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Inmaculada C. Alvarez, Javier Barbero, Luis Orea, Andrés Rodríguez-Pose

Departamento de Economía

Universidad de Oviedo

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Inmaculada C. Alvarez
Universidad Autónoma de Madrid and Oviedo Efficiency Group

Javier Barbero
Universidad Autónoma de Madrid and Oviedo Efficiency Group

Luis Orea
Universidad de Oviedo and Oviedo Efficiency Group

Andrés Rodríguez-Pose
London School of Economics and Political Science

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Abstract

In this paper, we examine the impact of institutional quality on the returns of key drivers of economic growth in 230 European Union (EU) NUTS-2 regions from 2009 to 2017. To estimate region-specific elasticities, we employ a latent class modelling approach, considering the quality of government and the degree of authority in each region as mediators. Our findings reveal significant variation in the returns to education, physical capital investment, and innovation across regions. Moreover, we observe that changes in government quality and regional authority influence the ability of EU regions to leverage different types of investment effectively. These results emphasize the importance of considering the government quality in regions where investments are made in order to maximize the returns on European Cohesion investment.

Keywords: Institutional quality, European funds, public investment, regional development

JEL Codes: O43, E61, H54, R11

1. Introduction

There has been a considerable amount of research dedicated to explaining the disparities in growth among countries and regions. Standard economic growth models suggest that production is influenced by various inputs (Solow, 1957). Over time, the dominant neoclassical growth model has been expanded to consider additional factors such as technology and human capital as determinants of economic growth (Barro, 1991; Mankiw et al., 1992; Islam, 1995). However, there is still no consensus on which variables are the driving forces behind growth (Temple, 1999).

This lack of consensus has led to the emergence of alternative theories, ranging from endogenous growth theory to new economic geography. Since North's (1990) seminal work, the role of institutions in economic development has been a subject of debate. Theoretical perspectives frequently associate institutional quality with economic development (Rodrik et al., 2004). On one hand, institutional quality is believed to enhance the business environment (Acemoglu et al., 2005). On the other hand, institutional improvements can also result from economic growth (Barro, 1999). Empirical research has arrived at similar conclusions. Glaeser et al. (2004), for instance, emphasize the importance of not only addressing measurement issues related to institutional quality but also employing appropriate econometric techniques to examine the role of institutions using country-level data. Other studies advocate for adopting a regional perspective to gain a better understanding of how institutional quality shapes economic development (Rodríguez-Pose, 2013; Rodríguez-Pose and Ganau, 2022).

Despite the increasing interest in the relationship between government quality and regional performance, there is limited evidence on how variations in the former influence the latter in European regions. Traditional growth empirics have primarily focused on examining average patterns, often at the country level (Temple, 1999). However, when growth patterns diverge among regions, the validity of country-wide policy recommendations becomes questionable, as average parameters fail to capture the true drivers of growth in each specific location (Brock and Durlauf, 2001). To address this gap, several methodologies have been proposed to account for parameter heterogeneity. For example, Durlauf and Johnson (1995) employed regression tree analysis to identify threshold values for specific economic variables. Other studies have expanded upon this method by exploring different threshold variables (e.g., Papageorgiou, 2002). Quantile regression approaches have also been utilized to examine the effects of democracy, corruption, and economic freedom on economic outcomes (Li and Kumbhakar, 2022). More recently, researchers have turned to the use of latent class models (Paap et al., 2005, Davis et al., 2007), extending their application by incorporating stochastic frontier production functions with a latent class structure (Greene, 2002; Orea and Kumbhakar, 2004). Battisti and Parmeter (2013) utilized a (multivariate) mixture analysis to identify country cluster groups and the dynamic transitions between regimes.

However, the analysis of institutional quality and its impact on regional economic growth has predominantly focused on the country level, with only a limited number of studies exploring this topic at the subnational level. These studies indicate that government quality not only directly influences economic growth but also indirectly affects it through its impact on the efficiency of various types of public investment (Rodríguez-Pose and Garcilazo, 2015, Barbero et al., 2022). Institutional quality has a significant effect on economic performance, particularly in less developed or declining regions, which can shape the returns on physical and human capital as well as innovation in regional economic development (Rodríguez-Pose and Ketterer, 2020, Rodríguez-Pose and Ganau, 2022). Additionally, many less developed regions face challenges in terms of smart specialization, a key instrument of EU cohesion policy reforms (McCann and Ortega-Argiles, 2015).

In this paper, we aim to fill this research gap by conducting a comprehensive analysis of the impact of institutions on economic development in European regions. We employ an empirical specification based on the Neoclassical growth model that incorporates the dimension of inequality (Barro and Sala-i-Martín, 1992). Our study contributes to a better understanding of subnational economic growth by identifying EU regions where education, investment in physical capital, and innovation play a crucial role. Through our empirical approach, we identify regions with particularly high or low returns on these factors, thus identifying potential candidates for public and private investment. Given the significant public funding allocated to physical capital investment, education, and innovation in Europe, our analysis can assist policymakers in improving the allocation of public investment and maximizing the benefits of Cohesion investment. To achieve this objective, we propose estimating a latent-class economic growth model to derive region-specific coefficients for the aforementioned drivers of economic growth (Greene, 2005; Orea et al., 2015).

We anticipate substantial variation in the effects of different types of investment on regional development across regions for several reasons. The diversity of economic ecosystems and institutional settings across regions will determine the returns on investment (Jackson, 2011). Although existing literature has primarily focused on institutional quality (Charron et al., 2021; Rodríguez-Pose and Ganau, 2022), further research is needed to gain a better understanding of these heterogeneous effects (Bachtrögler et al., 2020). Studies on the absorption capacity of European funds suggest that the institutional framework and fiscal decentralization play a crucial role in explaining disparities between less developed and more developed regions in Europe (Kersan-Škabić and Tijanić, 2017). Hence, we aim to demonstrate how regional variations in institutional conditions and absorption capacity influence the economic growth trajectories of European regions.

Following Greene (2005), we calculate region-specific coefficients by utilizing the estimated probabilities of class membership and coefficients for each class. This approach enhances our understanding of different investment patterns in the traditional drivers of economic growth. Additionally, we incorporate covariates into the model to examine whether the classification of European regions into classes depends on the quality of their institutions and the degree of their authority, aligning with Liu et al. (2020).

Our analysis builds upon the approach of Orea and Kumbhakar (2004) and Liu et al. (2020) but extends it by introducing a non-linear relationship between region-specific coefficients and the quality of regional institutions and degree of authority. We conduct various counterfactual analyses to explore the marginal effects on the returns of education, investment in physical capital, and innovation resulting from marginal improvements in the quality of regional institutions or changes in the degree of regional authority.[1]

In this study, we extend previous research by examining not only the average effect of changes in the institutional environment on economic growth but also the potential convergence in parameters. We investigate how different investment patterns

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[1] As "marginal" we mean a variation of one standard deviation in our variables measuring quality of institutions and regional authority.

and heterogeneous parameters for the traditional drivers of economic growth are conditioned by institutional quality and regional authority levels. Moreover, we explore potential catching-up effects associated with changes in the institutional environment. To further analyse the effect of European Funds on regional development, we employ auxiliary regressions to instrument endogenous variables in the economic growth equation, particularly in relation to investment in physical and human capital and innovation. Our analysis sheds light on how less developed regions in the EU can narrow the gap with their more developed counterparts. In essence, we examine both average and catching-up effects in the returns (elasticities) of the traditional drivers of economic growth when considering changes in the institutional environment.

The structure of the paper is as follows. Section 2 provides a concise overview of the institutions present in European countries and emphasizes their role in explaining disparities in economic performance. In Section 3, we introduce the econometric approach, specifically the latent class approach, and outline the methodology used to estimate the marginal effects of institutional factors. Section 4describes the data sources utilized in our analysis. In Section 5, we focus on the role of institutions in regional development, presenting our empirical application to European regions. Finally, in Section 6, we present the main findings of the study and offer policy recommendations based on our results.

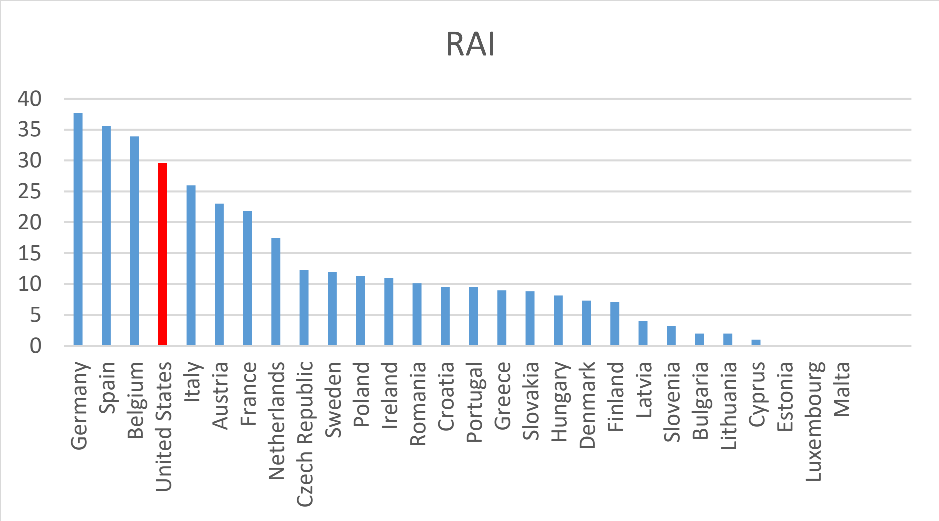
2. Institutions and government quality in Europe

Local and regional governments play a crucial role in shaping the economic performance of territories (Rodríguez-Pose, 2013). The quality of regional governments directly impacts the outcomes of public investments and the ability to effectively utilize European Funds, thereby influencing economic growth (Rodríguez-Pose and Garcilazo, 2015). Consequently, variations in government quality, decentralization levels, and governance practices across regions have significant implications for their development potential (Muringani et al., 2019).

These parameters have undergone changes in recent years. Between 1950 and 2007, 21 out of 27 EU member states have considerably decentralized political power (Shair-Rosenfield et al., 2020). More recently, central governments in Belgium and Italy have renegotiated decentralization agreements with their regions, while the Norwegian government announced a reform of its regional decentralization system in September 2018. Certain European regions, such as Scotland and Catalonia, have gone beyond seeking greater devolved powers and have organized legal and illegal independence referenda.

European policy agendas presuppose that regions have the necessary authority to implement policies, and that decentralization and financial capacity play a positive role in utilizing European funds effectively (Van Wolleghem, 2019). However, decentralization levels vary significantly across countries and even within countries. The Regional Authority Index (RAI) (Hooghe et al., 2016; Shair-Rosenfield et al., 2020) serves as the most widely used measure of regional authority in terms of self-rule and shared rule by regional governments. It covers the period from 1950 to 2018. The RAI is a composite measure that encompasses various variables or dimensions of regional authority. Five dimensions assess the extent of self-rule (institutional depth, policy scope, fiscal autonomy, borrowing autonomy, and representation), while the other five dimensions capture the degree of shared rule (law making, executive control, fiscal control, borrowing control, and constitutional reform). There are substantial variations in regional autonomy across European countries (see Figure 1). Regions in Germany, Spain, and Belgium enjoy the highest level of autonomy in Europe, surpassing the powers held by states in the United States (used as a point of comparison). In contrast, regions in Estonia, Luxembourg, and Malta have no powers in terms of regional autonomy.

