570	-0.953	0.233	-2.240*	0.0333	-0.0892	0.0947	-3.568**	-0.611	-0.179	-1.947	0.511	-0.855*
	(5.865)	(0.841)	(0.165)	(1.299)	(0.0343)	(0.360)	(0.963)	(1.543)	(0.575)	(0.299)	(2.895)	(0.362)	(0.449)
Other rural development payments	24.46	-0.349	0.981	10.94**	-0.117	-0.531	0.319	8.083*	0.663	5.817**	-7.223	0.307	5.570**
	(20.08)	(3.535)	(2.997)	(4.750)	(0.235)	(1.798)	(7.216)	(4.352)	(2.675)	(2.392)	(13.72)	(1.605)	(2.366)
Subsidies on intermediate consumption	10.78	0.621	0.179	2.173	0.166*	0.319	3.106*	-0.664	0.358	1.166**	3.260	-0.612	0.707
	(8.080)	(1.674)	(0.430)	(1.881)	(0.0874)	(0.984)	(1.761)	(1.880)	(1.659)	(0.568)	(4.352)	(0.819)	(0.456)
Subsidies on external factors	-17.89	-0.315	-0.497	-4.532	-0.406	-0.190	-1.022	-3.760	-0.448	0.435	-6.361	0.308	-1.104
	(20.31)	(3.522)	(1.082)	(4.132)	(0.264)	(0.868)	(4.180)	(3.300)	(1.015)	(0.953)	(6.795)	(1.327)	(0.880)
Decoupled payments	0.440	0.225	0.00571	-0.102	-0.0155**	-0.00508	0.0334	0.0963	0.0618	-0.137***	0.287	0.0492	-0.0581
	(0.645)	(0.180)	(0.0316)	(0.147)	(0.00757)	(0.0761)	(0.130)	(0.156)	(0.128)	(0.0499)	(0.389)	(0.0661)	(0.0482)
Additional aid	-314.0	-89.40**	8.480	-87.36*	-0.825	34.34	34.79	-124.7**	41.40	-27.28*	-42.52	-18.31	-42.64***
	(225.1)	(37.20)	(19.65)	(49.71)	(1.821)	(22.35)	(52.05)	(52.50)	(27.50)	(13.86)	(148.9)	(17.41)	(15.71)
Support_Art68	-23.88	-2.253	-2.126	-3.133	-0.316**	-0.990	-6.983**	2.039	0.0664	-1.391	-6.123	-2.469*	-0.199
	(15.61)	(1.846)	(1.376)	(3.142)	(0.150)	(1.153)	(3.100)	(2.813)	(1.569)	(1.117)	(8.450)	(1.481)	(0.945)
Other subsidies	-3.224	-3.041***	0.513	0.514	0.124**	-1.009	0.452	-0.761	-1.869**	0.195	1.636	0.372	-0.351
	(3.870)	(0.726)	(0.369)	(0.877)	(0.0504)	(0.628)	(1.002)	(0.826)	(0.938)	(0.348)	(3.355)	(0.641)	(0.250)
Constant	503.6***	74.33***	26.29**	91.93**	4.475**	3.031	84.22***	59.90**	-3.972	12.21	116.1**	38.85***	-3.823
	(143.8)	(21.81)	(11.01)	(36.79)	(2.099)	(6.308)	(31.66)	(23.10)	(8.596)	(7.776)	(58.20)	(14.67)	(6.289)
Observations	242	242	242	242	242	242	242	242	242	242	242	242	242
R-squared	0.858	0.792	0.679	0.790	0.290	0.623	0.618	0.811	0.533	0.721	0.673	0.570	0.655

Note: Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Source: Authors' elaboration.

Table 5i
Common agricultural policy and sub categories of cohesion policy.

