LUND UNIVERSITY
School of Economics and Management

Master's Programme in Economics

How does the degree of rurality affect different determinants of economic growth?

An empirical analysis with spatial data of European NUTS-2 regions from 2000-2019.

by

Philipp Goltzsche

ma2585go-s@student.lu.se

NEKN01

Master's Thesis (15 credits ECTS)

25th May 2022

Supervisor: Pontus Hansson

Abstract

The heterogeneity in regional growth rates within the European Union has been subject to a vast array of studies and research. However, there exists surprisingly little literature focusing on the impact of regional structural development on the economic growth processes. Given that the treaty on the functioning of the European Union emphasises the strengthening of the economic and social cohesion by reducing disparities in the level of development between regions, a deeper understanding of regional growth processes is vital to achieve that goal. In this thesis, the interaction effects of regional rurality on a selection of growth variables are empirically analysed to assess differences in the growth mechanisms of 226 urban and rural European NUTS-2 regions. The findings show that regional typology is significantly relevant to the growth impact of several important determinants as their effects vary greatly with regional rurality taken into account. The results are robust to several different estimation techniques that account for country fixed effects, endogeneity and spatial autocorrelation.

Keywords: rurality, determinants of economic growth, country fixed effects, Spatial Autoregressive (SAR) model, European regions

Acknowledgements

First, I would like to thank my supervisor Pontus Hansson for the helpful discussions, remarks and feedback throughout the writing process of this thesis. Second, I would like to express my gratitude towards the staff and teachers at Lund University, in particular at the Department of Economics at the School of Economics and Management, for all their work and assistance over the past year. Last, but certainly not least, I want to express my sincerest thanks to my family and friends for their continuous support during my studies.

Contents

1 Introduction

This thesis aims to investigate the effect of rurality on determinants of regional economic growth in the European Union. It is based on an array of data for 226 NUTS (Nomenclature of Territorial Units) regions, disaggregated at level 2 throughout the period of 2000 until 2019. The interaction effect of several different growth determinants with the regional degree of rurality is analysed by using three different econometric approaches: a baseline pooled ordinary least squares (OLS) regression (i), a country fixed effects approach that is subsequently enhanced with instrumental variables (ii), and a spatially augmented regression (SAR) (iii) to account for spatial autocorrelation in regional growth rates.

Economic wealth and development levels vary significantly across countries and regions. Even within the relatively wealthy and well-developed European Union, regional differences remain large. Figure 1 depicts the heterogeneity of economic growth rates in European regions from 2000 to 2019. Clear geographical patterns are visible with higher growth rates in the central and eastern European regions and lower growth being present in the southern and western areas. These differences in growth processes have been subject to a plethora of research on a regional and global scale that analysed a variety of growth determinants (e.g. R. J. Barro et al., 2003; Huang, Zhang, and Rozelle, 2007; Ciccone and Jarocinski, 2010; Cuaresma, Doppelhofer, and Feldkircher, 2014). However, articles focusing on economic growth processes in rural regions are fewer in number and less general in nature (e.g. Agarwal, Rahman, and Errington, 2009; Freshwater, 2016).

In this paper, the influence of rurality on the impact of regional growth determinants is explicitly analysed by including a newly compiled rurality index as an interaction variable in the empirical regressions. The index was determined by taking the Eurostat classification of NUTS level 3 regions into predominantly urban, intermediate, and predominantly rural regions into account and compiling it into an index ranging from 0 (predominantly urban) to 1 (predominantly rural) for level 2 of the NUTS aggregation. The result can be seen in Figure 2. The EU, much like the Organisation for Economic Cooperation and Development (OECD) mainly takes population density into account when defining the typology of a region [1]. Due to a relatively sparse and scattered population in addition to other systemic challenges that will be introduced in section 2 of this thesis, rural regions are generally less developed and productive than their urban or metropolitan counterparts. However, 83 % of the total European Union area is classified as rural, containing about a third of its population. While the average GDP per capita of rural regions was only three-quarters of the EU average, growth rates remain rather heterogeneous (European Commission, 2021). As Table 1 illustrates, seven rural regions are among the top ten NUTS-2 regions with the highest GDP growth rates between 2000 and 2019. Contrarily, nine out of the ten regions with the lowest growth rates in that period are also all classified as predominantly rural.

Table 1: European NUTS2 regions ranked according to their average annual growth rate from 2000 to 2019. Bold regions are defined as being predominantly rural.

No.	Region	Growth 00-19	Growth 00-05	Growth 05-10	Growth 10-15	Growth 15-19
1	RO32	0,0876	0,1138	0,1042	0,0533	0,0768
2	**RO11**	0,0860	0,1066	0,0952	0,0416	0,1045
3	**RO42**	0,0837	0,1127	0,1039	0,0324	0,0863
4	**RO41**	0,0815	0,0894	0,0981	0,0372	0,1062
5	**RO31**	0,0810	0,1060	0,0952	0,0457	0,0763
6	**RO12**	0,0778	0,0826	0,1016	0,0400	0,0892
7	LT01	0,0770	0,1244	0,0570	0,0627	0,0607
8	BG41	0,0754	0,1150	0,0912	0,0254	0,0686
9	**RO22**	0,0753	0,0894	0,0835	0,0586	0,0681
10	**LT02**	0,0698	0,1043	0,0543	0,0612	0,0566
...	...	...	...	...	...	...
217	**EL53**	0,0117	0,0645	-0,0039	0,0145	-0,0386
218	**EL62**	0,0116	0,0546	-0,0105	-0,0221	0,0276
219	**EL52**	0,0111	0,0429	0,0009	-0,0186	0,0212
220	**EL43**	0,0105	0,0506	-0,0058	-0,0180	0,0165
221	ITI2	0,0100	0,0124	0,0085	-0,0055	0,0282
222	**EL54**	0,0094	0,0421	-0,0019	-0,0174	0,0161
223	**EL42**	0,0090	0,0432	-0,0072	-0,0096	0,0097
224	**EL41**	0,0086	0,0627	0,0072	-0,0208	-0,0207
225	**EL51**	0,0073	0,0400	0,0074	-0,0330	0,0166
226	**EL64**	0,0048	0,0327	-0,0154	-0,0184	0,0241

To understand the different regional growth processes, one needs to analyse the impact various determinants have on economic growth. This thesis puts specific emphasis on the

[1] The classification process involves a three-step procedure: (1) Classification of rural areas through population density in a grid-system, (2) share of regional population living in these rural areas and (3) accounting for potential city centers.

interaction effects of those determinants with a region's degree of rurality. It assesses the influence of regional development on frequently used categories of growth determinants. They include economic capital, human capital, social capital, and environmental capital and are further presented in section 2. Three different estimation techniques are employed to allow for robust results. This empirical analysis will help to visualise the different growth paths of rural and urban regions by finding evidence of significant rural interaction effects. The aim is to provide a basis for further investigations into rural growth processes in Europe and for policies trying to facilitate further structural development within the EU. By acknowledging the impact of regional typology on growth determinants relevant policy conclusions can be drawn to help foster local advancements and structural cohesion, a goal directly specified in Article 174 of the treaty on the functioning of the European Union.