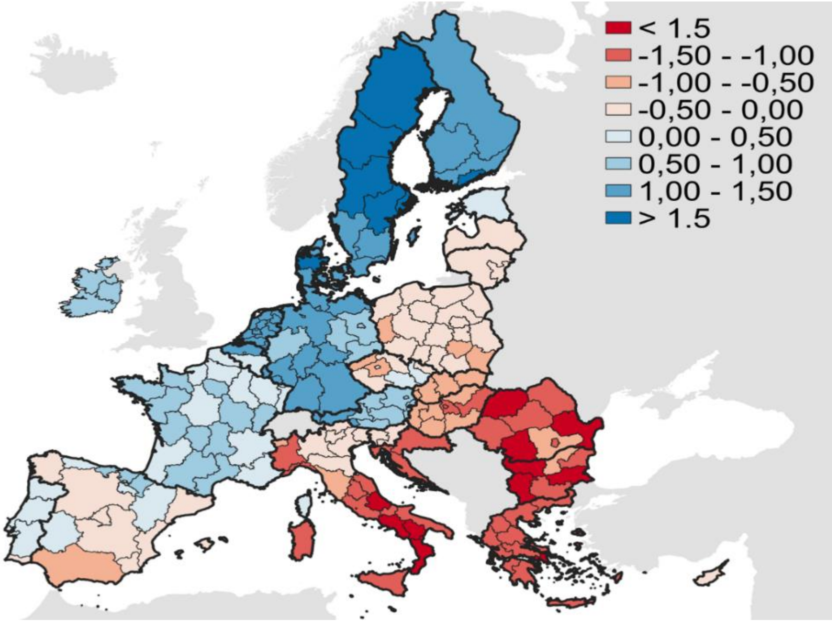
Figure 1: Regional Authority Index in European countries in 2018



Source: own elaboration from Hooghe et al., 2016; Shair-Rosenfield et al., 2020

The quality of subnational governments within the EU also exhibits significant variation. The European Quality of Government Index (QI) (Charron et al., 2021) is the most commonly used indicator to assess government quality. It is derived from a survey conducted in all 208 NUTS 1 and NUTS 2 regions of the EU 27 member states, with over 129,000 respondents in the latest wave. The survey gauges citizens' perceptions and experiences regarding public sector corruption, as well as their opinions on the efficiency, impartiality, and quality of public sector services.

Figure 2: European Quality of Government in 2017



Source: Charron et al., (2021). EuroGeographics for the administrative boundaries.

Figure 2 provides an overview of the quality of government across European regions in 2017. The distribution of government quality in Europe is closely linked to the levels of socio-economic development and social trust within EU regions (Charron et al., 2014). The highest levels of subnational government quality are observed in the Nordic countries and certain central regions. Conversely, government quality is relatively low in regions situated in the southeastern part of Europe. However, internal disparities are evident in various countries, including those with lower subnational government quality such as Italy, Bulgaria, Romania, as well as countries ranking higher in terms of government quality, such as Spain.

Differences in decentralization have both positive and negative impacts on government quality (Treisman, 2002). Likewise, variations in government quality can influence the effectiveness of decentralization processes (Charron et al., 2010, 2014). This reciprocal relationship signifies that subnational authority and regional government quality are interconnected and, in turn, have implications for economic growth as they shape the efficacy of public expenditure and the capacity to utilize European funds.

3. Methodology

This section presents the econometric specification employed to examine the relationship between government quality, decentralization, and economic growth, both directly and indirectly. To explore this connection, we adopt a latent class economic growth (LCEG) model.[2] The process begins with the introduction of a basic economic growth model that considers the influence of physical and human capital, innovation,

[2] The econometric specification of the auxiliary regressions used to instrument our endogenous variables is shown in Appendix B.

institutional quality, and regional growth. Subsequently, we incorporate this model into a latent class framework and demonstrate how the LCEG model allows for the estimation of region-specific coefficients. Finally, we outline our approach for conducting counterfactual analyses.

3.1. Basic economic growth model

The empirical specification for regional economic growth is based on the well-established model proposed by Mankiw et al. (1992), which incorporates physical investment and human capital. In this framework, the economy is characterized by a Cobb-Douglas production function for N regions along T periods with constant returns to scale as follows:

$$Y_{it} = A_{it} K_{it}^{\alpha_K} H_{it}^{\alpha_H} L_{it}^{1-\alpha_K-\alpha_H} \qquad (1)$$

where Y_{it} is the production of the i[th] region in period t, K_{it} is physical capital, H_{it} represents human capital and L_{it} is the employment level. The parameter A_{it} is the region's total factor productivity level, which varies over time due to technological progress. The production function satisfies the neoclassical properties, and we assume $\alpha_K > 0$ and $\alpha_H > 0$, allowing the convergence equation to be solved.

The neoclassical growth model introduced by Mankiw et al. (1992) assumes that L_{it} grows at rate n_{it}, while K_{it} depreciates at a constant rate δ, and A_{it} grows exogenously at a constant rate g. Using the partial-adjustment specification introduced by Mankiw et al. (1992) and yearly rates of growth as in Islam (1995), we obtain the following convergence equation in per worker terms:

$$\Delta lny_{it} = \beta_0 - \beta_1 lny_{it-1} + \beta_2 lns_{it}^K + \beta_3 lns_{it}^H - \beta_4 \ln(n_{it} + g + \delta) \qquad (2)$$

where $\Delta lny_{it} = lny_{it} - lny_{it-1}$, s_{it}^K and s_{it}^H are, respectively, investment in physical capital and educational levels, the latter as a proxy for human capital; λ represents the speed of convergence; and the ß parameters are functions of the original parameters of the model.[3] The use of this model allows us to contrast the existence of the convergence between regions after controlling for the determinants of the steady state, named "conditional convergence".

Additionally, and following Jones (1995), we assume that the technology parameter A_{it} depends on the regions' innovation effort, which implies estimating equation (2) once it has been extended by adding R&D investment (s_{it}^{RD}) as an additional driver of regional economic growth, and our proxy for innovation. This specification can be viewed as a semi-endogenous economic growth model, as it aims to mimic the endogenous model introduced by Romer (1990).[4] Consequently, all our empirical analyses are performed based on the following baseline specification:

$$\Delta lny_{it} = \beta_0 - \beta_1 lny_{it-1} + \beta_2 lns_{it}^K + \beta_3 lns_{it}^H - \beta_4 \ln(n_{it} + g + \delta) + \beta_5 lns_{it}^{RD} + \eta_i + v_{it} \qquad (3)$$

[3] In particular, $\beta_0 = \frac{\beta_1 lnA_0}{1-\alpha}\beta_1 = 1 - e^{-\lambda}$, $\beta_2 = \frac{\beta_1 \alpha_K}{1-\alpha}$, $\beta_3 = \frac{\beta_1 \alpha_H}{1-\alpha}$, $\beta_4 = \frac{\beta_1 \alpha}{1-\alpha}$, and $\alpha = \alpha_K + \alpha_H$.

[4] Rodriguez-Pose and Ganau (2022) propose a similar specification, but they also assume that A_{it} is a function of the quality of regional institutions.

where we have also added a term (η_i) capturing time-invariant unobserved region-specific effects and a traditional disturbance term (v_{it}), which is assumed to be identically and independently distributed.

Finally, some of the determinants of regional economic growth can be considered endogenous (Caselli et al., 1996). Therefore, it is necessary to re-estimate the model with instrumental variables (Wooldridge, 2002). Consistent estimates can be obtained by estimating our (linear) economic growth model augmented with the residuals from a set of auxiliary regressions, in which the endogenous variables are regressed with respect to exogenous variables that meet the characteristics of a valid instrument (see, e.g., Amsler et al., 2016).[5] Testing whether the coefficients of these residuals are statistically significant is equivalent to performing Hausman tests of endogeneity.

3.2. LCEG Model

All slope parameters in equation (3) are common to all regions and time-invariant. As this assumption has not only been questioned in several studies but may also jeopardize the effectiveness of the policy measures aimed at stimulating the economic growth of each region, in this subsection we embed the basic economic growth model described above into a latent class structure with the aim of capturing *unobserved* differences in the returns (elasticities) of traditional economic growth drivers.

Latent class models (LCM) —also called finite mixture models— have been used in several research fields to control, using econometrics, for the existence of heterogenous observations in our sample.[6] A conventional LCM model assumes a finite number of classes (groups) and allocates each observation in the sample probabilistically to a particular class. In our application, a specific economic growth function is estimated for each class.

The issue is that the presence of one economic growth model or another is not directly observed by the researcher, and, at most, only partial environmental indicators are available. The allocation of regions to a particular class relies on the estimated class membership probabilities that reflect the uncertainty researchers may have about the true partition of the sample.

Conditional on class $j = (1, \ldots J)$, the traditional economic growth model can be re-written as follows:

$$Y_{it} = \beta_j X_{it} + \eta_{i|j} + v_{it|j} \tag{4}$$

where $Y_{it} = \Delta lny_{it}$, X_{it} is a M vector of economic growth drivers; β_j is a M vector of class-specific slope parameters; $\eta_{i|j}$ is a region-specific fixed effect; and $v_{it|j}$ is a noise term that follows a zero-mean normal distribution with constant standard error (σ_{vj}).[7]

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[5] The auxiliary regression (reduced form) models for the endogenous regressors of the economic growth model in equation (3) can be written as $x_{it} = g(Z_{it}, \alpha) + \varepsilon_{it}$, where x_{it} is an economic growth driver, and Z_{it} is a set of instrumental variables. In particular, we consider investment, innovation, and human capital as endogenous variables.

[6] See Orea and Kumbhakar (2004), Greene (2005), Bos et al. (2010), and Orea et al. (2015) for some applications of these models.

[7] In our basic economic growth model $X_{it} = (1, lny_{it-1}, lns_{it}^{K}, lns_{it}^{H}, \ln(n_{it} + g + \delta), lns_{it}^{RD})$. However, as we consider investment, innovation, and education as endogenous variables, our final specification is $Y_{it} =$

Given the set of N fixed-effects that should be estimated, the naive way to estimate the whole set of parameters within a latent class structure consists simply in maximizing the likelihood function of a weighted sum of J class-specific likelihood functions over $J(M+N+1)$.[8] The large dimension of N in our application, renders such a direct estimation impossible. Hence, finding a way to optimize only over the $J(M+1)$ class-specific parameters would greatly simplify the problem.

We introduce here a method which achieves this objective based on a within-transformation of the model. If we use a within-transformation of equation (4), we obtain a model specification as follows:

$$Y_{it}^{*} = \beta_j X_{it}^{*} + v_{it|j}^{*} \tag{5}$$

where $Y_{it}^{*} = Y_{it} - \sum_{t=1}^{T} Y_{it}/T$, $X_{it}^{*} = X_{it} - \sum_{t=1}^{T} X_{it}/T$, and $v_{it|j}^{*} = v_{it|j} - \sum_{t=1}^{T} v_{it|j}/T$. Please note that the fixed effects in equation (4) vanish if we carry out a within-transformation of the model. Using this empirical strategy, we only need to maximize over the $M+1$ parameters of each class, that is, $\beta_j = (\beta_j^1, \dots, \beta_j^M)$ and σ_{vj}.