Variables	(1) Total rural policy expenditure	(2) Subsidies on investments SE406	(3) Total subsidies - excluding on investments SE605	(4) Total subsidies on crops SE610	(5) Compensatory payments/area payments SE611	(6) Set aside premiums SE612	(7) Other crops subsidies SE613	(8) Total subsidies on livestock SE615	(9) Subsidies dairying SE616	(10) Subsidies other cattle SE617	(11) Subsidies sheep & goats SE618	(12) Other livestock subsidies SE619
Structural characteristics index	-97.38	-6.743	-90.64	-5.985*	-0.746	-0.0172	-4.922	-21.41	-4.393	-20.41**	-1.850**	5.245
	(72.71)	(12.86)	(62.40)	(3.375)	(0.790)	(0.0172)	(3.590)	(16.50)	(3.345)	(10.34)	(0.893)	(9.437)
GDP PPS per inhabitant	-0.00110***	-5.63e-06	-0.00109***	-1.53e-05	-4.38e-06**	-5.12e-08	-9.90e-06	-2.79e-05	-6.82e-06	-2.78e-05	-1.84e-06	8.58e-06
	(0.000373)	(2.14e-05)	(0.000370)	(9.53e-06)	(1.80e-06)	(3.70e-08)	(8.98e-06)	(3.49e-05)	(1.47e-05)	(1.83e-05)	(1.73e-06)	(2.32e-05)
Business support	0.504*	-0.000205	0.504*	-0.00342	0.00165	-1.00e-05	-0.00389	0.0245	0.0262**	0.0146	-0.000851	-0.0155
	(0.287)	(0.0293)	(0.268)	(0.0127)	(0.00163)	(3.19e-05)	(0.0129)	(0.0397)	(0.0130)	(0.0120)	(0.00130)	(0.0316)
Energy	-0.127	0.0227	-0.150	-0.00940	0.00116	4.86e-05	-0.0104	-0.00343	-0.0179	-0.0186	-0.00138	0.0345
	(0.319)	(0.0361)	(0.297)	(0.0155)	(0.00184)	(4.56e-05)	(0.0147)	(0.0525)	(0.0190)	(0.0208)	(0.00208)	(0.0403)
Environment and natural resources	0.102	0.0236	0.0780	0.0118	-0.00501*	-0.000142*	0.0163	0.00283	-0.000532	-0.00301	-0.00139	0.00776
	(0.168)	(0.0195)	(0.155)	(0.0213)	(0.00263)	(7.80e-05)	(0.0224)	(0.0296)	(0.00883)	(0.0173)	(0.00258)	(0.0145)
Human resources	-4.250*	-0.417	-3.834*	-0.0137	-0.0106	-0.000283	0.00628	-0.203	-0.0126	0.123	0.0167	-0.330
	(2.300)	(0.341)	(2.015)	(0.108)	(0.0148)	(0.000355)	(0.112)	(0.476)	(0.0756)	(0.283)	(0.0284)	(0.345)
IT infrastructure and services	-0.817	0.108	-0.925	0.0304	-0.0158*	-0.000181	0.0464	0.0883	-0.0170	-0.0230	-0.00728	0.136
	(0.947)	(0.144)	(0.832)	(0.0579)	(0.00914)	(0.000230)	(0.0619)	(0.181)	(0.0380)	(0.0395)	(0.00617)	(0.162)
Research and Technology	0.439**	-0.00327	0.442**	0.0270*	-0.00111	-1.53e-05	0.0279*	-0.0350	-0.00306	-0.0109	0.00170	-0.0227
	(0.208)	(0.0257)	(0.192)	(0.0137)	(0.00156)	(3.91e-05)	(0.0143)	(0.0417)	(0.0173)	(0.0157)	(0.00212)	(0.0293)
Social infrastructure	-0.452**	-0.0108	-0.441**	-0.0319	0.00524*	0.000105	-0.0379	0.0771	0.0479*	0.0259	0.00135	0.00194
	(0.226)	(0.0266)	(0.209)	(0.0256)	(0.00306)	(7.13e-05)	(0.0278)	(0.0527)	(0.0269)	(0.0213)	(0.00204)	(0.0165)
Technical assistance	-0.875	-0.127**	-0.748	-0.0832*	0.00728	8.86e-05	-0.0914*	-0.0555	-0.00142	0.0232	0.00281	-0.0802
	(0.538)	(0.0608)	(0.489)	(0.0444)	(0.00497)	(0.000114)	(0.0470)	(0.0822)	(0.0298)	(0.0280)	(0.00336)	(0.0585)
Tourism & Culture	0.457	0.127	0.330	-0.0210	-0.00156	-1.64e-05	-0.0190	0.165	-0.00700	0.00626	-0.00120	0.167
	(0.957)	(0.171)	(0.800)	(0.0351)	(0.00382)	(8.81e-05)	(0.0371)	(0.217)	(0.0373)	(0.0354)	(0.00364)	(0.197)
Transport infrastructure	0.104*	6.21e-05	0.104*	-0.00145	0.000367	-2.14e-06	-0.00172	0.00689	0.00492*	0.00137	-0.000305	0.000900
	(0.0549)	(0.00369)	(0.0531)	(0.00321)	(0.000380)	(1.47e-05)	(0.00321)	(0.00646)	(0.00277)	(0.00340)	(0.000393)	(0.00321)
Urban and rural regeneration	-0.712**	-0.0803*	-0.632**	-0.00553	-0.00897**	-0.000189**	0.00323	-0.176**	-0.0679*	-0.0798**	-0.00304	-0.0252
	(0.292)	(0.0411)	(0.259)	(0.0284)	(0.00454)	(8.18e-05)	(0.0279)	(0.0725)	(0.0347)	(0.0328)	(0.00325)	(0.0216)
Other	0.000665	0.0317	-0.0310	0.252***	-0.0153**	-0.000280**	0.271***	-0.0287	0.0572	-0.0231	-0.00665*	-0.0561
	(0.494)	(0.0798)	(0.436)	(0.0618)	(0.00627)	(0.000141)	(0.0653)	(0.116)	(0.0389)	(0.0358)	(0.00360)	(0.0884)
Constant	142.0**	9.296	5.082*	0.707	0.0153	4.067	23.59*	3.086	22.72***	1.311**	-3.518	
	(55.02)	(9.054)	(48.15)	(2.639)	(0.574)	(0.0129)	(2.745)	(12.04)	(2.421)	(8.075)	(0.644)	(6.690)
Observations	242	242	242	242	242	242	242	242	242	242	242	242
R-squared	0.563	0.466	0.579	0.640	0.521	0.387	0.600	0.329	0.570	0.357	0.407	0.140