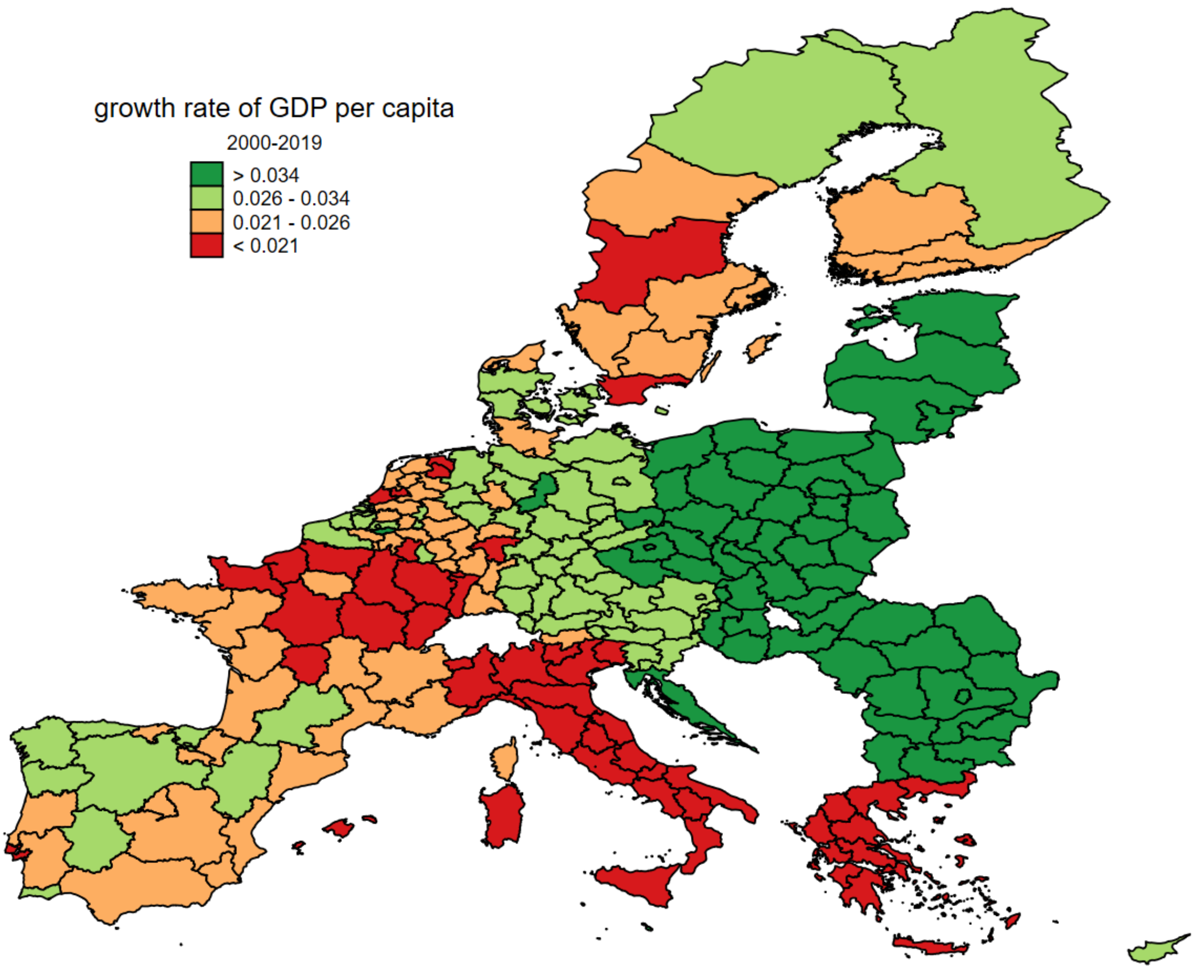

Figure 1: Spatial distribution of economic growth in European regions. The values are expressed as the average annual growth rate of GDP per capita in purchasing power standard (PPS).

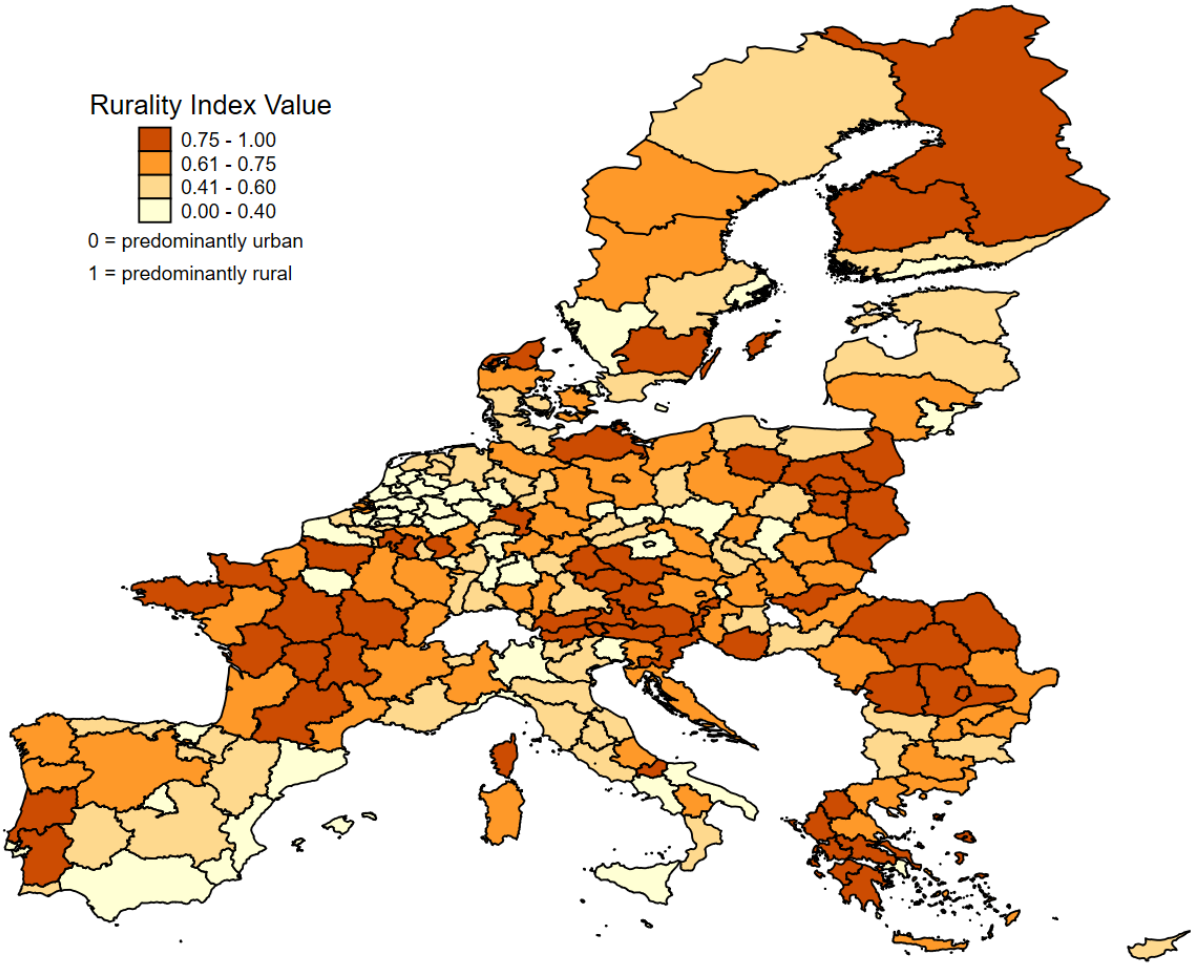

Figure 2: Spatial distribution of rural and urban European regions. The values are expressed as a continuous index with values close to one representing greater rurality and values close to 0 representing greater urbanisation in the respective region.

This thesis is structured as follows: Section 2 conceptualises and introduces several growth determinants and discusses their impact and importance for rural regions by presenting current research. In section 3, the theoretical baseline model is constructed as a foundation for the methodological framework which is set up in section 4, together with the data and variables used for the empirical analysis. Section 5 presents and discusses the results obtained through the different econometric regressions and finally, section 6 concludes.

2 Determinants of economic growth and rural regions

This section is geared towards introducing the theoretical and empirical background of several economic growth determinants as well as highlighting some of the current research that has been done in this field. The multi-dimensional reasons for heterogeneous regional economic performances depend on the accessibility and the deployment of different forms of capital. In this section the various capital factors associated with distinctive economic performances are introduced within the context of the neoclassical growth theory. Starting by outlining the importance of economic capital, the section continues with human and social capital and concludes by introducing environmental capital. Commonly used growth determinants are identified for each category and explained with the help of a wide array of literature. Simultaneously, their specific impact on rural areas is assessed and discussed, relying on current research.

To understand why growth rates differ among countries and regions, there exists a large, steadily growing body of research that assesses the impact of growth determinants of countries (Ciccone and Jarocinski, 2010; Porter, 1996), regions (Armstrong, Taylor, and Taylor, 2000; Cuaresma, Doppelhofer, and Feldkircher, 2014; Kramar, 2015; Paci, 1997) and rural areas (Agarwal, Rahman, and Errington, 2009; John M Bryden and Dawe, 1998; John Bryden and Hart, 2005; Freshwater, 2016). In addition to the great amount of literature that analyses the impact of specific growth determinants, it shows that aspects and roots of different growth performances are multi-dimensional and dependent on a country's or region's endowment with several factors (R. J. Barro et al., 2003). The previously described classification of regions into rural and urban areas expresses some of the core elements of these differences. Although this classification helps to explain certain causes of growth heterogeneity, it can only be a part of a broader framework taking into account further aspects (Agarwal, Rahman, and Errington, 2009).

2.1 Economic capital

Most of the existing analysis of growth determinants, bases its empirical research on the neoclassical Solow-Swan growth model (Solow, 1956; Swan, 1956). Its baseline framework stipulates economic growth to be dependent on the initial level of production, the share of investments, as well as the exogenously given rates of population growth, technological progress and capital depreciation. These variables vary consistently among countries and regions and are therefore a staple used in economic growth research as foundational baseline indicators on which extensions can be built and the functionality of the model can be tested with. The share of savings, or the increase of the physical capital stock by investments, is expected to have a positive impact on growth which is also confirmed empirically (R. J. Barro et al., 2003; Cuaresma, Doppelhofer, and Feldkircher, 2014; Ketterer and Rodríguez-Pose, 2018). These investments by private persons or businesses increase the total amount of capital and subsequently the capital intensity. Investments in economic capital are typically associated with a lot of different facets like the accessibility of digital and physical infrastructure (John Bryden and Hart, 2005) as well as the distance to the main sales markets (North and Smallbone, 1996). These tend to put rural regions at a disadvantage, meaning that according to Freshwater (2016) investments are expected to have a less positive impact on economic growth in more remote areas.