Encompassing in $\theta_j = (\beta_j, \sigma_{vj})$ all the parameters associated with class j, the conditional likelihood function of an observation belonging to class j can be denoted by $LF_{it|j}(\theta_j)$. The unconditional likelihood is then obtained as the weighted sum of the J class-specific likelihood functions, where the weights are the so-called prior class membership probabilities. That is:

$$LF_{it}(\theta, \delta) = \sum_{j=1}^{J} LF_{ijt}(\theta_j) \cdot \Pi_{ijt}(\delta_j' q_{it}) \tag{6}$$

where $\theta = (\theta_1, \dots, \theta_J)$, $\delta = (\delta_1, \dots, \delta_J)$, $0 \leq \Pi_{ijt} \leq 1$, $\sum_{j=1}^{J} \Pi_{ijt} = 1$, and δ_j is a vector of parameters to be estimated. Following Greene (2005), the prior class membership probabilities (Π_{ijt}) are modelled as a function of a set of region-specific variables (q_{it}) that are likely to condition the class classification of European regions.[9] As Π_{ijt} should be in between 0 and 1, Greene (2005) proposes using a multinomial logit model to parametrize the prior class membership probabilities:

$$\Pi_{ijt}(\delta_j' q_{it}) = \frac{exp(\delta_j' q_{it})}{1+\sum_{j=1}^{J-1} exp(\delta_j' q_{it})}\ , \quad j = 1, \dots, J-1 \tag{7}$$

where the last probability is obtained residually, considering that the sum of all probabilities should be equal to one.

The overall likelihood function resulting from (6) and (7) is a continuous function of the vectors of parameters θ and δ, and can be written as:

$$ln\, LF\,(\theta, \delta) = \sum_{i=1}^{N} \sum_{t=1}^{T} ln\, LF_{it}\,(\theta, \delta) = \sum_{i=1}^{N} \sum_{t=1}^{T} ln\{\sum_{j=1}^{J} LF_{it|j}(\theta_j) \Pi_{ij}(\delta_j' q_{it})\} \tag{8}$$

$\beta_j X_{it} + \xi \hat{\varepsilon}_{it} + \eta_{i|j} + v_{it|j}$, where $\hat{\varepsilon}_{it}$ is a vector of reduced-form residuals. In this case, the number of regressors $M = 9$.

[8] We should also add the parameters of the so-called prior class membership probabilities.

[9] In our application, q_{it} includes the quality of government (QI_{it}), the regional authority index (RAI_{it}), and the dummy variable identifying less developed regions ($less\ developed_i$). This allows examining whether the class classification of the European regions depends on the quality of their institutions and their degree of authority.

Maximizing the above likelihood function gives consistent estimates of the vectors of parameters θ and δ.[10] The estimated coefficients can be then used to compute the posterior class membership probabilities using the following expression:

$$P(j|it) = \frac{\Pi_{ij}\left(\delta_j' q_{it}\right) \cdot LF_{it}(\theta_j, \delta_j)}{\sum_{j=1}^{J} \Pi_{ij}\left(\delta_j' q_{it}\right) \cdot LF_{it}(\theta_j, \delta_j)} \tag{9}$$

The computed posterior probabilities can be used to allocate each region to a particular class or, alternatively, to compute region-specific coefficients (elasticities) as shown in the next subsection. As mentioned in the introduction, the estimated parameter heterogeneity allows us to unveil the existence of different investment patterns in the traditional drivers of economic growth.

3.3. Region specific parameters

As Greene (2002) and Orea and Kumbhakar (2004) have shown the LCM can be viewed as a discrete version of the random parameters model. Following Greene (2005), we estimate the region-specific parameters using the posterior class membership probabilities and the estimated class-specific parameters as follows:

$$\hat{\beta}_{it}(q_{it}) = \sum_{j=1}^{J} P(j|it)\hat{\beta}_j = \sum_{j=1}^{J} \frac{\Pi_{ij}\left(\hat{\delta}_j' q_{it}\right) \cdot LF_{it}(\hat{\theta}_j, \hat{\delta}_j)}{\sum_{j=1}^{J} \Pi_{ij}\left(\hat{\delta}_j' q_{it}\right) \cdot LF_{it}(\hat{\theta}_j, \hat{\delta}_j)} \hat{\beta}_j \tag{10}$$

Although the set of j-class parameters ($\hat{\beta}_j$) in equation (10) are common to all observations, each region has its own coefficient ($\hat{\beta}_{it}$) because they have different posterior class-membership probabilities. Notice that the posterior probabilities depend not only on the relative goodness-of-fit of each class when explaining the economic growth of each region, but also on the estimated prior probabilities, which in turn depend on a set of class-membership determinants (q_{it}).

Given that the quality of government (QI_{it}) and the regional authority index (RAI_{it}) are included in q_{it}, these variables determine the posterior class-membership probabilities, as long as the vector of parameters δ_j is statistically significant. This implies that the institutional factors QI_{it} and RAI_{it} are also determinants of the parameter heterogeneity found across regions. Therefore, as changes in institutional factors can modify the returns of both education and investments in physical capital and innovation, regional (and national) governments could enhance regional development through a better institutional environment.

3.4. Marginal effects

The analyses in previous subsections are standard. They follow research by Orea and Kumbhakar (2004), Greene (2005), and Liu et al. (2020). In this subsection we extend

[10] LF (θ, δ) is the correct likelihood function if the noise term is independently distributed over time. This assumption is not satisfied once we use a within-transformation of equation (4). Álvarez et al. (2006) indicate that maximum likelihood estimates based on the assumption of independent observations are consistent even if the observations are not independent, so long as the (marginal) distribution is correctly specified. However, the estimated variances of the estimated parameters, calculated under the assumption of independence, will not be correct if independence does not hold. Efficient estimates can be obtained if we build overall likelihood function using the joint distribution of $v_{i|j}^* = (v_{i1|j}^*, \ldots, v_{iT|j}^*)$.

the above analyses to compute *marginal* effects attributable to *marginal* changes in the institutional environment.

With this in mind, we propose undertaking several counterfactual analyses where new values for $\hat{\beta}_{it}$ are simulated once a standard deviation improvement in those variables that measure the quality of institutions and regional authority is generated.[11] That is, the institutional factors for each region take on the value of $QI_{it} + \sigma_{QI}$ and $RAI_{it} + \sigma_{RAI}$, where σ_{QI} and σ_{RAI} are respectively the standard deviations of QI_{it} and RAI_{it}.[12] We next see how these 'shocks' affect the returns of investments in physical capital, education, and innovation, ceteris paribus, with the relative goodness-of-fit of each class explaining the economic growth of each region. That is, the new values for $\hat{\beta}_{it}$ are simulated as follows:

$$\hat{\beta}_{it}(q_{it} + \sigma) = \sum_{j=1}^{J} \frac{\Pi_{ij}\left[\hat{\delta}'_j(q_{it}+\sigma)\right] \cdot LF_{it}(\hat{\theta}_j, \hat{\delta}_j)}{\sum_{j=1}^{J} \Pi_{ij}\left[\hat{\delta}'_j(q_{it}+\sigma)\right] \cdot LF_{it}(\hat{\theta}_j, \hat{\delta}_j)} \hat{\beta}_j \tag{11}$$

where $\sigma = \sigma_{QI}$ if $q_{it} = QI_{it}$, and $\sigma = \sigma_{RAI}$ if $q_{it} = RAI_{it}$. The impact on the returns (elasticities) of each economic growth driver can be evaluated by visually comparing the distributions of both $\hat{\beta}_{it}(q_{it})$ and $\hat{\beta}_{it}(q_{it} + \sigma)$, or by testing whether both distributions are equivalent using a Kolmogorov-Smirnov test.

In order to examine whether there is a catching-up effect in the elasticities of each economic growth driver when the institutional environment changes, we propose estimating the following *beta-convergence* auxiliary regression:

$$\Delta\hat{\beta}_{it} = a_0 + a_1\hat{\beta}^*_{it} + \varsigma_{it} \tag{12}$$

where $\Delta\hat{\beta}_{it} = \hat{\beta}_{it}(q_{it} + \sigma) - \hat{\beta}_{it}(q_{it})$, and $\hat{\beta}_{it} = \hat{\beta}_{it}(q_{it})$. The estimated a_1 coefficient in equation (12) can be interpreted as a traditional beta-convergence parameter or a *catching-up effect*. If a_1 takes negative values, this means that 'beta-poor' regions (i.e., regions with modest original elasticities) would exhibit a larger improvement in terms of returns of traditional economic growth drivers than 'beta-rich' regions that already have larger returns from education or investments in physical capital and innovation. If a_1 takes positive values, we conclude that an increase in the institutional environment has increased the difference between 'beta-poor' regions and 'beta-rich' regions.

In summary, while the Kolmogorov-Smirnov tests allow us to measure the *average effect* of a change in the institutional environment, the beta-convergence auxiliary regressions in equation (12) investigate if there is also a *catching-up* effect in the returns (elasticities) of traditional drivers of economic development when the institutional environment changes.

4. Data

The empirical analysis of the econometric approach described above is conducted using a sample of 230 EU NUTS-2 regions spanning the period 2009-2017. Data on regional gross domestic product (GDP) in constant prices is obtained from the Annual

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[11] The approach we take is similar to that of Fuller and Sickles (2023), who focus their simulation exercise on the error term that is assumed to be spatially correlated across geographical units.

[12] Both σ_{QI} and σ_{RAI} are approximately equal to one as both variables were originally standardized when they were computed.

Regional Database of the European Commission's Directorate General for Regional and Urban Policy (ARDECO). Information on gross fixed capital formation (GFCF), which serves as a proxy for physical capital, population, human capital (measured as the percentage of the population aged 25 to 64 with tertiary education), and gross domestic expenditure on R&D (GERD), representing innovation, is sourced from Eurostat.

The quality of regional institutions is assessed using the European Quality of Government Index (Charron et al., 2021), which provides data on institutional quality (QI) for the years 2010, 2013, 2017, and 2021. Following the approach of Rodríguez-Pose and Ketterer (2020), we interpolate the data for the intervening years, and for the period before 2010, we assume that the difference between regional and national quality of government remains constant. Descriptive statistics for the variables are presented in Table 1.

Table 1: Descriptive Statistics

Variable	Mean	Std. dev.	Min	Max
Growth of real GDP per capita (%)	0.636	3.521	-16.106	14.565
Real GDP per capita (€)	26,044.213	14,047.786	3,755.248	98,748.211
Population growth (%)	0.118	0.881	-11.046	5.635
Investment (Million €)	9,894.758	11,779.106	234.260	142,594.797
R&D (€ per capita)	499.307	584.546	3.905	3,884.269
Education (%)	25.969	8.829	8.300	57.100
European Funds (% of GDP)	1.087	1.537	0.001	10.545
Quality of Government	0.086	0.998	-2.796	2.818
Regional Authority Index	14.933	9.205	0.000	27.000
Less developed	0.202	0.402	0.000	1.000

Note: Descriptive statistics based on a sample of 1.813 observations for 230 regions.

In Appendix A, Table A.1 presents the descriptive statistics disaggregated between less developed and more developed regions. Significant disparities are observed in terms of economic growth, investment, and institutional factors. As expected, more developed regions exhibit higher levels of economic growth and investment in physical capital, R&D, and education. These regions also tend to have higher government quality and subnational authority. Conversely, less developed regions experience slower population growth, but they receive a larger proportion of European funds as a percentage of GDP in an effort to address this situation. However, the observed differences in institutional factors may pose challenges to achieving the objectives of European Funds in terms of territorial cohesion. This motivates our research, where we undertake a comprehensive analysis of how variations in institutional factors, specifically government quality and subnational authority, can contribute to further regional polarization in terms of the returns on different public investments and, consequently, the effectiveness of European investment.

5. Results

5.1. Basic economic growth models

In this subsection, we present the parameter estimates of equation (3) and discuss the role of each traditional driver in the economic growth of our EU regions. Equation (3) does not include variables capturing the institutional regional environment, as we include the institutional factors —QI_{it} and RAI_{it}— as additional regressors in an extension of equation (3). We follow previous studies that examine the role of institutions in regional development (see, for example, Crescenzi et al., 2016 and Rodríguez-Pose and Ganau, 2022).