Note: Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Source: Authors' elaboration.

Table 5ii
Common agricultural policy and sub categories of cohesion policy.

Variables	(13) Environmental subsidies SE621	(14) LFA subsidies SE622	(15) Other rural development payments SE623	(16) Total support for rural development SE624	(17) Subsidies on intermediate consumption SE625	(18) Subsidies on external factors SE626	(19) Decoupled payments SE630	(20) Single Farm payment SE631	(21) Single Area payment SE632	(22) Additional aid SE640	(23) Support Art68 SE650	(24) Other subsidies SE699
Structural characteristics index	-2.799	-12.89	-0.527	-16.22	0.979	0.191	-39.05	-30.82	-7.972	-0.258**	-2.842***	-9.163
	(9.797)	(15.90)	(0.705)	(25.34)	(1.805)	(0.636)	(27.72)	(26.83)	(6.457)	(0.111)	(1.082)	(5.872)
GDP PPS per inhabitant	-8.27e-05**	-3.06e-05	-3.77e-06*	-0.000117*	-4.43e-05*	-1.54e-05**	-0.000858***	-0.000859***	2.57e-06	-1.08e-06***	-3.74e-06	-1.55e-05
	(3.64e-05)	(3.25e-05)	(2.06e-06)	(6.58e-05)	(2.30e-05)	(7.30e-06)	(0.000300)	(0.000304)	(1.93e-05)	(3.32e-07)	(2.90e-06)	(9.90e-06)
Business support	0.0249	0.0179	-0.00309	0.0397	0.0257**	0.00642**	0.418**	0.413**	0.00554	-0.000336	-0.00110	-0.00675
	(0.0374)	(0.0422)	(0.00229)	(0.0799)	(0.0114)	(0.00286)	(0.178)	(0.170)	(0.0386)	(0.000254)	(0.00204)	(0.0115)
Energy	0.00224	0.0101	0.00311	0.0155	-0.0114	-0.00250	-0.133	-0.101	-0.0325	0.000295	-0.00461	-0.00541
	(0.0425)	(0.0507)	(0.00416)	(0.0956)	(0.0120)	(0.00268)	(0.173)	(0.153)	(0.0437)	(0.000401)	(0.00373)	(0.0177)
Environment and natural resources	0.0208	0.0179	0.00159	0.0403	0.00823	0.00118	-0.00855	-0.0322	0.0236	-4.05e-05	0.000605	0.0222*
	(0.0203)	(0.0249)	(0.00165)	(0.0451)	(0.00680)	(0.00142)	(0.0930)	(0.0892)	(0.0274)	(0.000337)	(0.00245)	(0.0132)
Human resources	-0.555	-0.535	-0.0451	-1.135	-0.0978*	-0.0390*	-2.300**	-2.365***	0.0687	-0.00386	-0.0117	-0.0449
	(0.387)	(0.461)	(0.0284)	(0.863)	(0.0583)	(0.0204)	(0.893)	(0.896)	(0.144)	(0.00318)	(0.0238)	(0.0979)
IT infrastructure and services	0.0724	0.121	0.00989	0.203	-0.0813**	-0.0164**	-1.116**	-0.930**	-0.186	0.000633	-0.00984	-0.0342