In theory, the total amount of an economy's population is associated with higher growth rates. However, this link has been found not to hold up empirically. On the other hand, while the rate of population change is seen as an exogenously given constant in the Solow-Swan model, it is an important factor of economic growth disparities between countries (R. J. Barro et al., 2003) and regions (Cuaresma, Doppelhofer, and Feldkircher, 2014). An increase in the population leads to an increase in the total workforce which in turn reduces the capital stock per unit of effective labour in the neoclassical growth theory. It is therefore associated with a negative effect on the growth rate of the economy (R. J. Barro et al., 2003). Freshwater (2016) argues that rural regions are generally more vulnerable to negative net migration and ageing demographics. Subsequently, a declining total population and potentially even a positive impact on the growth of rural economies can be expected.

The initial income of a country or region in the form of its GDP at the beginning of the analysed period plays an important role in a plethora of research articles (Paci, 1997; Cornett and Sørensen, 2008; Bisciari, Essers, Vincent, et al., 2020). It is used to determine the rate of convergence between the regions in the sample. The term absolute convergence (β-convergence) describes the neoclassical hypothesis that poorer regions experience higher growth rates and are therefore bound to catch up with richer regions (R. J. Barro et al., 2003). In other words, the convergence theory would imply that the level of GDP at the beginning of a period is inversely related to a region's growth rate over the entire period. R. Barro and Sala-i-Martin (2004) stipulate that the concept of conditional convergence is more in line with empirical evidence. They state that only countries or regions that possess a similar initial endowment of other factors like physical or human capital are expected to converge to the same level of GDP. Their findings suggest an annual long-term speed of convergence of roughly 2 percent. The convergence theory is commonly applied on a sub-national level as well. Kramar (2015) finds regional convergence disparities within Europe and Artelaris, Kallioras, and Petrakos (2010) examine the existence of convergence clubs in Eastern Europe showing that convergence can also be observed on a smaller scale.

2.2 Human capital

The concept of human capital as it is known today was defined by Becker (1964) and B. R. Johnson (1990) who refer to it as the additional value acquiring education, knowledge and special skills useful to the production process, provide to labour. Further research identified a wide array of human capital variables that influence economic growth in a region or country. These include educational attainment and labour skill level (John Bryden and Hart, 2001; Chand and Srivastava, 2014), entrepreneurship (Dabson et al., 2001; Fortunato, 2014; McElwee and Atherton, 2021), migratory movements (Freshwater, 2016) and quality of life (Deller et al., 2001). Generally, rural economies experience a lower degree of education due to less industries that require a high intensity of human capital. Barkley, Henry, and Li (2004) support this theory by finding evidence that an increase in educational attainment levels grants higher benefits to metropolitan areas than to their rural counterparts. On the other hand, Agarwal, Rahman, and Errington (2009) manage to show that a more targeted increase in specific vocational training and provision of skill-related further education have an notably positive impact on rural economic growth.

Especially important for rural areas is the increase of productivity through innovations. Freshwater (2016) argues that the common phenomenon of decreasing rural populations leaves productivity increases as the only viable way to ensure growth despite a decline in the labour force. The well-known link between increasing productivity and innovation (e.g. OECD, 2011) is a reason why innovations are now seen as essential drivers of economic growth in urban and rural regions (Aghion and P. W. Howitt, 2008). In the standard neoclassical growth models, the rate of technological progress is exogenously given but extensions commonly internalise it as a function of physical and human capital (see section 3) or by basing it entirely on endogenously modelled innovation and research sectors leading to the creation of improved product variants in the product-variety model (Romer, 1990) or the total replacement of old products in the Schumpeterian growth model (Aghion and P. Howitt, 1992).

To measure the rate at which innovations occur empirically, one commonly has to fall back on the investment of physical capital in the research and development sector, the number of patents acquired or the amount of labour working in the science and engineering field. Freshwater (2016) points out that this could lead to some biases towards metropolitan areas as innovations in rural areas mostly occur in small and medium-sized enterprises, not in universities, governmental or corporate research facilities and is therefore not represented in most of the statistics. North and Smallbone (2006) and Freshwater and Wojan (2014) suggest that disruptive innovations in rural regions are likely to be made by a small group of individuals that create a business to solve existing problems which makes the differentiation between entrepreneurship and innovation especially difficult. Due to these measurement errors, innovations are expected to positively impact growth in rural areas, albeit to a lesser degree than in urban regions. J. Wu, Zhuo, and Z. Wu (2017) find that the impact on economic growth of the national innovation system in China is more positive for rural regions with a higher amount of labour mobility or proximity to urban areas. This result is in line with the findings of Rodríguez-Pose and Crescenzi (2008) that stipulate a low impact of research and development on structurally backwards or peripheral European regions. When it comes to inter-regional innovation cooperation Hjaltadóttir, Makkonen, and Mitze (2020) were able to find evidence that highlights the importance of a region's structural properties by finding lower levels of innovation spillovers between pairs of rural regions when compared to urban pairs.

Other growth determining facets of human capital that show consistent differences between urban and rural areas are of demographic nature. Freshwater (2016) and Van Der

Gaag and De Beer (2015) see a significant trend of an ageing and subsequently declining population throughout Europe, with an especially negative impact in rural regions. Green (2016) finds specific persistent labour matching problems and high unemployment rates for low-skilled workers in rural areas which exacerbate strong migratory tendencies of younger demographics towards metropolitan regions. Similarly, Deller et al. (2001) and Bruce et al. (2010) find significant relevance of amenities and the quality of life in rural regions to their economic performance. Iverson and Maguire (2000) find a connection between the quality of life measures and the movement pattern of businesses and residents to remote areas while O'Hagan and Cecil (2007) stress the importance to attract urban commuters to rural areas as they increase the resilience of the regional economy. To measure the quality of life, one can rely on a set of different variables including the access to critical infrastructures like schools, healthcare or recreational facilities, the crime rate, poverty risk or climate and environmental conditions (Deller et al., 2001). These quality-of-life measures certainly retain a degree of relevance for urban regions as well, but Freshwater (2016) finds their impact on rural economies to be substantially distinct. He suggests that accessibility of some of these amenities is limited to different, typically less advanced sub-categories in rural regions.

2.3 Social capital

By introducing social capital as a further dimension, more differences in economic performances can be explained. A big factor of social capital is the quality and effectiveness of institutions (Rupasingha, Goetz, and Freshwater, 2002). There is an ongoing debate whether political institutions cause economic growth or whether the institutional quality is improved by a growing economy and its associated human and physical capital accumulation. As advocates for one side, Acemoglu, S. Johnson, and Robinson (2001), Dollar and Kraay (2003) and Acemoglu, Naidu, et al. (2019) find strong evidence that constrained or democratic governments and institutions cause economic growth. On the other side, R. J. Barro (1996) and Glaeser et al. (2004) reject this hypothesis by suggesting the inverse causation to be true. As a form of social capital, Bryden et al. (2004) finds the effectiveness and cooperation within and between governmental institutions to exert a certain influence on regional economic performance. Ketterer and Rodríguez-Pose (2018) and Rodríguez-Pose and Ganau (2022) support this assumption by finding significant impacts of regional institutional quality on the economic growth of European regions. Agarwal, Rahman, and Errington (2009) argue that governance quality is of special importance to rural areas as it can balance out the aforementioned lack of other means of production like human capital and infrastructure. They discuss the greater influence of the public sector on investments, as an employer and through greater interactions with the private sector in rural regions.

An important facet of the interplay between physical and social capital accumulation can be observed in the role of government expenditures. Better functioning institutions help to assure a more targeted, efficient and cohesive distribution of funds promoting symmetric development patterns across countries and regions (Khan, Raza, and Vo, 2020). Their impact on growth however is not undisputed, especially as it contradicts the theories of a favourable limited government. Mitchell et al. (2005) and Alexiou (2009) argue that excessive, uncontrolled government spending harms regional economic growth. Targeted investments by the government, on the other hand, are found to be positively associated with growth, similarly to private investments in economic capital. Generally, Hsieh and Lai (1994) suggest that the impact of government expenditure varies greatly across time and between countries and cannot be linked to higher or lower growth rates.