The estimated coefficients are presented in Table 2. Column (I) shows the estimation of the basic economic growth model in equation (3). Columns (II) and (III) present the augmented version of equation (3) with QI_{it} and RAI_{it}t, respectively, and their interactions with the growth drivers. Finally, in column (IV), we include both institutional factors (QI_{it} and RAI_{it}) simultaneously, along with their interactions with the other factors of economic growth. The interactions allow us to assess how institutions contribute to the returns of the other factors. [13] All specifications are estimated using a fixed-effects estimator to control for unobserved region-specific effects that may be correlated with the traditional economic growth drivers. [14]

The estimated coefficients in Table 2 indicate that, for all specifications, the traditional drivers of economic growth are statistically significant and have the expected sign. Education, investment in physical capital, and innovation measured through R&D expenditures positively contribute to regional development. The coefficients of lagged GDP per capita and population growth are negative, indicating a significant process of convergence in terms of income per capita.

The coefficients in columns (II) and (IV) suggest that regional government quality has a less direct impact on economic growth but plays an indirect role. Better government quality enhances both the returns on local investment in innovation (as indicated by the elasticity of lns_{it}^{RD})) and regional convergence, as shown by the negative and significant coefficient of the interaction $lny_{it-1}QI_{it}$. The coefficient of the interaction $lns_{it}^{H}QI_{it}$ is negative and statistically significant. Although unexpected, this negative coefficient suggests that increases in government quality will have a larger effect on economic growth in regions with lower education levels compared to regions with better-educated individuals. Thus, having good institutions in regions with lower education levels is critical for economic growth.

Regarding the effect of regional authority, columns (III) and (IV) demonstrate that higher levels of regional autonomy are not necessarily associated with higher growth rates, although regions with more autonomy appear to converge faster. Additionally, we observe that regional authority contributes to the positive effect of investment in physical capital, while the interaction with human capital is negative, indicating that education is less relevant in regions with higher levels of decentralization.

[13] All the explanatory variables have been mean centered, so that the first-order coefficients can be interpreted as elasticities evaluated at the sample mean.

[14] All specifications have also been estimated after adding the residuals (not shown) of the set of auxiliary regressions used to control for the potential endogeneity of lns_{it}^{K}, lns_{it}^{RD} and lns_{it}^{H}. The coefficients of these residuals were statistically significant. We can thus reject the null hypothesis that they are exogenous variables. The estimated auxiliary regressions are shown in Table B.1. in Appendix B. We do not instrument the institutional variables because they affect economic growth through their effect on the prior class-membership probabilities in our LCEG model.

Table 2: Parameter estimates. Basic economic growth models.

	(I)		(II)		(III)		(IV)	
lny_{it-1}	-0.337	***	-0.360	***	-0.374	***	-0.411	***
	(0.033)		(0.030)		(0.034)		(0.030)	
$\log(n_{it} + g + \delta)$	-0.021	***	-0.110	***	-0.099	***	-0.093	***
	(0.008)		(0.011)		(0.010)		(0.011)	
lns_{it}^{K}	0.112	***	0.116	***	0.113	***	0.117	***
	(0.018)		(0.019)		(0.017)		(0.018)	
lns_{it}^{RD}	0.059	***	0.052	***	0.032	*	0.037	**
	(0.019)		(0.017)		(0.016)		(0.016)	
lns_{it}^{H}	0.124	***	0.151	***	0.179	***	0.184	***
	(0.022)		(0.022)		(0.021)		(0.021)	
QI_{it}			-0.002				-0.000	
			(0.006)				(0.007)	
$lny_{it-1}QI_{it}$			-0.062	***			-0.063	***
			(0.015)				(0.016)	
$\log(n_{it} + g + \delta)QI_{it}$			-0.048	***			0.001	
			(0.006)				(0.016)	
$lns_{it}^{K}QI_{it}$			0.001				0.001	
			(0.005)				(0.005)	
$lns_{it}^{RD}QI_{it}$			0.022	***			0.024	***
			(0.005)				(0.005)	
$lns_{it}^{H}QI_{it}$			-0.024	**			-0.020	*
			(0.010)				(0.010)	
RAI_{it}					-0.039	***	-0.047	***
					(0.009)		(0.008)	
$lny_{it-1}RAI_{it}$					-0.059	**	-0.038	*
					(0.026)		(0.023)	
$\log(n_{it} + g + \delta)RAI_{it}$					-0.051	***	-0.047	***
					(0.006)		(0.015)	
$lns_{it}^{K}RAI_{it}$					0.013	**	0.011	*
					(0.006)		(0.006)	
$lns_{it}^{RD}RAI_{it}$					0.006		-0.004	
					(0.006)		(0.005)	
$lns_{it}^{H}RAI_{it}$					-0.028	***	-0.021	***
					(0.008)		(0.007)	
Intercept	0.006	***	0.019	***	0.019	***	0.027	***
	(0.000)		(0.005)		(0.006)		(0.007)	
Number of observations	1813		1813		1813		1813	
Number of regions	230		230		230		230	
F statistic	59.38		46.50		54.47		42.26	
Model test p-value	0.00		0.00		0.00		0.00	
Adjusted R-squared	0.40		0.46		0.46		0.49	

Note: Clustered standard errors by region in parenthesis. *** p<0.01, ** p<0.05, * p<0.1. All estimations include the residuals of the auxiliar equations for Investment, R&D and Education. Estimations based on a sample of 1,813 observations for 230 regions.

These findings support the results of previous studies such as Crescenzi et al. (2016) and Rodríguez-Pose and Ganau (2022), which highlight the indirect influence of government quality and regional authority on regional development in European regions.

They shape the returns of investment in physical and human capital and innovation, thus impacting the convergence process.[15]

However, a notable limitation of linear analyses is that the effect on the returns of traditional economic growth drivers is assumed to be common across all European regions. Yet, there are significant differences in the quality of institutions and the level of autonomy among regions, which may result in regional heterogeneity in the returns of specific investments. To address this limitation, we nest our basic economic growth model into a latent class framework. As explained in Section 2, this approach allows us to obtain heterogeneous parameters that are conditional on the variation of institutional quality and subnational autonomy in Europe. This method provides valuable insights for governments and European institutions when considering how variations in institutional quality affect the economic returns of public spending interventions and the distribution of European funds, respectively. In the following sections, we present the results obtained using the LCEG model.

5.2. LCEG model

The first step in an LCM (Latent Class Model) is to determine the number of classes or regimes. We test for the optimal number of growth regimes using statistical criteria such as the Akaike and Bayesian Information Criteria (AIC and BIC), which penalize overfitted specifications. The preferred specification is the one with the lowest AIC or BIC values, or the most parsimonious one if there are no noticeable changes in AIC or BIC values. Based on the model selection statistics (refer to Figure C.1 in Appendix C), we find that a three-regime specification for the economic growth equation is favoured.

Accordingly, we estimate our LCEG (Latent Class Economic Growth) model with three classes. In addition to estimating the coefficients of the economic growth model, our LCEG model requires estimating the coefficients of the prior class-membership probabilities. These probabilities depend on factors such as government quality (QI_{it}), regional authority index (RAI_{it}),), a dummy variable identifying less developed regions, and the interaction term $QI_{it} \cdot less\ developed_i$.[16] The estimated coefficients of the prior class-membership probabilities are presented in Table 3.

The reference group is the first class, so a positive coefficient indicates a higher probability of belonging to the second or third class and a lower probability of belonging to the first class. The positive and statistically significant coefficients of the institutional variables suggest that regions with high institutional quality and/or autonomy tend to belong to the second class. Additionally, the last column indicates that regions with a high degree of autonomy are predominantly found in the third class. On the other hand, the coefficient of less developed regions is not statistically significant when both institutional

[15] In Table 2 the variables have been centered to the global mean Therefore, the direct effect of institutional quality can be interpreted as elasticity evaluated at the sample mean. In contrast to previous literature the direct effect of institutional quality is not significant. However, using the standard approach based on panel data estimation of fixed effects without this transformation, the direct effect of institutional quality becomes positive and significant, in line with most scholarly literature.

[16] Table S.2 in the Supplementary Online Appendix shows the regions classified as less developed. the interaction $RAI_{it} \cdot lagging_i$ is not included as it yielded convergence problems during the maximization of the likelihood function.

factors —QI_{it} and RAI_{it}— are included as determinants of the prior class-membership probabilities. Overall, the estimated coefficients in Table 3 suggest that most regions with poor institutional quality belong to the first class, although there may be exceptions.

Table 3: Estimated coefficients of the prior class-membership probabilities.

	Class/Regime		
	1	2	3
QI_{it}	-	0.799***	-0.607
		(0.274)	(0.581)
$less\ developed_i$	-	-0.355	0.548
		(1.344)	(0.826)
$QI_{it} \cdot less\ developed_i$	-	0.398	0.635
		(0.969)	(0.090)
RAI_{it}	-	0.743***	0.423*
		(0.158)	(0.230)
$Intercept$	-	0.255	0.280
		(0.275)	(0.316)
Observations	300	861	652

Note: Clustered standard errors by region in parenthesis. *** p<.01, ** p<.05, * p<.1.
Source: own elaboration.

We provide a detailed examination of this classification in Appendix D. Table D.1 presents the most probable class predictions for more and less developed regions, showing the distribution of these regions across the different classes. According to the signs and significance of the parameters in Table 3, we observe that the second class predominantly consists of more developed regions due to their high levels of institutional quality and authority. A considerable number of more developed regions can also be found in the third class. Lagging-behind regions in Europe are mostly allocated to the first class. Additionally, some regions in the third class exhibit a prominent level of authority. Therefore, it is necessary to consider the characteristics of regions belonging to each class when explaining the disparities in the differentiated effects of different types of investment on their economic development.

After examining the number of classes and their characteristics in our LCGE (Latent Class Growth Econometrics) model, we summarize the returns of the traditional economic growth drivers. Table 4 presents the estimated parameters of a simple one-class economic growth model, as well as the coefficients of the three growth regimes estimated using our LCGE model. The first column represents the same model presented in the first column of Table 3. Since this model assumes common coefficients for all European regions, the estimated coefficients can be interpreted as an average effect on economic growth. The estimated coefficients indicate a positive average effect of the traditional growth drivers, with European regions converging in terms of income per capita over the analysed period.

The first and second classes show the highest effects of investment on economic growth. Education has a consistently high impact across all classes, but it is particularly significant in less developed regions (Class 1). Similarly, physical capital investment yields the greatest returns in less developed regions (Class 1) and regions with high institutional quality (Class 2). These findings indicate that there are no average or representative effects of economic growth determinants for European regions. Instead, the LCM analysis reveals the existence of different regional regimes, which are partly determined by variations in institutional conditions. Furthermore, as observed in Bos et al. (2010), the rate of convergence differs between these regimes.