	(0.159)	(0.199)	(0.0109)	(0.367)	(0.0315)	(0.00710)	(0.446)	(0.457)	(0.117)	(0.00111)	(0.00683)	(0.0367)
Research and Technology	0.00951	-0.00815	-0.00189	-0.000537	0.0346***	0.00704***	0.378***	0.317**	0.0618**	-0.000128	0.00221	0.0310**
	(0.0298)	(0.0373)	(0.00246)	(0.0685)	(0.00992)	(0.00234)	(0.124)	(0.122)	(0.0260)	(0.000251)	(0.00205)	(0.0126)
Social infrastructure	-0.0195	-0.0202	0.00273	-0.0370	-0.0316***	-0.00720***	-0.375***	-0.321**	-0.0541*	7.39e-06	-0.00261	-0.0353**
	(0.0283)	(0.0343)	(0.00222)	(0.0616)	(0.00968)	(0.00219)	(0.133)	(0.128)	(0.0305)	(0.000271)	(0.00235)	(0.0139)
Technical assistance	-0.145**	-0.192**	-0.00179	-0.338**	-0.00993	-0.00126	-0.152	0.248	-0.400**	0.000173	-0.0120*	-0.108***
	(0.0698)	(0.0970)	(0.00441)	(0.167)	(0.0183)	(0.00401)	(0.270)	(0.229)	(0.180)	(0.000467)	(0.00711)	(0.0364)
Tourism & Culture	0.163	0.196	0.0171	0.376	-0.00922	-6.39e-05	-0.200	-0.204	0.00258	0.00115	0.000532	0.0190
	(0.191)	(0.236)	(0.0130)	(0.439)	(0.0212)	(0.00489)	(0.295)	(0.260)	(0.0977)	(0.00114)	(0.00536)	(0.0301)
Transport infrastructure	0.00764*	0.00692	-0.000223	0.0143	0.00501*	0.00119*	0.0756**	0.0610*	0.0146	3.49e-07	0.000425	0.00224
	(0.00458)	(0.00566)	(0.000457)	(0.0102)	(0.00294)	(0.000616)	(0.0378)	(0.0362)	(0.0132)	(6.50e-05)	(0.000603)	(0.00415)
Urban and rural regeneration	-0.0737**	-0.100**	-0.00528**	-0.179**	-0.0168	-0.00301	-0.201	-0.143	-0.0565	-0.000917**	-0.00982***	-0.0504*
	(0.0337)	(0.0509)	(0.00207)	(0.0829)	(0.0110)	(0.00254)	(0.124)	(0.127)	(0.0602)	(0.000360)	(0.00300)	(0.0266)
Other	-0.0547	-0.0693	0.00144	-0.123	0.0121	0.00163	-0.164	-0.241	0.0782	-0.00180***	-0.00496	0.0186
	(0.0911)	(0.113)	(0.00703)	(0.210)	(0.0120)	(0.00277)	(0.196)	(0.183)	(0.0589)	(0.000596)	(0.00444)	(0.0221)
Constant	7.424	10.69	1.150**	19.26	-0.165	3.866***	72.48***	67.37***	4.793	0.316***	2.259***	8.606**
	(7.127)	(11.22)	(0.540)	(18.01)	(1.580)	(1.053)	(24.45)	(24.05)	(4.506)	(0.0873)	(0.812)	(4.244)
Observations	242	242	242	242	242	242	242	242	242	242	242	242
R-squared	0.437	0.452	0.408	0.442	0.662	0.702	0.624	0.563	0.857	0.429	0.621	0.715