However, nowadays especially rural, structurally lagging regions are heavily relying on institutional funding. The European Cohesion Policy is a framework to facilitate similar economic performances between countries and regions within the European Union by allocating funding to disadvantaged areas to alleviate disparities in economic development. Therefore, the European Commission promotes regional structural and investment funds. At their core, they all aim to create jobs, a sustainable economy and a business environment as well as to facilitate digitalisation within countries and regions. The impact of this cohesion policy has been subject to thorough research, coming up with mixed results. Mohl and Hagen (2010) find evidence that poor lagging regions profit particularly from funding whereas the total impact on all regions was not significantly positive. On the other hand, Pinho, Varum, and Antunes (2015) suggest a more positive outcome of European structural funding in richer regions with more human capital and a higher rate of innovation. They were not able to find proof of the European cohesion funds generating any additional growth in disadvantaged regions. Similarly, Gagliardi and Percoco (2017) show that EU funding has an especially positive impact on rural regions closer to urban areas while more remote and underdeveloped regions are negatively affected by the policy through further emigration.

2.4 Environmental capital

Several entirely exogenous determinants of a region's economic performance can be summarised as environmental capital. They include the natural geography, resource endowment and pollution of a region (Agarwal, Rahman, and Errington, 2009). Diamond and Ordunio (1999) explain that first-nature geography and resource availability have shaped cultures, nations and economic performance since the beginning of human history. Still today, many of the economical disparities between regions are influenced by underlying natural and geographic conditions (Ketterer and Rodríguez-Pose, 2018). Important environmental factors that are found to impact economic growth are the access to navigable rivers and coasts which both exert a positive effect on growth. Additionally, natural resource endowments are found to negatively impact regional growth ("resource curse" (J. D. Sachs and Warner, 2001)). The effect of climate on growth is also significant. Studies found higher temperatures to be related to lower economic development levels on a global and national scale with the tropical climate zones lagging behind the temperate zones (Gallup, J. Sachs, and Mellinger, 1998).

In Europe, geographic extremes are largely absent from the continent. Subsequently, Ketterer and Rodríguez-Pose (2018) find first-nature geography to have a significantly weaker influence on current growth rates than other growth determinants. However, Capello (2009) and Benos, Karagiannis, and Karkalakos (2015) show that European geography does influence the existence and degree of spatial spillovers of physical and human capital between regions. Geography is expected to impact rural regions more than urban areas as they are more reliant on industries that are dependent on climate conditions and natural resources like agriculture, forestry, fishing or mining (Agarwal, Rahman, and Errington, 2009). Other geographically distinct differences in the growth rates are visible in Figure 1 with higher growth rates in the East and North when compared to the West and South. This is mainly caused by institutional challenges after the Fall of the Eastern bloc, during the Great Recession in 2008 and the following Euro crisis (Dijkstra, Garcilazo, and McCann, 2015).

3 Theoretical Model

In this section the theoretical framework which is used as a foundation for the subsequent empirical analysis is introduced and explained. The empirical model used to assess the regional economic growth rates in rural and urban areas of Europe is founded on a simple neoclassical Solow-Swan growth model (Solow, 1956; Swan, 1956). In the following segment I adopt and introduce the set-up of Ertur and Koch (2007) taking spatial spillovers of growth determinants and cross-regional technological interdependence into account. Furthermore, additional forms of capital are assumed to affect the production and spatial adoption process of new technologies. Economic capital through capital investments and population changes, human capital by educational attainment as well as innovation and research processes, and social capital through institutional quality and efficiency (Rodríguez-Pose and Crescenzi, 2008; Ketterer and Rodríguez-Pose, 2018).

In this approach, economic growth in region i (with $i = 1, ..., N$) at time t is derived from the following Cobb-Douglas production function:

$$Y_i(t) = A_i(t) K_i^{\alpha} H_i^{\beta} Q_i^{\gamma} L_i^{1-\alpha-\beta-\gamma} \tag{1}$$

where $A_i(t)$ represents the aggregate level of technology, $K_i(t)$ the stock of physical capital, $H_i(t)$ the accumulated human capital, $Q_i(t)$ the social capital parameter and $L_i(t)$ the amount of labour supply. All input factors exhibit diminishing returns to scale ($\alpha+\beta+\gamma < 1$) $A_i(t)$ in itself can be expressed as follows:

$$A_i(t) = \Omega(t) k_i^{\phi}(t) h_i^{\psi}(t) q_i^{\zeta} \prod_{j \neq i}^{N} A_j^{\delta w_{ij}}(t) \tag{2}$$

where $\Omega(t)$ represents an exogenous proportion of technological progress which is considered to be identical for all regions and which grows at a constant rate μ: $\Omega(t) = \Omega(0)e^{\mu t}$. $k_i(t) = K_i(t)/L_i(t)$, $h_i(t) = H_i(t)/L_i(t)$ and $q_i(t) = Q_i(t)/L_i(t)$ are the levels of respective capital per unit of labour. An increase in investments in $k_i(t)$, $h_i(t)$ or $q_i(t)$ subsequently enhances the aggregate level of technology through knowledge spillovers in addition to the total level of a region's associated capital stock. The parameters ϕ, ψ and ζ represent the degree of home externalities for the respective capital accumulation. However, not every investment is expected to create technological progress. Consequently, $0 \leq \phi < 1$, $0 \leq \psi < 1$ and $0 \leq \zeta < 1$ is expected to hold. The fifth term together with the coproduct in Equation 2 symbolises the spatial spillover effects between regions i and j which in turn are also positively affected by the capital investments. The technology spillovers are affected by the parameter δ (with $0 \leq \delta < 1$) which measures the degree of spatial externalities and w_{ij} which is an exogenous friction weight. It holds that $0 \leq w_{ij} \leq 1$, $w_{ii} = 0$ and $\sum_{j \neq i}^{N} w_{ij} = 1$ for $i = 1, ..., N$. Generally, the spatial friction weights increase as the connectivity between two regions increases which is leading to enhanced spillover effects. To analyse technological interdependence between regions and its effect on regional production, Equation 2 is expressed in matrix form:

$$A = \Omega + \phi k + \psi h + \zeta q + \delta \mathbf{W} A \tag{3}$$

where A is an $N \times 1$ vector of technology levels, k an $N \times 1$ vector of the physical capital level per worker, h an $N \times 1$ vector of the human capital level per worker, q an $N \times 1$ vector of the social capital level per worker and $\mathbf{W}$ an $N \times N$ weight matrix. Equation 3 can be solved for A, assuming that $\delta \neq 0$ holds and $\mathbf{W}$ is being invertible. If $|\delta| < 1$ holds, further development and regrouping subsequently lead to the following equation for region i:

$$\begin{aligned} A_i(t) = \Omega^{\frac{1}{1-\delta}}(t) & \left(k_i^{\phi}(t) \prod_{j=1}^{N} k_j^{\phi + \sum_{r=1}^{\infty} \delta^r w_{ij}^r}(t) \right) \left(h_i^{\psi}(t) \prod_{j=1}^{N} h_j^{\psi + \sum_{r=1}^{\infty} \delta^r w_{ij}^r}(t) \right) \\ & \left(q_i^{\zeta}(t) \prod_{j=1}^{N} q_j^{\zeta + \sum_{r=1}^{\infty} \delta^r w_{ij}^r}(t) \right) \end{aligned} \tag{4}$$

Inserting this equation into the Cobb-Douglas production function from Equation 1 and expressing the results in per capita terms (by multiplying with $1/L_i(t)$) leads to the following growth model with spatial interdependence:

$$y_i(t) = \Omega^{\frac{1}{1-\delta}}(t) \left(k_i^{\nu_{ii}}(t) \prod_{j \neq i}^{N} k_j^{\nu_{ij}}(t) \right) \left(h_i^{\eta_{ii}}(t) \prod_{j \neq i}^{N} h_j^{\eta_{ij}}(t) \right) \left(q_i^{\omega_{ii}}(t) \prod_{j \neq i}^{N} q_j^{\omega_{ij}}(t) \right) \tag{5}$$

with $\nu_{ii} = \alpha + \phi \left(1 + \sum_{r=1}^{\infty} \delta^r w_{ii}^r\right)$, $\nu_{ij} = \phi \left(1 + \sum_{r=1}^{\infty} \delta^r w_{ij}^r\right)$, $\eta_{ii} = \beta + \psi \left(1 + \sum_{r=1}^{\infty} \delta^r w_{ii}^r\right)$, $\eta_{ij} = \psi \left(1 + \sum_{r=1}^{\infty} \delta^r w_{ij}^r\right)$, $\omega_{ii} = \gamma + \zeta \left(1 + \sum_{r=1}^{\infty} \delta^r w_{ii}^r\right)$ and $\omega_{ij} = \zeta \left(1 + \sum_{r=1}^{\infty} \delta^r w_{ij}^r\right)$.