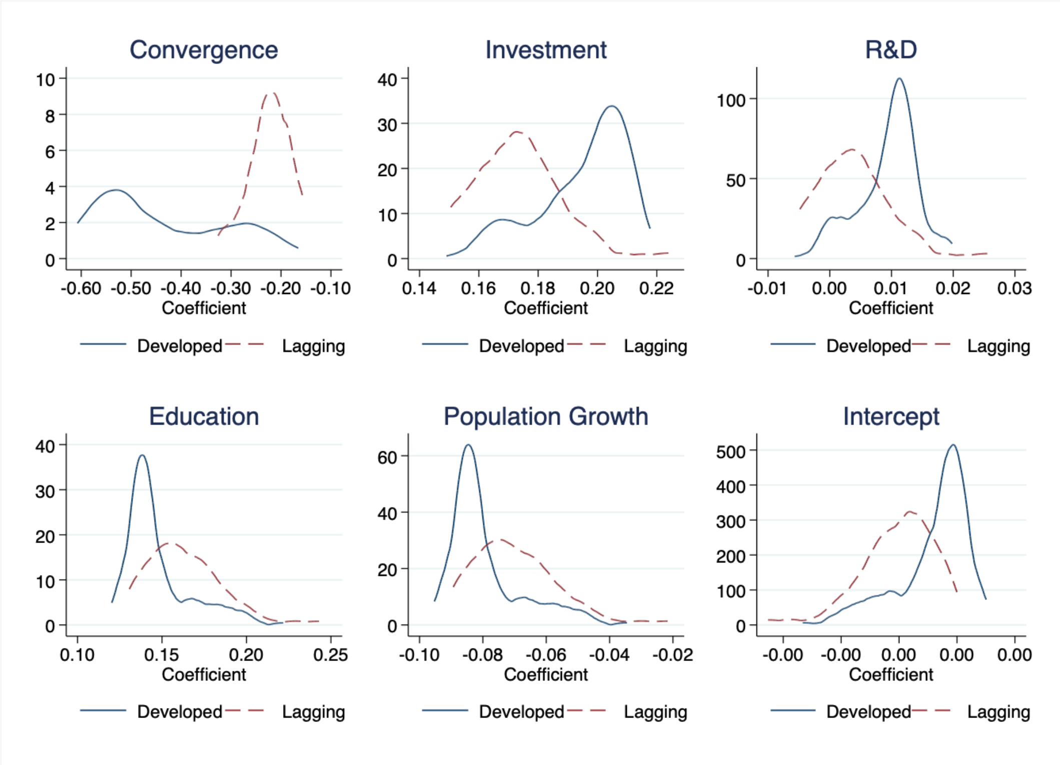
The distinctive feature of our latent class model is the ability to obtain heterogeneous parameters for the traditional economic growth drivers across regions. Following Greene (2005), we estimate the region-specific parameters using the posterior class membership probabilities and the estimated class-specific parameters using equation (10). Figure 3 depicts the level and dispersion of the parameters associated with the speed of convergence and different determinants in the economic growth equation, distinguishing between more and less developed regions. We observe substantial dispersion, which is more pronounced for the parameters of investment, R&D, and education in less developed regions. Convergence is the norm among more developed regions. These results confirm that there is no average effect at the regional level, even within regions of the same country. Furthermore, Figure 3 illustrates that more developed regions exhibit a steeper process of growth convergence and a more significant effect of physical capital investment and R&D, while the effect of education is more relevant for less developed regions. The negative effect of population growth on development is more pronounced in more developed regions. The intercept, which represents average economic growth, has a modest positive effect overall, but it is higher for more developed regions. Both parameters also exhibit greater dispersion in less developed regions.

Table 4: Latent Class estimation results

Variable	All	Class 1	Class 2	Class 3
Lag logGDP (lny_{it-1})	-0.337 ***	-0.315 ***	-0.668*	-0.111 ***
	(0.033)	(0.108)	(0.046)	(0.030)
logPopulation growth	-0.021 ***	-0.014 **	-0.098 ***	-0.097 ***
log $(n_{it} + g + \delta)$	(0.008)	(0.003)	(0.017)	(0.019)
logInvestment (GCF)	0.112***	0.234***	0.212***	0.133***
(lns_{it}^{k})	(0.018)	(0.026)	(0.015)	(0.019)
logR&D expenditure	0.059***	0.029	0.012	-0.012
(lns_{it}^{RD})	(0.019)	(0.020)	(0.020)	(0.015)
logHuman Capital	0.124***	0.256***	0.115***	0.118***
(lns_{it}^{H})	(0.022)	(0.032)	(0.025)	(0.035)
$Intercept$	0.000	-0.005***	0.003***	0.002*
	(0.000)	(0.001)	(0.001)	(0.002)
Observations	1,813	300	861	652

Note: Robust standard errors in parentheses clustered by region. *** p<0.01, ** p<0.05, * p<0.1. The dependent variable is the growth rate of GDP per capita.

Figure 3: Kernel density of heterogeneous coefficients.



Source: own elaboration

Figure 4 illustrates a map showing the convergence parameters specific to each region, which can be estimated using the latent class specification in our model. The figure reveals significant heterogeneity in the convergence patterns of individual regions. It's important to note that in a latent class setting, all regions converge to their respective steady states, which can be seen as region-specific weighted averages of three different class-specific steady states. These findings align with Bos et al. (2010), who also discovered that countries converge to their own regime-specific steady states, with varying rates of convergence.

Additionally, since the probability of the most probable class is often quite high, the estimated region-specific convergence parameters primarily capture a convergence process within the regions belonging to the same class.[17] Therefore, these estimated convergence rates should not be interpreted as global rates of convergence across all EU regions in terms of income per capita.

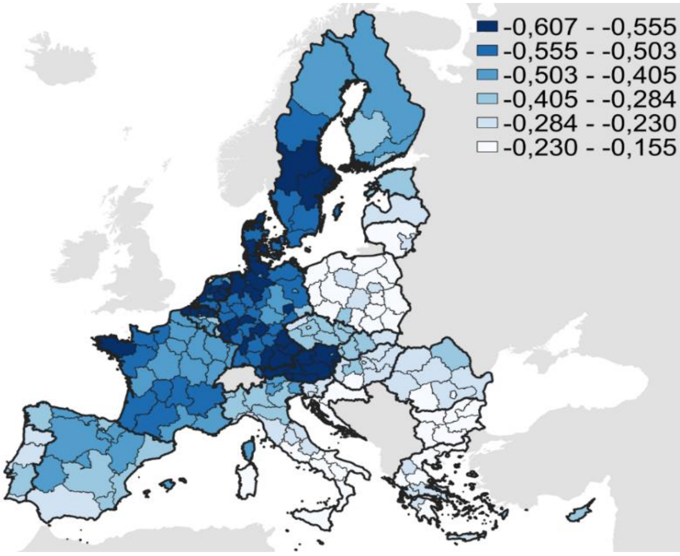
It is worth highlighting that regions in Class 2, which mostly consists of developed regions, exhibit an average income per capita growth rate of 0.35%. Conversely, regions in Class 1 and 3, which include lagging regions with the exception of one, have a slightly higher growth rate of approximately 1.22%. This implies the presence of a convergence process between lagging and developed regions, which is in line with Rodríguez-Pose and Ketterer (2020).

[17] We state "mainly" because the regions allocated to a particular class have often non-zero probabilities of belonging to other classes.

Notably, Class 2, predominantly comprising developed regions, exhibits the largest convergence parameter (-0.66). The convergence parameters in the other two classes, which include a mix of developed and lagging regions, are also negative, but their magnitudes (-0.31 and -0.11) are smaller than in Class 2. This result is likely due to the higher coefficient of variation in growth rates observed in Class 2 compared to the other two classes.

In summary, our results suggest that Europe has witnessed more convergence in income per capita within developed regions (Class 2) than within lagging and less developed regions (Class 1 and 3). This finding is similar to the map presented by Firgo and Huber (2014), whose analysis focused on convergence within countries across EU regions.

Figure 4: Map of convergence coefficients.



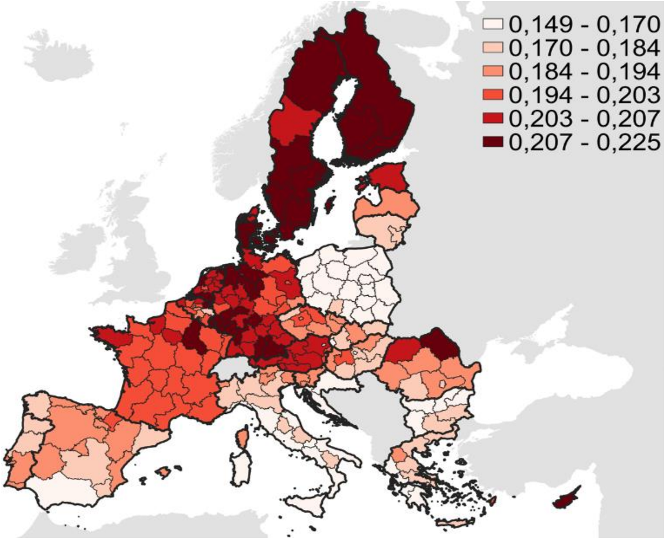
Note: regions are classified in six equal count intervals. Average coefficient overall years.
Source: EuroGeographics for the administrative boundaries.

The map depicted in Figure 4 illustrates distinct convergence patterns among developed regions, lagging regions, and even within developed regions themselves. Convergence is particularly prominent in central and northern Europe, as well as in the northern regions of some southern European countries. On the other hand, lower convergence rates are observed in less developed regions of Eastern Europe. It is important to note that these convergence rates primarily reflect the convergence processes within regions belonging to the same class.[18] In most countries, regions tend to belong to the same class, indicating that the regions in Eastern Europe generally experience similar rates of growth in income per capita compared to other regions within their respective countries. In contrast, although the economic growth in many regions of central and northern Europe may be slower, their less favourable regions are converging rapidly towards wealthier regions in this geographical area.

[18] This explains why we do not find a remarkable heterogeneity in convergence rates within each country, except for Spain and Italy, which both show significant internal disparities.

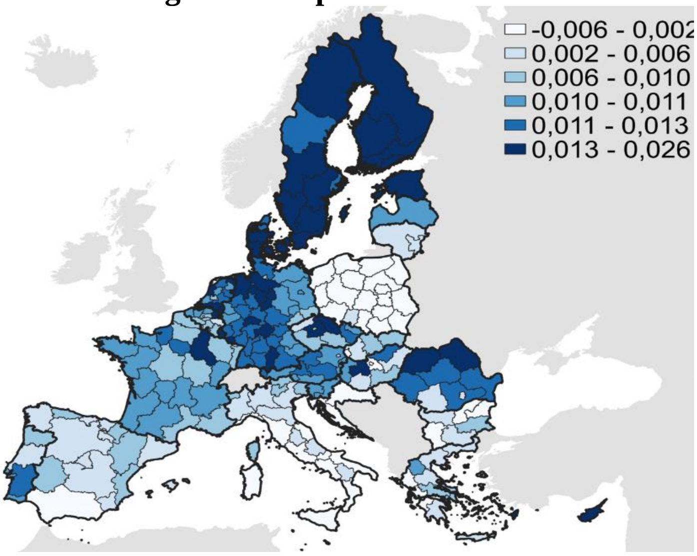
Figures 5-7 present maps that highlight the unequal distribution of coefficients for physical capital investment, R&D, and human capital across regions. Regions with the highest returns on investment in physical capital and R&D are primarily located in the Nordics and Central Europe. However, some less-developed regions in Eastern Europe, particularly in Romania, Czechia, and Hungary, also exhibit relatively high returns on physical capital investment. The same trend applies to innovation. Therefore, governments of these regions and the European Union should prioritize public investment of this nature. Conversely, in Southern and Southeastern Europe, low government quality poses a significant barrier to realizing returns on investments in physical capital and innovation (Rodríguez-Pose and Di Cataldo, 2015). In terms of the returns on education, Figure 7 demonstrates substantial differences across regions and emphasizes the significant role of education in less developed regions and certain regions in northern countries (Firgo and Huber, 2014). Consequently, investing in human capital yields relatively higher returns in less developed European regions with lower government quality and, except for Spain, lower autonomy.