Note: Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Source: Authors' elaboration.

Table 6
Bi-directional relationships between cohesion and common agricultural policy.

Cohesion policy		Common agricultural policy
Synergies between:		
Business support	<->	Subsidies on dairying SE616
Social infrastructure	<->	Subsidies on dairying SE616
Transport infrastructure	<->	Subsidies on dairying SE616
Other	<->	Other crops subsidies SE613
Research and technology	<->	Other subsidies SE699
Trade offs between:		
Human resources	<->	Single farm payment SE631
IT infrastructure and services	<->	Compensatory payments/area payments SE611
Social infrastructure	<->	Other subsidies SE699
Urban and rural regeneration	<->	Subsidies on investments SE406
Urban and rural regeneration	<->	Set aside premiums SE612
Urban and rural regeneration	<->	Subsidies other cattle SE617
Other	<->	Additional aid SE640

Source: Authors' elaboration.

important, the importance of measures and other instruments to support the non-agricultural economy in the region can be observed to be growing (Crescenzi and De Filippis, 2016; Camaioni et al., 2013; Gallent et al., 2003).

(i) To what extent do synergies coincide with the most structurally disadvantaged regions?

Results from estimating Eq. (2) are shown in the Appendix. Including an interaction term between policy expenditures and both the structural characteristics index and GDP allows for the identification of policy fund synergies (or trade-offs) that coincide with weaker (or stronger) regions. Estimates show that disadvantaged regions do attract expenditure synergies between Total CAP Pilar 1 and Total Cohesion expenditure. Specifically, these 'pro-cohesion policies' when mixed with CAP Pilar 1 expenditure in aggregate are: IT infrastructure and services, Research and Technology, and Urban and rural regeneration. Similarly, results show that aggregate cohesion expenditure combined with Additional aid (SE640) and Other subsidies (SE699) do provide synergies and are also attracted by weaker regions. Combined, these results provide evidence to support the presence of 'pro-cohesion' policies that provide a cumulative impact and are focussed on structurally disadvantaged regions.

5. Summary and concluding remarks

We analyse the relationship between EU cohesion policy and Common Agricultural Policy Pilar 1 over the 2007-2013 programming period. As conventional wisdom suggests, the empirical evidence confirms that there are implications for the overlap of these policies within the same region. Results identify the policies sub-categories for which a positive association is empirically detected and that work successfully in tandem, and also those that, rather than converging toward regional development goals, are actually acting as substitutes as testified by the negative empirical association. In other words, the policy mechanism is empirically consistent with a setting in which a trade-off arises where one policy is used in place of funding that is absent. The identification of funding categories that provide areas with a synergistic (or conflicting) impact is key to informing the structure of future policy.

Synergies between CAP support for milk production in the EU and cohesion policy funds for infrastructure and business development are identified. On the other hand, there appear trade-offs between outlays on urban and rural regeneration and some subsidies for investments and agricultural production of farms within the CAP. In both cases, the specificity of the region (or its specialisation) correlated to the way the funds are absorbed under both policies.

Such synergies were explored to test if they correlate to the structural characteristics of territories. The analysis detects a positive association indicating that structurally disadvantaged regions seem to attract expenditure synergies between policies. Nonetheless, the extent of the positive spillovers between policies remains an open empirical issue that can provide insights to help shape future policy allocation. The extent to which the reformed CAP will be able to exploit potential synergies with other policy interventions (and avoid conflicts) is likely to be a crucial aspect in shaping the perception and social acceptance of the programme (Kiryluk-Dryjska and Baer-Nawrocka, 2019).