These terms represent the returns to scale and the spatial externalities affecting the degree of existing spillover effects. If it is assumed that there are no externalities present ($\delta = \phi = \psi = \zeta = 0$), it would follow that $\nu_{ii} = \alpha$, $\eta_{ii} = \beta$, $\omega_{ii} = \gamma$ and $\nu_{ij} = \eta_{ij} = \omega_{ij} = 0$. This results in the following simplified expression of the per capita production function without spatial spillovers:

$$y_i(t) = \Omega(t) k_i^{\alpha}(t) h_i^{\beta}(t) q_i^{\gamma}(t) \tag{6}$$

In the following methodology section a general empirical model is built on Equation 6 and a model that is used in the spatially augmented regression is based on Equation 5.

4 Empirical Methodology

The interaction effect of regional growth determinants and the degree of rurality is assessed by using three different specifications. First, as a baseline case, the entire regional cross-section is pooled which takes different growth specifications within and in-between countries into account. This OLS regression is commonly used as an initial step in the analysis. Second, a country fixed effect approach is applied to account for national particularities in the growth processes. This allows to put a focus on the impact the degree of rurality has on regional growth determinants within a country. Furthermore, several instrumental variables are introduced to the country fixed effects estimation to account for potential endogeneity issues. Among others, Capello (2009), Cuaresma, Doppelhofer, and Feldkircher (2014) and Benos, Karagiannis, and Karkalakos (2015) argue that regional growth data is significantly spatially correlated which may impact standard inference if left unaccounted. In a third step, the baseline model is therefore spatially augmented to consider relevant spatial spillover effects between regions.

This section introduces the methodological structure built on the previously introduced neoclassical Solow-Swan growth model. This framework will be used in the upcoming empirical process analysis and is therefore additionally spatially augmented. The second subsection is dedicated to introducing the data and variables used in the model. Finally, some concerns regarding endogeneity and multicollinearity are mentioned and discussed.

4.1 Model specification

Keeping the conceptual theoretical framework in mind, Equation 6 serves as the underlying model for the first regressions without spatial autocorrelation. In applying it to my empirical analysis, I follow Cuaresma, Doppelhofer, and Feldkircher (2014) in their specification of a suitable model. The first two empirical approaches can be expressed within this general framework:

$$y = \alpha\iota_N + \beta_k\mathbf{X_k'} + \theta_k\mathbf{X_k'}R_N + \varepsilon \tag{7}$$

where y is an $N \times 1$ vector of the GDP per capita growth rates (in PPS), the dependent variables. α is the intercept with ι_N being a $1 \times N$ vector of ones, $\beta_k = (\beta_1, ..., \beta_k)$ and $\theta_k = (\theta_1, ..., \theta_k)$ are both $1 \times k$ vectors of parameters with β_k capturing the impact of the explanatory variables on the growth rates and θ_k expressing the interaction effects of the growth determinants with the regional degree of rurality. $\mathbf{X_k} = (x_1, ..., x_k)$ is an $N \times k$ matrix of all the explanatory variables that are categorised as economic, human, social and environmental capital. $R_N = (R_1, ..., R_N)$ is an $N \times 1$ vector containing the rurality index values over a sample of N regions and with a total of k explanatory variables. ε is representing an N-dimensional shock process to account for exogeneous effects.

To account for spatial autocorrelation introduced in the third regression step, Equation 7 can easily be extended to the following spatial autoregressive model which is based on Equation 5:

$$y = \alpha\iota_N + \beta_k\mathbf{X_k'} + \theta_k\mathbf{X_k'}R_N + \rho\mathbf{W}y + \phi_k\mathbf{X_k'}\mathbf{W} + \psi_k\mathbf{X_k'}\mathbf{W}R_N + \varepsilon \tag{8}$$

where the same specifications as before hold. In addition, $\mathbf{W}$ is a spatial weight matrix that specifies spatial interdependence among the regional growth rates y and the explanatory variables in $\mathbf{X_k}$. An element of $\mathbf{W}$ is given by $w_{ii} = 0$ and $w_{ij} = d_{ij}^{-1}\ \forall\ i \neq j$ where d_{ij} is representing the distance between region i and region j. The distance between regions is thereby measured from the center of one NUTS-2 region to the center of the others. ρ indicates the extent of existing spatial autocorrelation for the dependent variable. The $k \times 1$ vectors $\phi_k = (\phi_1, ..., \phi_k)$ and $\psi_k = (\psi_1, ..., \psi_k)$ represent the degree of spatial externalities for the explanatory variables and the interaction variable. Thus, if $\phi_k = \psi_k = \rho = 0$, the model would account for no spatial autocorrelation and consequently revert back to its previous specification in Equation 7.

4.2 Data and variables

To measure the different growth determinants of urban and rural regions in Europe, this thesis relies on a wide array of different explanatory variables. All of them are collected over 19 years from 2000 to 2019 and for 226 European regions of 26 different countries within the NUTS-framework. The regions correspond to the second out of three levels of disaggregation within the classification and are all listed in Table B.1 in the Data Appendix. Choosing the second NUTS-level has been a compromise between a greater amount of smaller and thereby more local regions as a basis for the analysis and the availability of data. Even at the second NUTS-level, data for some regions was either incomplete or missing altogether. Recent changes in the NUTS nomenclature and the creation or merging of several regions further complicated the data collection process[2]. That is why some European regions[3], as well as all of the EU outermost regions, are excluded from the empirical analysis.

The included growth determinants are collected from various sources that are all listed in Table B.2 in the Appendix together with the descriptive statistics for each variable. Most of them stem from the Eurostat regional database and the Annual Regional Database of the European Commission's Directorate-General for Regional and Urban Policy (ARDECO). The observed time frame is divided up into four 5-year intervals (2000-2005, 2005-2010, 2010-2015, and 2015-2019). This span was chosen to reduce the impact of the business cycle on the growth process while simultaneously allowing for more observations to be used in the data analysis (Haaf and Kool, 2017). The year 2020 is left out of the analysis on purpose due to significant externalities created by the Covid-19 pandemic, impacting regional dependent and explanatory variables. A separate study on

[2]The coding and the boundaries of the NUTS regions changed several times from 2000 to 2019. The framework was only formally introduced in 2003. Since then it was amended and enlarged five times. This thesis uses the most recent NUTS 2021 classification and compiled all of the data accordingly.

[3]Namely all of the Irish, two Croatian, and Hungarian regions as well as the autonomous Finnish region of Åland.

the impact of Covid-19 on regional growth disparities is commendable, but not part of this thesis.

The dependent variable is defined by the average annual growth rate of each European region's GDP per capita in Purchasing Power Standard (PPS). Figure 1 and Figure 2 show the spatial heterogeneity in growth rates and structural development of the European regions. To analyse the effects of rurality on the growth process and the different growth determinants, a newly created index representing the degree of regional rurality is used as an interaction variable. It encompasses the official NUTS-3 classification into predominantly urban, intermediate, and predominantly rural regions made by the European Commission and aggregates it onto the NUTS-2 level while being expressed in an index structure. The resulting continuous index ranges from 0; being predominantly urban NUTS-2 regions to 1; being predominantly rural NUTS-2 regions. Naturally, the aggregation from level 3 to level 2 of the NUTS-framework leads to some inaccuracies and does not reflect the typology of a region in its entirety. However, it serves as a good indication and its continuous properties allow for a more nuanced perspective in comparison to the usage of a simple dummy variable. Nonetheless, the index has its limitations that have to be kept in mind when interpreting the interaction effects.

The growth determinants can be grouped into five groups that correspond mostly with the different forms of capital introduced in section 2. The first group is categorised as economic capital and represents a baseline neoclassical growth model. It serves as a foundation on which the other groups are added on individually one by one, and all together in a final regression. The variables used here include the level of initial income in a region at the beginning of a period in form of the logarithm of the GDP per capita in PPS which is expected to have a negative effect on growth. The population change is calculated as the annual increase or decrease of the total regional population and is usually found to have a negative impact on the growth rates. Finally, following Cuaresma, Doppelhofer, and Feldkircher (2014) the rate of investments in physical capital is represented by the initial share of gross fixed capital formation (GFCF) of the regional gross value added (GVA). Physical capital investments are generally associated with positive growth effects.

The second group of growth determinants analysed in the regressions represent different forms of human capital. Education levels are represented by the share of the population that obtained at least a Bachelor's degree or a local equivalent. To represent regional innovation processes, the human resources in science and technology (HRST) that indicate the share of the population working as a scientist or engineer are used, considering that these fields of work are typically responsible for the most innovations. In addition, the research sector is taken into account by adding the gross domestic expenditures on research and development (GERD) for each region to the regression. The combination of the units of labour working on innovation and the physical capital spent on research is representing the innovative structure of a region. Other forms of human capital are also taken into account by adding the share of the population aged between 15 and 64 to factor in the demographic structure of the region that is considered to actively contribute to the regional GDP growth. All of the human capital variables included in the empirical analysis are expected to exert a positive impact on the economic growth rate.