Figure 5: Map of investment coefficients



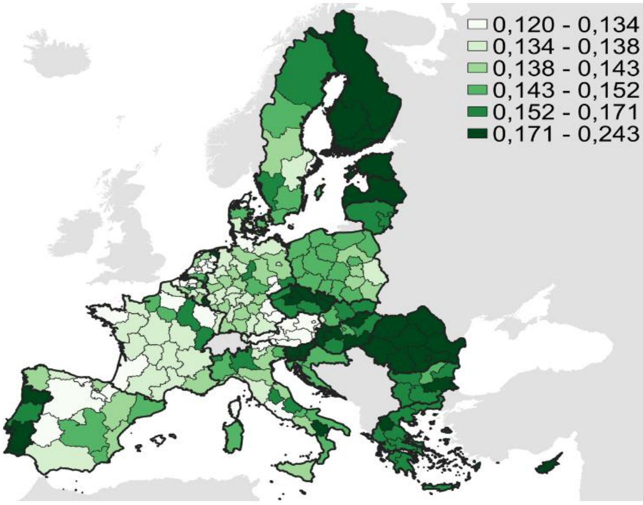
Note: regions are classified in six equal count intervals. Average coefficient overall years.
Source: EuroGeographics for the administrative boundaries.

Figure 6: Map of R&D coefficients



Note: regions are classified in six equal count intervals. Average coefficient overall years.
Source: EuroGeographics for the administrative boundaries.

Figure 7: Map of education coefficients



Note: regions are classified in six equal count intervals. Average coefficient overall years.
Source: EuroGeographics for the administrative boundaries.

The key policy recommendations derived from these findings are as follows: a) obtaining region-specific parameters enables more nuanced recommendations regarding the types of investments that yield greater economic returns from public investment and Cohesion policy, and b) local institutional ecosystems influence the impact of traditional economic growth drivers. In the following subsection, we will delve into how improving regional institutions can affect the returns of public investment in European regions.

5.3 Are institutions important in fostering economic growth in European regions?

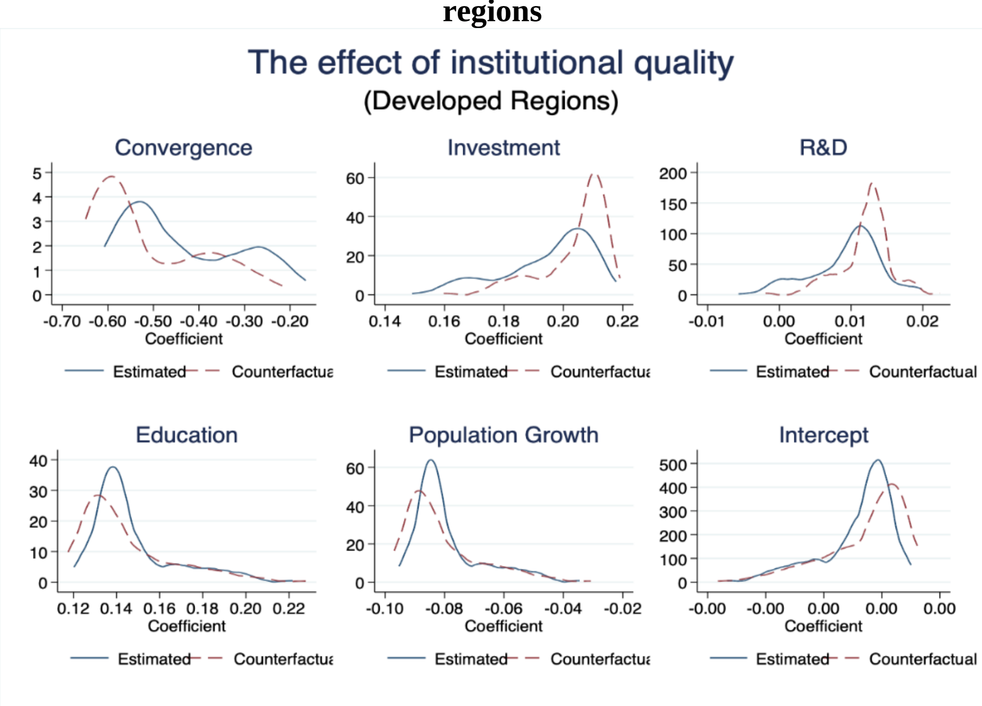
Our previous analysis demonstrates that the economic growth returns of physical and human capital, as well as local innovative capacity, are influenced by the quality of government in each region (Rodríguez-Pose and Ganau, 2022). In other words, the parameters shown in Figure 3 are subject to change if the regional institutional quality and authority are modified. This provides an opportunity to calculate the marginal effects on the returns of education, physical capital investment, and innovation resulting from marginal changes in the institutional environment.

5.3.1. Marginal effects attributed to improvement in quality of institutions.

In this subsection, we conduct a counterfactual analysis to examine the impact of changes in government quality (QI_{it}). Specifically, we simulate the effects on the returns of education, physical capital investment, and innovation of increasing institutional quality by one standard deviation for all regions. We also explore the effects on the speed of convergence and other parameters. The new distributions of coefficients for more and less developed regions are illustrated in Figures 8 and 9, respectively.

Figure 8 demonstrates that a one-standard-deviation improvement in the quality of government in more developed regions leads to a significant increase in the elasticities of physical capital and R&D investment in most of these regions. Additionally, this group of regions experiences a higher speed of convergence. However, the elasticities of education investments tend to remain lower, even at higher levels of government quality. This finding aligns with previous results obtained using a simple linear specification that interacted QI_{it} with traditional economic growth drivers. We observe an intensified negative effect of population growth and a positive effect on the intercept, representing the average economic growth.

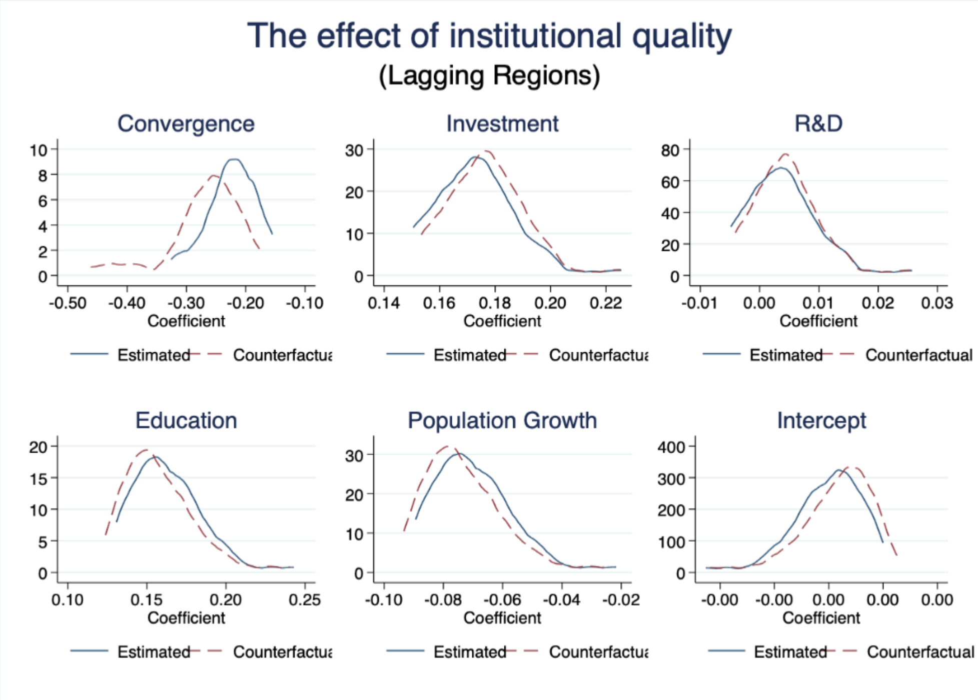
Figure 8: The effect of government quality on elasticities in more developed regions



Note: Counterfactual analysis of an increase in the institutional quality indicator by one standard deviation for all regions. Source: Own elaboration

Figure 9 displays the effects of changes in the quality of government on the estimated elasticities for less developed regions. Generally, the estimated effects in these regions are smaller compared to more developed ones. Nevertheless, less developed regions exhibit improvements in terms of speed of convergence, investment, and R&D expenditure when government quality is enhanced. According to the results presented in Figure 9, we also observe a significant positive effect on the constant term, indicating an enhancement in the average economic growth of less developed regions.

Figure 9: The effect of Government quality on the elasticities of less developed regions



Note: Counterfactual analysis of an increase in the institutional quality indicator by one standard deviation for all regions.
Source: Own elaboration

In Appendix E, we explore the presence of both average and catching-up effects in the returns (elasticities) of the traditional drivers of economic development after improving QI_{it}_it in both more and less developed regions. The Kolmogorov-Smirnov tests in Table E.1 indicate that changes in the elasticities of all more developed regions are statistically significant, confirming the importance of the shifts observed in the kernel curves shown in Figure 8. Conversely, for less developed regions, only the shift in the kernel curve of lagged GDP per capita remains statistically significant. Additionally, we present beta-convergence tests in Table E.2, based on equation (12). For more developed regions, these tests suggest a greater concentration in the parameters associated with investment, innovation, and the speed of convergence, while the heterogeneity among the parameters of education, population growth, and the constant term has slightly increased. Regarding less developed regions, the beta-convergence test reveals a higher dispersion in the speed of convergence, while improvements in the parameters of investment and innovation contribute to reducing the heterogeneity between regions.

In conclusion, improvements in the quality of government have an impact on the economic performance of European regions. These improvements influence the returns of physical capital and innovation in terms of regional economic performance (Rodríguez-Pose and Ganau, 2022). Specifically, enhancing government quality leads to increased returns on investments in physical capital and innovation and facilitates a closer process of convergence in terms of economic performance. Moreover, improvements in government quality result in an increased parameter of the intercept, representing average economic growth. Furthermore, the elasticities for education decrease, and the negative effect of population growth intensifies, although these effects are less pronounced in less developed regions. The improvements in government quality in more developed regions also contribute to reducing the heterogeneity of parameters to a greater extent compared to less developed regions. Thus, more developed regions can also benefit from a process of territorial cohesion.

Therefore, improving government quality is crucial for determining the returns of different types of investments. Weak government quality poses a significant barrier to economic growth and territorial cohesion during the period under analysis.

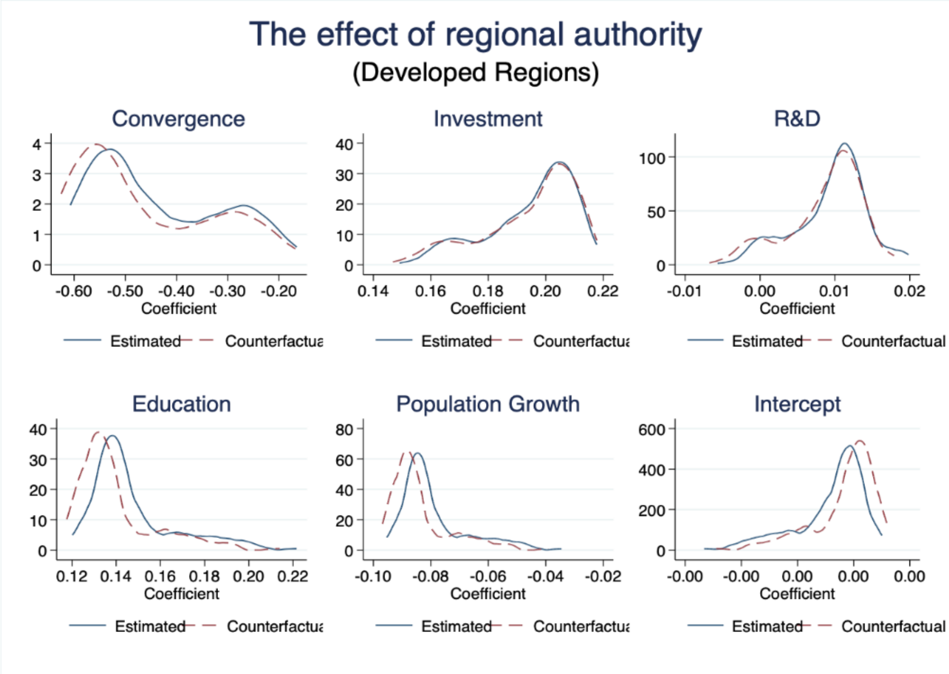
5.3.2. Marginal effects attributed to larger degrees of regional autonomy.