Admittedly, while shedding some light on the big picture of this complex issue, the empirical exercise has limitations mainly due to both (i) the methodological challenges in representing the multidimensional nature of structural characteristics of places and (ii) the underlying structure of data on EU expenditure categories that are unavoidably connected to each other. Nonetheless, we deem our analysis contributes to the extant literature as it provides an innovative interesting standpoint, especially with respect to the use of the novel $\sigma-\mu$ methodology; our findings call for a detailed sector-by-sector analysis specifically addressing the empirical connections as well as the economic mechanisms at work in each sector. This exercise is left as a future research agenda.

Declaration of funding

Dataset and analysis funded as part of a Horizon 2020 project, PERCEIVE: Perception and Evaluation of Regional and Cohesion Policies by Europeans and Identification with the Values of Europe. GA No. 693529. This study was funded also by the European Union - NextGenerationEU, in the framework of the GRINS - Growing Resilient, Incluive and Sustainable project (GRINS PE00000018 - CIP E63C22002120006). The views and opinions expressed are solely those of the authors and do not necessarily reflect those of the European Union, nor can the European Unionn be held responsible for them.

Declaration of interests

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

All authors acknowledge that financial support for the project work reported herein was provided by the European Commission. Further, all authors declare they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

CRediT authorship contribution statement

Pawel Chmieliński: Writing – review & editing, Writing – original draft, Data curation, Conceptualization. **Alan Collins:** Writing – review & editing, Writing – original draft, Supervision, Formal analysis, Data curation, Conceptualization. **Adam Cox:** Writing – review & editing, Writing – original draft, Formal analysis, Data curation, Conceptualization. **Gianpiero Torrisi:** Writing – review & editing, Writing – original draft, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.gcrs.2025.100012.

Appendix

Table Appendix A
Cohesion policy and common agricultural policy.

Variables	(1) Total cohesion policy	(2) Business support	(3) Energy	(4) Environment and natural resources	(5) Human resources	(6) IT infrastructure and services	(7) Research and Technology	(8) Social infrastructure	(9) Technical assistance	(10) Tourism and Culture	(11) Transport infrastructure	(12) Urban and rural regeneration	(13) Other
Structural characteristics index	-560.8***	-74.71***	-29.71**	-115.3***	-2.043	-11.97*	-84.89***	-87.25**	-12.36	-17.62*	-93.55	-32.57**	1.106
	(157.9)	(23.56)	(12.09)	(42.02)	(1.875)	(6.360)	(32.47)	(34.81)	(7.775)	(10.29)	(68.01)	(15.05)	(12.96)
Rural expenditure per capita	0.446	0.108	-0.0130	0.122	-0.00280	-0.133**	-0.146	0.182	-0.223*	0.0266	0.516**	-0.0282	0.0372
	(0.581)	(0.103)	(0.0183)	(0.112)	(0.00309)	(0.0596)	(0.110)	(0.145)	(0.114)	(0.0304)	(0.229)	(0.0299)	(0.0404)
Rural policy expenditure per capita * Structural characteristics index	-0.987	-0.184	0.0513*	-0.0620	0.00253	-0.0559	-0.0232	-0.168	-0.132	0.0498	-0.488	0.106**	-0.0837
	(1.182)	(0.174)	(0.0271)	(0.220)	(0.00638)	(0.0640)	(0.145)	(0.300)	(0.118)	(0.0562)	(0.506)	(0.0470)	(0.0901)
GDP PPS per inhabitant	-0.00266***	-0.000494***	-7.94e-05***	-0.000247**	-1.46e-05	-0.000131**	-0.000632***	-0.000106	-0.000180	-7.12e-05*	-0.000519**	-0.000172***	-1.54e-05
	(0.000745)	(0.000150)	(2.89e-05)	(0.000121)	(9.49e-06)	(6.20e-05)	(0.000168)	(0.000106)	(0.000110)	(3.75e-05)	(0.000230)	(5.50e-05)	(2.17e-05)
Rural expenditure per capita * GDP PPS per inhabitant	1.20e-05	1.39e-06	-4.54e-07	-2.24e-06	-4.56e-08	5.72e-06*	7.08e-06*	-2.58e-06	1.04e-05*	-1.33e-06	-4.79e-06	-1.63e-06*	5.33e-07
	(1.47e-05)	(2.65e-06)	(5.60e-07)	(3.09e-06)	(9.66e-08)	(3.01e-06)	(4.27e-06)	(4.18e-06)	(5.80e-06)	(9.03e-07)	(7.15e-06)	(9.13e-07)	(9.12e-07)
Constant	504.0***	83.42***	22.67**	86.50***	2.569*	14.06***	90.13***	61.32**	17.22**	16.55**	77.13	32.55***	-0.149
	(124.0)	(19.48)	(8.890)	(31.77)	(1.527)	(5.345)	(24.65)	(25.51)	(7.181)	(7.557)	(49.07)	(11.34)	(8.911)
Observations	242	242	242	242	242	242	242	242	242	242	242	242	242
R-squared	0.802	0.696	0.672	0.723	0.244	0.623	0.595	0.705	0.555	0.659	0.645	0.526	0.193