In a third step, the impact and rural interaction effects of social capital factors are analysed. For this purpose an institutional quality variable created by Charron, Lapuente, and Dijkstra (2012), Charron, Dijkstra, and Lapuente (2015), Charron, Lapuente, and Annoni (2019) and Charron, Lapuente, and Bauhr (2021) is introduced. The European Quality of Government Index (EQI) measures public sector corruption, allocation, and quality based on survey data from NUTS-2 regions. To capture the interplay between the government sector and the economy, a government spending variable in the form of annual payments from European Union structural investment funds is introduced. The scale of this variable on a European level allows for comparability as the institution and the funding criteria are the same for all European regions. Moreover, the structural funding as part of the cohesion program is specifically set up to target structurally lagging regions, making analysis of the interaction effect with the rurality index intuitively reasonable. Both social capital variables are expected to be positively related to economic growth.

As a fourth group, variables depicting the regional sectoral and employment structure are introduced. These variables are expected to assert effects on every other determinant-group and are therefore an important inclusion to account for the potential dilution of other growth determinant effects. To measure the sectoral structure of a region, the share of the total GVA of the agriculture and service sector (following the NACE2 definition) is included. In addition, the unemployment rate accounts for labour market frictions in the regions and is likely to be negatively related to regional growth rates.

The final group added are geographic variables representing environmental capital. Included are the cooling (CDD) and heating degree days (HDD) that reflect the climate conditions of the region. CDD/HDD are measuring how hot/cold the regional temperature was over the year with each temperature assigning a certain amount of days to each variable. Finally, to account for geographic location and as it has been found to significantly affect growth in Europe (see Figure 1), the longitude of the region's center point is included (J. D. Sachs and Warner, 2001; Artelaris, Kallioras, and Petrakos, 2010). After the interaction effects have been determined individually for each group of variables, all of them are combined in the sixth and final regression to account for all growth determinants simultaneously, thus giving the most complete representation of the regional growth process.

4.3 Endogeneity & multicollinearity issues

An important and well-known issue in the field of economic growth theory is the question of endogeneity between regional economic growth and some of the explanatory variables. To mitigate the potential problems associated with endogeneity, I follow Cuaresma, Doppelhofer, and Feldkircher (2014) and Haaf and Kool (2017) by using data for my growth determinants that have been measured at the beginning of the respective sample period, treating the regressors as predetermined. In combination with the application of country fixed effects, the endogeneity problem associated with some of the growth determinants should be further reduced. To further limit endogeneity risks, one could also introduce additional lagged explanatory variables. However, Hauk and Wacziarg (2009) point out that using lagged regressors extensively could lead to larger biases and subsequently lower consistency than the standard ordinary least-squares estimator which will be applied in the next section. As a compromise, lagged regressors for the initial level of GDP per capita and capital investments are introduced as instrumental variables. Moreover, in line with Acemoglu, S. Johnson, and Robinson (2001), Ketterer and Rodríguez-Pose (2018) and others, several previously mentioned historical variables are used as additional instruments in the two-stage least squares estimation. As discussed in section 2 of this thesis, institutions represent an important factor in growth processes. However, it is difficult to establish causality between higher growth and regional institutional quality. The historical instrumental variables are chosen to address the concern of reverse causality and to establish reasonably exogenous sources of institutional heterogeneity between regions. The choice of these instruments with institutions dating far back in time comes from the fact that early institutional stability, either through being part of the Roman Empire or the Frankish Empire under Charlemagne, is likely to have influenced modern institutional systems in a certain capacity. The historic detachment from modern growth rates renders these dummy variables useful and considerably exogenous.

Another potential problem that is common with interaction effects, is the presence of multicollinearity. High correlation among interaction terms and main effects is normal, and is therefore to be expected. It might lead to increased standard errors of the affected variables' coefficients. This decreases efficiency of the coefficient estimates, however, it does not affect their unbiasedness. Cuaresma, Doppelhofer, and Feldkircher (2014) show that multicollinearity does not change the quality of the estimation results. So while it is not optimal, some degree of collinearity in the interaction effects is inevitable in the upcoming analysis and has to be taken into consideration when interpreting the results.

5 Results

This section reports the empirical results for 226 European NUTS-2 regions from the period of 2000 until 2019. The previously presented standard Solow model serves as the base to which growth variables from previously introduced categories are added independently. Finally, all considered determinants are analysed to get a broad picture of the interaction process between them and the rurality index. Initial Breusch–Pagan tests reveal the presence of heteroskedasticity. Therefore, robust standard errors are applied to the upcoming regressions. Section 5.1 presents the results obtained by a pooled OLS estimation, section 5.2 discusses the findings of panel data estimation with country fixed effects, with and without instrumental variables and finally, section 5.3 reports the findings obtained by a spatially augmented growth model. The different estimation techniques should corroborate each others findings and allow for increased robustness of the results.

5.1 OLS regression results

The results of the pooled OLS regional cross-section estimation are reported in Table 2. They show that the growth determinants and their respective interaction effects are broadly in line with intuitive expectations. Column (1) reports the neoclassical baseline model with no further added assumptions. In columns (2) to (5), the impact and interaction effects of different forms of capital are sequentially analysed by adding them to the economic capital variables. Column (6) pools all the categories and variables and jointly estimates their respective parameters.

When looking at the rurality index, one can observe a largely significant positive effect on economic growth. This finding combined with the highly significant negative impact of initial income is generally in line with the commonly accepted theory of conditional convergence. It shows that structurally lagging regions with lower levels of development tend to grow faster on average than regions with a high level of wealth and development whose growth rates are lower. The rate of convergence is found to be somewhere between two and six percent which is roughly in line with the commonly found two percent result when taking overestimation due to cyclical effects associated with the use of panel data into account (R. Barro and Sala-i-Martin, 2004). Some of the model specifications also report a significant negative coefficient for the interaction effect of initial income and the degree of rurality. This corresponds to an even slower growth in relatively wealthy rural regions indicating a faster rate of convergence which in turn can be explained by the positive growth effects of rurality previously mentioned.

Population change appears to exert a significant negative impact which is turning less negative or even slightly positive, the more rural a region is found to be. The positive interaction effect can be attributed to the unclear direction of population change in rural areas. While urban areas are generally expected to experience a growing population, especially rural and remote regions suffer from negative net migration, declining birth rates, and increasing gentrification. This leads to increased accumulation of capital per capita, productivity per capita, and subsequently higher GDP per capita even if all other determinants are held constant. Gross fixed capital formation representing physical capital investments is found to have a significant positive impact on growth. However, due to the significantly negative interaction effect with the rurality index, regions with a higher degree of rurality are experiencing far less positive growth effects from investments. As a possible explanation for that, one could refer to the disadvantaged position of many rural regions associated with market accessibility, labour productivity and infrastructure availability that render capital investments less effective.

Concerning the first variable group added to the regression, the chosen determinants of human capital are also generally found to behave as expected. The share of the population with tertiary education has a negative interaction effect with the rurality index, leading to a negative total impact in rural regions. A possible reason for this is the lack of available positions requiring a high educational level in rural regions, leading to that population share working in less productive jobs or commuting to urban agglomerates and contributing to their GDP instead of the one of their home region. When looking at the two independent variables of interest, measuring innovation through human resources and expenditures in research & development (HRST & GERD), the significance of their results does not transfer to the total model specification (column 6). The share of scientists and engineers exerts a positive impact on economic growth in both urban and rural regions with a positive rurality interaction effect. This could be due to the inclusion of engineers who are commonly found in small and medium enterprises that are the backbone of many rural regions throughout Europe. The negative effect of GERD that turns positive for rural regions does not maintain its significance but could be explained by diminishing returns of expenditure in urban regions that have a generally better equipped research sector than their rural counterparts. The population share between 15 and 64, representing people of working age, does not appear to be significant although rural areas seem to benefit slightly more than urban regions. Potentially because of their more precarious demographic situation.

Analysing the effects of social capital independently (column 3), reveals high significance for both included variables and their interaction products that do not entirely carry over to the total analysis that encompasses all the variables (column 6). The quality of government index (EQI) exerts a significantly positive rural interaction effect which is in line with the expectations of the greater importance of the public sector because of a higher economic dependency on it in rural areas that has previously been alluded to in section

2. The European structural funding appears to be more beneficial to rural, structurally underdeveloped regions which is a reasonable finding considering it is a form of targeted government spending. The estimation results show that its target of fostering cohesion among European regions seems to be achieved although a definite statement remains difficult due to present endogeneity issues and insignificant findings in the final estimation step.