In the counterfactual analysis, we also examine the effect of changes in the degree of regional autonomy. We simulate the impact of a one-standard-deviation increase in the RAI_{it} index for all regions on the elasticities of economic growth. The new distributions of coefficients for more and less developed regions are shown in Figures 10 and 11 respectively. Table E.1 in Appendix E tests the hypothesis that the counterfactual coefficients are, on average, smaller (or larger) than the estimated ones. Additionally, Table E.2 in Appendix E presents beta-convergence tests based on equation (12) to assess whether catching-up effects are associated with greater degrees of autonomy.

Overall, we find that the elasticities of economic growth drivers in both more and less developed regions are less responsive to changes in the RAI_{it} index compared to changes in the QI_{it} index. Figure 10 suggests that a higher degree of regional autonomy in more developed regions improves the speed of convergence and leads to greater economic growth. The Kolmogorov-Smirnov tests in Table E.1 confirm the significance of these shifts in the kernel curves. Conversely, there is a negative and statistically significant effect on the elasticities of education and population growth, while the effect on investment and R&D expenditure elasticity is negative but not statistically significant. The beta-convergence tests in Table E.2 indicate that the increase in RAI_{it} results in greater convergence only in the elasticities of education, while the heterogeneity among the other parameters increases.

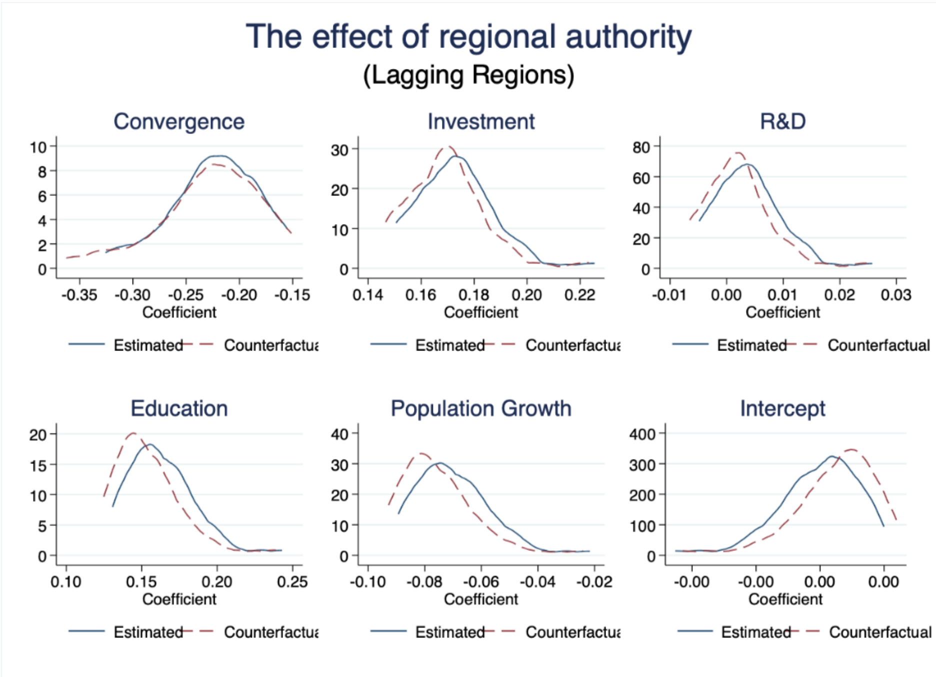
Figure 11 and Table E.1 show that a larger degree of regional autonomy in less developed regions leads to an increase in the intercept, representing an expansion in average economic growth. However, the analysis reveals significant negative effects on the elasticities of education and population growth. In terms of the beta-convergence test, we observe changes only in the convergence parameter of lagged GDP per capita, where the heterogeneity increases.

Figure 10: The effect of regional authority on the elasticities of more developed regions



Note: Counterfactual analysis of an increase in the regional authority index by one standard deviation for all regions.
Source: Own elaboration

Figure 11: The effect of regional authority on the elasticities of less developed regions



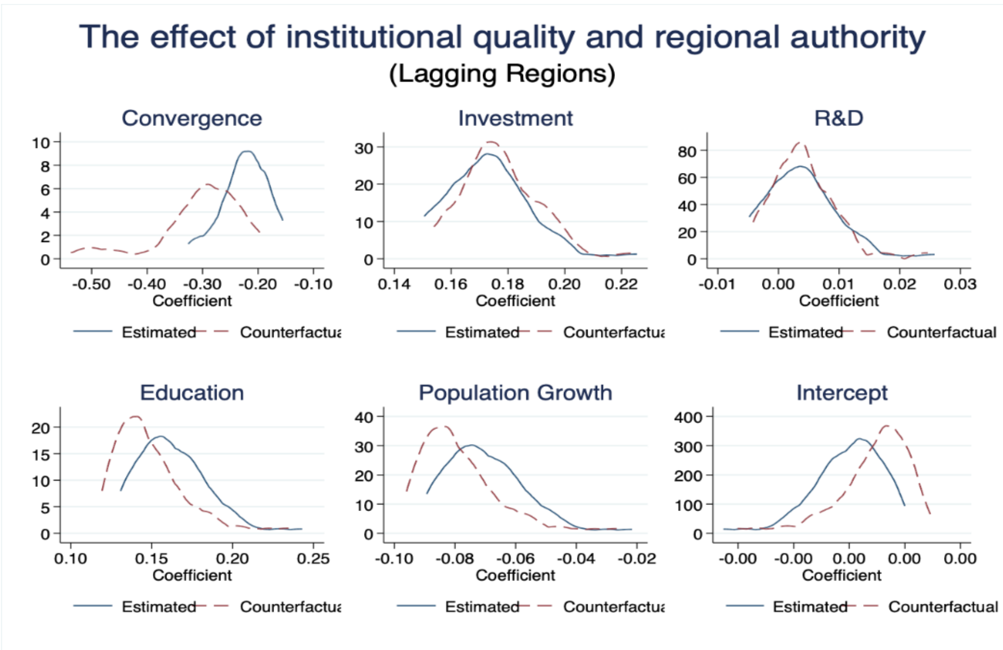
Note: Counterfactual analysis of an increase in the regional authority index by one standard deviation for all regions.
Source: Own elaboration

5.3.3. Combined marginal effects.

In conclusion, improvements in government quality have a greater impact than those in regional autonomy when aiming for better investment performance (see also Muringani et al., 2019). In this subsection, we focus on changes in both types of institutional factors (QI_{it} and RAI_{it}) in less developed regions. We increase the values of QI_{it} and RAI_{it} in all less developed regions by the average difference between more and less developed regions. Figure 12 presents the results of this new counterfactual analysis, and Appendix E provides tests of average and catching-up effects in elasticities between the original and counterfactual coefficients. We find that most less developed regions could enhance their economic growth and increase convergence by investing in traditional economic growth drivers. However, the elasticities of investment in physical capital and R&D expenditure remain largely unchanged compared to the previous scheme, while the role of education deteriorates and the negative effect of population growth intensifies.

The beta-convergence test in Table E.2 leads to the conclusion that changes in QI_{it} and RAI_{it} would exacerbate the differences in economic growth rates, given the positive and statistically significant coefficient found for lagged GDP. Interestingly, while a simultaneous increase in QI_{it} and RAI_{it} does not, on average, enhance the elasticities of investment in physical capital and R&D expenditure, it tends to homogenize both elasticities.

Figure 12: The effect of Government quality and regional authority on the elasticities of less developed regions



Note: Counterfactual analysis of an increase in the quality of the government indicator and regional authority index of less developed regions by the difference between the average of the more and less developed regions. Source: Own elaboration

6. Conclusions

Research on how institutions shape the drivers of economic growth in European regions typically assumes a uniform effect across all regions. Most studies examine the impact of government quality on the economic performance of EU regions as a whole or categorize them broadly by development level (e.g., Iammarino et al., 2019; Rodríguez-Pose and Ketterer, 2020). However, our research challenges this assumption and demonstrates that it is not the case. Using a latent class structure, we estimate region-specific effects of investments in physical and human capital and innovation in European regions, revealing significant variations in the returns on these investments based on government quality and regional autonomy. Therefore, the heterogeneous parameters observed across different regions are fundamentally dependent on institutional factors.

To obtain these results, we simulate counterfactual scenarios by improving the quality of government (QI) and regional autonomy (RAI) indices. We find that enhancing institutional quality has considerable growth effects and potentially influences the returns on physical and human capital and innovation. Specifically, improvements in government quality lead to higher returns on physical capital, education, and innovation, facilitating the convergence process. We also observe an increase in the intercept parameter, indicating greater economic growth, as well as a reduction in the elasticities of human capital investment and an intensified negative effect of population growth on economic growth. These effects are less significant in less developed regions. Additionally, improvements in government quality reduce parameter heterogeneity to a greater extent in more developed regions than in less developed ones, implying that institutional improvements can also drive convergence within developed regions. Ultimately, improvements in government quality are crucial in determining regional performance and optimizing the benefits of different types of growth-inducing investments.

Furthermore, our findings show that improvements in government quality have a greater impact on the drivers of economic growth compared to changes in regional autonomy, aligning with Muringani et al. (2019). Simulations of increased regional autonomy have a much lesser effect compared to improvements in government quality. Specifically, increasing the RAI index enhances the speed of convergence in more developed regions and contributes to average economic growth in both more and less developed regions.

Overall, our research reveals the existence of distinct economic growth patterns in European regions. Considering variations in regional autonomy and government quality, we identify three regimes. Economic growth in regions with high regional authority and government quality is primarily driven by investments in physical capital, while regions with lower government quality and authority experience growth propelled by human capital. Convergence rates also differ among these regimes, with more developed regions exhibiting faster convergence due to better institutions. Therefore, regions in the Nordic states and the core of Europe witness the highest returns on investment in physical capital and innovation, whereas most less developed regions — including some northern European regions— experience the highest economic growth from investing in education. Additionally, improvements in institutional quality have a greater impact in more developed regions but improving government quality also yields substantial economic growth benefits for most less developed regions, as well as producing significant positive effects on the returns of other investments.

The policy implications of our analysis are significant. Firstly, recognizing the highly heterogeneous returns on investment in economic growth across EU regions — contingent on government quality and level of autonomy— can improve public spending and facilitate more targeted investments, particularly at the EU level. This knowledge allows for interventions that prioritize investments with higher profitability potential based on the conditions of each territory. Secondly, our results highlight that institutional factors, particularly government quality, play a significant role in shaping the returns of traditional drivers of economic growth and influencing territorial cohesion. Therefore, addressing low returns on investment requires institutional improvements. Finally, efforts to enhance institutional quality should focus on regions where substantial increases in investment returns can be achieved, promoting territorial cohesion through more effective use of investments.