Note: Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Source: Authors' elaboration.

Table Appendix B i
Common agricultural policy and cohesion policy.

Variables	(1) Total rural policy expenditure	(2) Subsidies on investments SE406	(3) Total subsidies - excluding on investments SE605	(4) Total subsidies on crops SE610	(5) Compensatory payments/area payments SE611	(6) Set aside premiums SE612	(7) Other crops subsidies SE613	(8) Total subsidies on livestock SE615	(9) Subsidies dairying SE616	(10) Subsidies other cattle SE617	(11) Subsidies sheep & goats SE618	(12) Other livestock subsidies SE619
Structural characteristics index	-163.8**	-16.20	-147.6**	-3.009	-0.602	-0.0139	-2.094	-33.03**	-4.183	-20.69**	-2.148**	-6.015
	(68.10)	(11.26)	(59.48)	(2.851)	(0.757)	(0.0170)	(3.015)	(15.61)	(5.082)	(10.37)	(0.889)	(5.821)
Cohesion policy expenditure per capita	0.0411	0.00462	0.0364	0.00563**	-0.000612	-2.29e-05*	0.00630**	0.0146	0.0111	0.00228	-0.000527	0.00175
	(0.0371)	(0.00598)	(0.0321)	(0.00258)	(0.000562)	(1.20e-05)	(0.00269)	(0.0146)	(0.00678)	(0.00496)	(0.000328)	(0.00401)
Cohesion policy expenditure per capita * Structural characteristics index	0.00768	0.00143	0.00625	6.77e-05	-2.72e-05	-4.35e-07	9.96e-05	0.00155	-7.02e-05	1.19e-05	4.53e-06	0.00161
	(0.00571)	(0.00107)	(0.00466)	(0.000121)	(1.97e-05)	(3.71e-07)	(0.000120)	(0.00140)	(0.000202)	(0.000141)	(1.17e-05)	(0.00123)
GDP PPS per inhabitant	-0.00124**	3.58e-05	-0.00127**	-1.17e-05	-4.52e-06**	-4.14e-08	-6.35e-06	5.32e-05	1.16e-05	-1.22e-05	-2.01e-06	5.57e-05
	(0.000569)	(5.01e-05)	(0.000546)	(1.06e-05)	(1.85e-06)	(2.85e-08)	(1.04e-05)	(7.17e-05)	(2.37e-05)	(2.05e-05)	(1.55e-06)	(5.71e-05)
Cohesion expenditure per capita * GDP PPS per inhabitant	-4.28e-08	-7.06e-09	-3.58e-08	-3.86e-10	1.79e-10	0	-6.22e-10	-1.14e-08	-2.17e-09	-1.45e-09	-2.42e-10*	-7.59e-09
	(3.43e-08)	(6.06e-09)	(2.87e-08)	(1.04e-09)	(1.62e-10)	(0)	(1.03e-09)	(9.80e-09)	(3.84e-09)	(1.89e-09)	(1.24e-10)	(6.71e-09)
Constant	198.7***	13.76*	185.0***	2.847	0.590	0.0119	1.977	27.60**	1.910	22.11***	1.536**	2.046
	(51.99)	(8.048)	(45.98)	(2.100)	(0.546)	(0.0122)	(2.199)	(11.99)	(3.957)	(8.197)	(0.659)	(3.823)
Observations	242	242	242	242	242	242	242	242	242	242	242	242
R-squared	0.575	0.557	0.575	0.459	0.480	0.353	0.378	0.350	0.494	0.319	0.391	0.367