To account for the economic structure of a region, the fourth column takes the agricultural and service sector share as well as the unemployment rate into account. The findings are not surprising either. A high sectoral share of agricultural production appears to be negatively linked to the regional growth rates albeit having a significantly positive interaction effect that reflects the more important role of agriculture in rural areas. The business and finance sector shows signs of a positive impact on growth in urban areas and negative interaction with the degree of regional rurality. However, these findings are not found to be significant. Lastly, the unemployment rate exerts a negative, yet insignificant effect on growth with a slightly more negative impact on rural regions which might be explained by the typically higher structural and more persistent unemployment in these areas.

The last group of variables added to the regression is the environmental capital. Its geographic variables and growth determinants are generally not found to impact growth or to interact with the rurality index in any significant way. The only exception appears to be interaction effect of the number of Cooling Degree Days (CDD) which has a significantly negative effect on growth the more rural a region becomes. This can be explained by the higher number of CDD in Southern Europe and its significantly lower growth rates. Finally, the positive coefficient for a region's longitude can be explained by the higher growth rates in Eastern Europe, observable in Figure 1 although its significance does not transfer to the total regression (column 6).

Table 2: Pooled OLS paramater estimation.

2000-2019	Economic capital	Human capital	Social capital	Economic structure	Environmental capital	Total
	(1)	(2)	(3)	(4)	(5)	(6)
RID	0.261***	0.183*	0.347***	0.173*	0.253***	-0.0730
	(0.0687)	(0.0987)	(0.0747)	(0.0940)	(0.0690)	(0.118)
Initial income	-0.0200**	-0.0563***	-0.0235**	-0.0566***	-0.0271***	-0.0847***
	(0.01000)	(0.0127)	(0.0107)	(0.0151)	(0.0103)	(0.0149)
Initial income × RID	-0.0560***	-0.0211	-0.0779***	-0.0307	-0.0511***	0.0173
	(0.0146)	(0.0187)	(0.0163)	(0.0219)	(0.0151)	(0.0224)
Pop. change	-1.098***	-1.026***	-0.935***	-0.989***	-0.785***	-0.718***
	(0.221)	(0.200)	(0.188)	(0.199)	(0.209)	(0.177)
Pop. change × RID	1.050***	1.042***	0.850***	0.845**	0.864***	0.831***
	(0.351)	(0.325)	(0.311)	(0.329)	(0.334)	(0.291)
Investment	0.100***	0.0680**	0.0829***	0.102***	0.0800**	0.0545*
	(0.0320)	(0.0296)	(0.0291)	(0.0324)	(0.0316)	(0.0290)
Investment × RID	-0.137***	-0.108**	-0.129***	-0.159***	-0.139***	-0.118**
	(0.0505)	(0.0475)	(0.0468)	(0.0512)	(0.0491)	(0.0461)
Tertiary education		0.000404				0.000748***
		(0.000289)				(0.000264)
Tert. education × RID		-0.00152***				-0.00179***
		(0.000512)				(0.000462)
HRST		0.00362**				0.00177
		(0.00149)				(0.00146)
HRST × RID		0.00603**				0.00635**
		(0.00289)				(0.00270)
GERD		-0.00280**				-0.00179
		(0.00116)				(0.00126)
GERD × RID		0.00726***				0.00332
		(0.00203)				(0.00206)
Age		0.187***				0.0836
		(0.0565)				(0.0588)
Age × RID		0.0972				0.0560
		(0.0855)				(0.0976)
EQI			-0.00458**			-0.00541**
			(0.00191)			(0.00216)
EQI × RID			0.0139***			0.00820**
			(0.00312)			(0.00336)
Fund			-3.66e-05***			-2.02e-05
			(1.31e-05)			(1.27e-05)
Fund × RID			4.96e-05**			2.32e-05
			(2.23e-05)			(2.20e-05)
Unemployment				-0.000161		-0.000402
				(0.000222)		(0.000270)
Unemployment × RID				-0.00116***		-0.000203
				(0.000417)		(0.000499)
Agriculture				-0.250***		-0.118
				(0.0869)		(0.0830)
Agriculture × RID				0.224*		0.274**
				(0.117)		(0.112)
Services				0.0325		0.0271
				(0.0285)		(0.0280)
Services × RID				-0.0446		-0.0190
				(0.0500)		(0.0543)
CDD					7.53e-07	1.23e-05
					(1.41e-05)	(1.57e-05)
CDD × RID					-8.05e-05***	-6.89e-05**
					(2.64e-05)	(2.86e-05)
HDD					1.32e-06	4.50e-06**
					(2.28e-06)	(2.25e-06)
HDD × RID					-9.04e-07	-4.87e-06
					(3.75e-06)	(3.63e-06)
Longitude					0.000443**	5.05e-05
					(0.000216)	(0.000224)
Longitude × RID					-0.000322	-6.79e-05
					(0.000353)	(0.000341)
Constant	0.0994**	0.120*	0.123**	0.258***	0.127***	0.303***
	(0.0476)	(0.0669)	(0.0499)	(0.0657)	(0.0479)	(0.0761)
Observations	904	904	904	904	904	904
R-squared	0.466	0.575	0.505	0.514	0.561	0.639
Heterogeneity (p-value)	0.000	0.000	0.000	0.000	0.000	0.000

Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1. Interaction effects with the degree of rurality are highlighted.

5.2 Country fixed effects regression results

To further corroborate the findings of the pooled OLS estimation, country fixed effects are introduced to the panel data regression. Addressing the endogeneity concerns alluded to in section 4.3, they are additionally augmented with an instrumental variable regression using the 2SLS-estimator. Including country fixed effects allows for an analysis of growth and interaction effects within the countries of the EU. It accounts for individual country characteristics that are unobserved and independent of time yet affect the regional growth processes. Overall, the results for the panel data estimation with country-fixed effects are presented in Table 3 and support the findings reported in Table 2.

Cuaresma, Doppelhofer, and Feldkircher (2014) find that growth rate convergence within countries is a phenomenon more common in the Western European countries, whereas regional convergence between countries is more commonly found in Central and Eastern European countries. Generally, my findings show convergence within countries at an even faster rate than between them. However, the degree of rurality does no longer interact with the initial income in any significant way. The effect of rurality on the regional growth rates within countries is now found to be significant and negative. When accounting for country fixed effects, investments are still less positively associated to growth in these regions with highly significant negative interaction effects. The impact of population change is also found to be negative, as is expected, with a positive, although mostly insignificant, interaction effect with the rurality index across the board.

Human capital effects within countries are similar to the ones previously observed although slight differences are apparent. The general expenditure on research and development is no longer a significant determinant of regional economic growth within a country. The growth determinants associated with social capital, namely the institutional quality and the European funds do not have any significant impact on regional country-within growth processes when analysed together with all the other variables. On their own, social capital effects report a significant positive impact of the government quality index in rural regions but no significance of any level is determined for the interaction between the EU funds and the degree of regional rurality within a country. Generally, the economic structure appears to be more significant for regional growth effects within countries than for the growth processes determined by the pooled OLS. Now, the interaction effects of the business and finance sector with the rurality index remain significant at a 5 percent level when estimated together with all the variables. However, regional geography in form of environmental capital does not exert any significant effect on the regional growth rates nor does it exhibit any significant interaction effects with the degree of rurality. The only exception is the synergy of the number of cooling degree days and the rurality index which is significantly negative again.

Following the introduced methodology, several instrumental variables including lagged data and historical regional dummies are added to the regression to limit possible endogeneity issues associated with the institutional quality and to allow for causal interpretation. The results of the 2SLS-estimation are displayed in Table 4 and support the previous conclusions. Table B.3 in the appendix reports the results of the first-stage regression. An F-test for jointly insignificant instruments is conducted and rejected which implies that the applied instruments are useful.

The baseline findings remain qualitatively intact, the only exception being the negative interaction effect between capital investments and the rurality index which appears to be further reduced. Results for the growth determinants in the category of human capital (column 2) are generally unchanged. The negative effect of tertiary education and the positive one of human resources in science and technology in predominantly rural areas are in line with previous estimations and found to be significant. Social capital (column 3), previously found to be of relatively low significance, provides some interesting results with applied instrumental variables. The positive growth interaction between institutional quality and rural regions is found to be significant, whereas the positive effect of European cohesion funds on rural growth does not retain its significance when the regression is extended on all variables (column 6). Other slight differences emerge regarding regional economic structure. While similar results are obtained in its individual inspection, they lose their significance when jointly analysed with the other categories. The findings for environmental capital are yet again found to be insignificant apart from the number of cooling degree days indicating slower growth effects in rural regions with higher temperatures.

Table 3: Panel data parameter estimation with country fixed effects.