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Appendix A. Data

Table A.1.: Descriptive statistics for more and less developed regions.

	Mean	Std. Dev	Minimum	Maximum
More developed regions				
Growth of real GDP per capita (%)	0.786	3.362	-16.106	14.565
Real GDP per capita (€)	29,472.267	13,442.703	5,989.369	98,748.211
Population growth (%)	0.242	0.778	-6.426	5.635
Investment (Million €)	1,1286.503	12,525.965	234.260	142,594.797
R&D (€ per capita)	603.755	611.122	6.641	3,884.269
Human Capital (%)	27.721	8.704	8.300	57.100
ESIF Funds (% of GDP)	0.706	1.131	0.001	8.999
Quality of Government	0.366	0.859	-2.796	2.818
Regional Authority Index	16.404	8.988	0.000	27.000
Less developed regions				
Growth of real GDP per capita (%)	0.046	4.040	-14.319	12.921
Real GDP per capita (€)	12,537.492	5,847.551	3,755.248	25,617.303
Population growth (%)	-0.370	1.072	-11.046	3.583
Investment (Million €)	4,411.206	5,445.629	304.760	37,820.398
R&D (€ per capita)	87.775	65.225	3.905	242.314
Human Capital (%)	19.066	5.189	9.100	31.300
ESIF Funds (% of GDP)	2.587	1.953	0.060	10.545
Quality of Government	-1.020	0.693	-2.528	0.791
Regional Authority Index	9.136	7.640	1.000	24.500

Note: Descriptive statistics based on a sample of 1,446 observations for developed regions and 367 for less developed regions.
Source: own elaboration

Appendix B. Auxiliary regressions

The auxiliary regression models, also known as reduced form models, are used to analyse the endogenous regressors in the economic growth model equation (3). These models can be expressed as $x_{it} = g(Z_{it}, \alpha) + \varepsilon_{it}$, where x_{it} represents an economic growth driver, and Z_{it} represents a set of instrumental variables. Specifically, we focus on investment, innovation, and human capital as endogenous variables.

To explain investment, innovation, and human capital, we assume that the most appropriate exogenous variables are the growth rates of the population, a set of time dummies, and a set of European funds lagged three periods. The lag is due to the requirement that these funds must be spent within the second or third year after their allocation, as stipulated by the N + 2 or N + 3 rule.[19] By examining these auxiliary regressions, we can understand the role of European Funds in regional development, their contribution to economic growth drivers, and the existence of synergies between them. We obtain consistent estimates using the two-stage least squares (2SLS) method. Similar results are achieved (see, e.g., Amsler et al., 2016) when we estimate our linear economic growth model by including the reduced-form residuals as additional explanatory variables: $Y_{it}^* = f\left(X_{it}^*, \beta_j\right) + \xi \hat{\varepsilon}_{it} + v_{it|j}^*$.

We obtain regionalized data on EU funds from the Historic EU payments dataset provided by the Open Data Portal for the European Structural Investment Funds (ESIF). This dataset includes regionalized EU payments for various funds, including the European Regional Development Fund (ERDF), the European Social Fund (ESF), the Cohesion Fund (CF), the European Agricultural Fund for Rural Development (EAFRD), the European Maritime and Fisheries Fund (EMFF), the Youth Employment Initiative (YEI), and the Fund for European Aid to the Most Deprived (FEAD).

Table B.1 presents the estimated parameters of the auxiliary regressions for each endogenous regressor in the economic growth model. As mentioned earlier, we consider the European funds lagged three periods and the population growth rates as the most suitable exogenous variables to explain investment, innovation, and human capital. We can obtain consistent estimates by employing 2SLS estimation and including the reduced form residuals as additional explanatory variables in the economic growth model. The European funds that explain the different types of investment are the ones used to finance them.

It also highlights the significance of the ERDF in financing research and development (R&D). Additionally, the ESF has a positive impact on investment in human capital. Moreover, Table B.1 demonstrates the importance of other European funds in promoting investment in R&D and human capital. Therefore, these results indicate that European Funds contribute to investment in European regions. However, the coefficients associated with the interactions of ERDF and ESF with other funds suggest the presence of competition between them, as indicated by their negative signs.

[19] European funds must be spent by the second or third year after their allocation. This is known as the N + 2 or N + 3 rule. The funds are associated with each type of investment according to the objectives to which they are oriented. This information is available in the Cohesion Open Data Platform (https://cohesiondata.ec.europa.eu/overview/14-20)

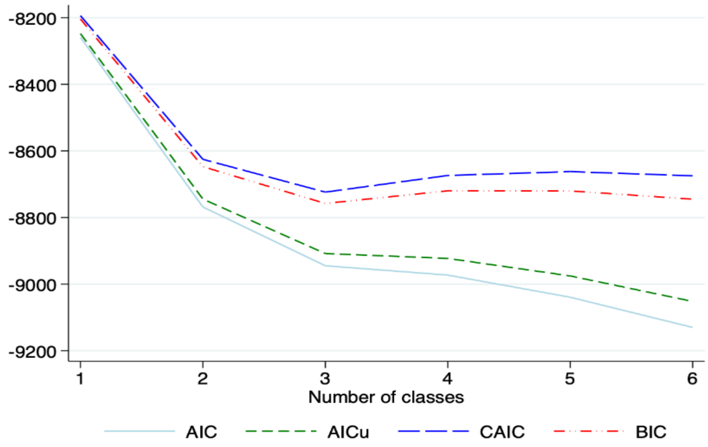
Table B.1: Auxiliar panel regression equations

	(1) GFCF	(2) R&D	(3) Education
$log\ ERDF_{it-3}$	2.772	10.956 ***	
	(3.122)	(2.418)	
$logCF_{it-3}$	-0.847		
	(3.084)		
$logESF_{it-3}$			6.933 ***
			(2.193)
$logERDF_{it-3} * logCF_{it-3}$	-204.969		
	(189.255)		
$log\ otherfunds_{it-3}$	2.558	16.885 ***	1.137 *
	(2.660)	(3.332)	(0.641)
$logERDF_{it-3} * logotherfunds_{it-3}$		-691.218 ***	
		(111.332)	
$logESF_{it-3} * logotherfunds_{it-3}$			-145.627 *
			(82.949)
$Lag\ \log(n_{it} + g + \delta)$	0.050	0.013	-0.023 **
	(0.055)	(0.042)	(0.010)
Intercept	8.829 ***	5.453***	3.033***
	(0.124)	(0.095)	(0.023)
Year-Effects	Yes	Yes	Yes
Observations (N)	1,813 (230)	1,813 (230)	1,813 (230)
F-statistics	29.04***	18.81***	58.77**
P-value	0.00	0.00	0.00

Note: Clustered standard errors by region in parenthesis. *** p<.01, ** p<.05, * p<.1.
ERDF: European Regional Development Fund. CF: Cohesion Fund. ESF: European Social Fund. Other funds include all the European funds not included in the other variables of the estimation.

Appendix C. Specification tests

Figure C.1.: Specification tests for determining the number of regimes.



Note: AIC: Akaike Information Criterion. AICu: X. CAIC: Consistent Akaike Information Criterion. BIC: Bayesian Information Criterion.
Source: own elaboration

Appendix D. Most probable class prediction

Table D.1.: Most probable class prediction for more and less developed regions.

Class	1	2	3	Total
More developed				
Frequency	212	852	382	1,446
Percent	11.69%	46.99%	21.07%	79.76%
Less developed				
Frequency	88	9	270	367
Percent	4.85%	0.50%	14.89%	20.24%
Total				
Frequency	300	861	652	1,813
Percent	16.55%	47.49%	35.96%	100.00%

Source: own elaboration

Appendix E. Kolmogorov-Smirnov and beta-convergence tests of QI and RAI

Table E.1.: Kolmogorov-Smirnov Tests

QI	Lagged GDP	Population growth	Investment	R&D expenditure	Human capital	Constant
More developed regions						
Counterfactual	-0.429***	-0.255***	0.000	0.000	-0.255***	0.016
	(0.000)	(0.000)	(1.000)	(1.000)	(0.000)	(0.952)
Baseline	0.000	0.021	0.380***	0.358***	0.021	0.326***
	(1.000)	(0.917)	(0.000)	(0.000)	(0.917)	(0.000)
Less developed regions						
Counterfactual	-0.369***	-0.173	-0.021	-0.043	-0.173	0.000
	(0.002)	(0.249)	(0.978)	(0.917)	(0.249)	(1.000)
Baseline	0.000	0.000	0.195	0.108	0.000	0.195
	(1.000)	(1.000)	(0.172)	(0.581)	(1.000)	(0.172)
RAI	Lagged GDP	Population growth	Investment	R&D expenditure	Human capital	Constant
More developed regions						
Counterfactual	-0.190***	-0.380***	-0.043	-0.070	-0.375***	0.000
	(0.001)	(0.000)	(0.706)	(0.399)	(0.000)	(1.000)
Baseline	0.011	0.000	0.065	0.000	0.000	0.337***
	(0.978)	(1.000)	(0.457)	(1.000)	(1.000)	(0.000)
Less developed regions						
Counterfactual	-0.108	-0.261**	-0.217	-0.217	-0.261**	0.000
	(0.581)	(0.044)	(0.114)	(0.114)	(0.044)	(1.000)
Baseline	0.065	0.000	0.000	0.000	0.000	0.282**
	(0.822)	(1.000)	(1.000)	(1.000)	(1.000)	(0.025)
QI and RAI	Lagged GDP	Population growth	Investment	R&D expenditure	Human capital	Constant
Less developed regions						
Counterfactual	-0.587***	-0.391***	-0.021	-0.108	-0.391***	0.000
	(0.000)	(0.001)	(0.978)	(0.581)	(0.001)	(1.000)
Baseline	0.000	0.000	0.195	0.130	0.000	0.413***
	(1.000)	(1.000)	(0.172)	(0.457)	(1.000)	(0.000)

Note: p-values in brackets. *** p<.01, ** p<.05, * p<.1. The "Counterfactual" row tests the hypothesis that the heterogeneous coefficients are smaller in the counterfactual. The "Baseline" row tests the hypothesis that the heterogeneous coefficients are smaller in the baseline. Source: own elaboration

Table E.2.: Beta-convergence tests

QI	Lagged GDP	Population growth	Investment	R&D expenditure	Human capital	Constant
More developed regions	-0.083*** (0.016)	0.073*** (0.020)	-0.284*** (0.011)	-0.307*** (0.013)	0.075*** (0.020)	0.094*** (0.018)
Less developed regions	0.392*** (0.096)	0.011 (0.023)	-0.080** (0.036)	-0.079*** (0.025)	0.012 (0.023)	0.037 (0.026)
RAI	Lagged GDP	Population growth	Investment	R&D expenditure	Human capital	Constant
More developed regions	0.047*** (0.006)	-0.001 (0.017)	0.059*** (0.010)	0.022* (0.013)	-0.104*** (0.010)	0.006 (0.017)
Less developed regions	0.179*** (0.029)	-0.001 (0.017)	-0.009 (0.019)	-0.015 (0.017)	0.000 (0.017)	0.006 (0.017)
QI and RAI	Lagged GDP	Population growth	Investment	R&D expenditure	Human capital	Constant
Less developed regions	0.549*** (0.167)	-0.006 (0.039)	-0.163** (0.063)	-0.156*** (0.046)	-0.003 (0.039)	0.036 (0.044)

Note: Standard errors in parenthesis. *** p<.01, ** p<.05, * p<.1. Mean difference is the average counterfactual value minus the average original (estimated) value.
Source: own elaboration