Note: Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Source: Authors' elaboration.

Table Appendix B ii
Common agricultural policy and cohesion policy.

Variables	(13) Environmental subsidies SE621	(14) LFA subsidies SE622	(15) Other rural development payments SE623	(16) Total support for rural development SE624	(17) Subsidies on intermediate consumption SE625	(18) Subsidies on external factors SE626	(19) Decoupled payments SE630	(20) Single Farm payment SE631	(21) Single Area payment SE632	(22) Additional aid SE640	(23) Support Art68 SE650	(24) Other subsidies SE699
Structural characteristics index	-14.85**	-27.17**	-1.307**	-43.33**	0.404	0.136	-57.26**	-46.41*	-10.51	-0.336***	-2.887***	-11.48**
	(7.069)	(13.49)	(0.610)	(19.94)	(1.718)	(0.638)	(28.47)	(27.28)	(7.494)	(0.107)	(0.997)	(5.768)
Cohesion policy expenditure per capita	0.00593	0.00340	0.000661	0.01000	0.00191	0.000431	0.00507	0.00650	-0.00136	-7.49e-05*	-0.000787**	-0.00119
	(0.00576)	(0.00729)	(0.000619)	(0.0135)	(0.00122)	(0.000292)	(0.0165)	(0.0162)	(0.00342)	(3.91e-05)	(0.000337)	(0.00162)
Cohesion policy expenditure per capita * Structural characteristics index	0.00160	0.00195	0.000127*	0.00368	-2.27e-05	-8.52e-06	0.000749	0.000681	5.83e-05	1.03e-05	1.47e-05	0.000236**
	(0.00117)	(0.00146)	(7.51e-05)	(0.00270)	(2.76e-05)	(8.72e-06)	(0.000713)	(0.000693)	(8.57e-05)	(6.52e-06)	(1.98e-05)	(0.000110)
GDP PPS per inhabitant	-5.93e-05	8.44e-06	2.41e-06	-4.85e-05	-6.78e-05**	-2.07e-05**	-0.00115***	-0.00109***	-5.98e-05	-6.36e-07*	-4.71e-06	-2.64e-05*
	(6.70e-05)	(7.07e-05)	(3.56e-06)	(0.000138)	(3.06e-05)	(8.58e-06)	(0.000410)	(0.000398)	(4.88e-05)	(3.56e-07)	(3.00e-06)	(1.43e-05)
Cohesion expenditure per capita * GDP PPS per inhabitant	-7.39e-09	-1.00e-08	-6.63e-10	-1.81e-08	2.89e-10	9.04e-11	-4.39e-09	-2.13e-09	-2.20e-09	-6.24e-11*	-7.88e-11	-1.85e-09**
	(6.71e-09)	(8.60e-09)	(4.74e-10)	(1.57e-08)	(3.25e-10)	(1.04e-10)	(5.64e-09)	(5.55e-09)	(2.41e-09)	(0)	(2.47e-10)	(7.35e-10)
Constant	14.82***	18.79*	1.368***	34.98**	1.635	4.224***	103.1***	93.79***	8.930	0.347***	2.297***	10.60**
	(5.113)	(9.667)	(0.485)	(14.32)	(1.312)	(1.022)	(23.22)	(22.29)	(6.094)	(0.0850)	(0.755)	(4.169)
Observations	242	242	242	242	242	242	242	242	242	242	242	242
R-squared	0.553	0.542	0.529	0.550	0.575	0.655	0.536	0.468	0.802	0.470	0.583	0.664

Note: Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Source: Authors' elaboration.

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