2000-2019	Economic capital	Human capital	Social capital	Economic structure	Environmental capital	Total
	(1)	(2)	(3)	(4)	(5)	(6)
RID	0.0513	-0.196	0.0636	-0.158*	0.0874	-0.381***
	(0.0850)	(0.128)	(0.0937)	(0.0812)	(0.0863)	(0.120)
Initial income	-0.0300***	-0.0503***	-0.0313***	-0.0679***	-0.0311***	-0.0792***
	(0.0106)	(0.0120)	(0.0106)	(0.0152)	(0.0110)	(0.0172)
Initial income × RID	-0.0136	-0.00542	-0.0174	0.0350**	-0.0118	0.0275
	(0.0190)	(0.0157)	(0.0206)	(0.0159)	(0.0196)	(0.0185)
Pop. change	-0.774***	-0.681**	-0.671**	-0.819***	-0.728***	-0.583**
	(0.277)	(0.252)	(0.269)	(0.228)	(0.260)	(0.222)
Pop. change × RID	0.926	0.804	0.748	1.051*	0.864	0.748
	(0.563)	(0.525)	(0.546)	(0.587)	(0.570)	(0.548)
Investment	0.266***	0.105***	0.154***	0.227***	0.270***	0.0455***
	(0.0195)	(0.0201)	(0.0195)	(0.0213)	(0.0198)	(0.0217)
Investment × RID	-0.176***	-0.190***	-0.133***	-0.217***	-0.169***	-0.156***
	(0.0339)	(0.0347)	(0.0337)	(0.0372)	(0.0344)	(0.0372)
Tertiary education		0.000645**				0.000739**
		(0.000305)				(0.000281)
Tert. education × RID		-0.00117***				-0.00143***
		(0.000311)				(0.000271)
HRST		0.00370**				0.00268
		(0.00176)				(0.00177)
HRST × RID		0.00274				0.00465**
		(0.00224)				(0.00219)
GERD		-0.000322				4.21e-05
		(0.00125)				(0.00128)
GERD × RID		0.00309				0.00222
		(0.00200)				(0.00198)
Age		-0.0907				-0.104
		(0.0704)				(0.0664)
Age × RID		-0.0205				0.0390
		(0.0894)				(0.106)
EQI			0.000485			0.00231
			(0.00319)			(0.00330)
EQI × RID			0.00519*			0.00352
			(0.00262)			(0.00339)
Fund			-1.55e-05			-8.05e-06
			(1.03e-05)			(7.26e-06)
Fund × RID			2.49e-06			-7.62e-07
			(1.23e-05)			(1.26e-05)
Unemployment				-0.000506*		-0.000305
				(0.000260)		(0.000185)
Unemployment × RID				0.000505		0.000700*
				(0.000381)		(0.000409)
Agriculture				-0.0912		0.0228
				(0.0999)		(0.119)
Agriculture × RID				0.234*		0.0503
				(0.132)		(0.140)
Services				0.0920***		0.0874***
				(0.0217)		(0.0287)
Services × RID				-0.0421		-0.109*
				(0.0618)		(0.0617)
CDD					-5.38e-06	1.74e-06
					(1.70e-05)	(1.45e-05)
CDD × RID					-5.22e-05**	-4.64e-05**
					(2.20e-05)	(2.20e-05)
HDD					2.47e-06	3.48e-06
					(2.98e-06)	(2.73e-06)
HDD × RID					-1.32e-06	-3.59e-06
					(3.43e-06)	(3.67e-06)
Latitude					0.000101	0.000217
					(0.000682)	(0.000258)
Latitude × RID					-0.000663	0.000369
					(0.000724)	(0.000275)
Constant	0.160***	0.620***	0.170***	0.311***	0.164***	0.702***
	(0.0500)	(0.0741)	(0.0503)	(0.0710)	(0.0505)	(0.0880)
Observations	904	904	904	904	904	904
R-squared	0.549	0.615	0.579	0.563	0.563	0.611
Heterogeneity (p-value)	0.000	0.000	0.000	0.000	0.000	0.000

Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1. Interaction effects with the degree of rurality are highlighted.

Table 4: Instrumental variable panel data parameter estimation with country fixed effects.

2000-2019	Economic capital	Human capital	Social capital	Economic structure	Environmental capital	Total
	(1)	(2)	(3)	(4)	(5)	(6)
RID	0.00143	-0.208*	0.0677	-0.234***	0.0433	0.456
	(0.0549)	(0.120)	(0.0840)	(0.0773)	(0.0569)	(0.413)
Initial income	-0.0360***	-0.0588***	-0.0477***	-0.0799***	-0.0371***	-0.0754***
	(0.00765)	(0.0109)	(0.0110)	(0.0127)	(0.00811)	(0.0188)
Initial income × RID	-0.00260	0.00910	0.0127	0.0532***	-0.000388	0.0390
	(0.0119)	(0.0178)	(0.0191)	(0.0181)	(0.0126)	(0.0315)
Pop. change	-0.709***	-0.648***	-0.713***	-0.771***	-0.672***	-0.472***
	(0.161)	(0.157)	(0.179)	(0.160)	(0.161)	(0.114)
Pop. change × RID	0.814***	0.754***	0.773***	0.981***	0.763***	0.649***
	(0.261)	(0.250)	(0.282)	(0.261)	(0.260)	(0.293)
Investment	0.0206	0.0804***	0.139***	0.194***	0.218***	0.175***
	(0.0196)	(0.0202)	(0.0203)	(0.0213)	(0.0198)	(0.0272)
Investment × RID	-0.00851	-0.0622***	-0.114***	-0.194***	-0.191***	-0.0798**
	(0.0340)	(0.0348)	(0.0345)	(0.0373)	(0.0345)	(0.0307)
Tertiary education		0.000675***				0.000830***
		(0.000233)				(0.000269)
Tert. education × RID		-0.00119***				-0.00138***
		(0.000357)				(0.000455)
HRST		0.00395***				0.00279
		(0.00133)				(0.00212)
HRST × RID		0.00223				0.00454**
		(0.00228)				(0.00198)
GERD		-0.000200				0.000402
		(0.00131)				(0.00450)
GERD × RID		0.00287				0.00149
		(0.00210)				(0.00759)
Age		-0.0845				-0.105
		(0.0599)				(0.0707)
Age × RID		-0.0354				0.0374
		(0.0890)				(0.129)
EQI			0.00114			0.0133
			(0.00765)			(0.0192)
EQI × RID			0.0461***			0.00779**
			(0.00703)			(0.00296)
Fund			-3.31e-06			-3.22e-06
			(1.23e-05)			(2.35e-05)
Fund × RID			1.55e-05*			-8.76e-07
			(1.95e-06)			(3.59e-05)
Unemployment				-0.000581**		-0.000170
				(0.000243)		(0.000388)
Unemployment × RID				0.000615		0.000771
				(0.000387)		(0.000475)
Agriculture				-0.120*		-0.00425
				(0.0718)		(0.0804)
Agriculture × RID				0.278***		0.0581
				(0.100)		(0.120)
Services				0.109***		0.126
				(0.0273)		(0.0837)
Services × RID				-0.0674		-0.171
				(0.0470)		(0.140)
CDD					-5.00e-06	2.05e-06
					(1.29e-05)	(3.20e-05)
CDD × RID					-5.25e-05**	-5.78e-05**
					(2.12e-05)	(2.92e-05)
HDD					1.97e-06	2.94e-06
					(2.50e-06)	(4.36e-06)
HDD × RID					-5.53e-07	-4.38e-06
					(3.75e-06)	(9.07e-06)
Latitude					3.49e-05	-0.000579
					(0.000535)	(0.00172)
Latitude × RID					-0.000858	-0.000212
					(0.000688)	(0.00251)
Constant	0.188***	0.633***	0.240***	0.361***	0.186***	0.848**
	(0.0354)	(0.0882)	(0.0489)	(0.0541)	(0.0377)	(0.356)
Observations	904	904	904	904	904	904
Heterogeneity (p-value)	0.000	0.000	0.000	0.000	0.000	0.000

Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1. Interaction effects with the degree of rurality are highlighted.

5.3 Spatial autoregressive regression results

While the country fixed effect estimations assumed spatial correlation of economic growth to a certain degree by assigning a common intercept to all regions within a country, that might actually not be the most accurate representation of growth processes in Europe. As most of the continent is a part of the European Union and/or the Schengen area, country borders do not represent large obstacles to growth spillovers anymore. To create a more realistic model of regional growth in Europe, sections 3 and 4 introduce a spatially augmented autoregressive model that takes geographical distance rather than country borders into account. Table 5 reports the results of this parameter estimation. The estimated parameters of the spatial weight matrices (ϕ, ψ, ρ) that represent the degree of spatial externalities, are listed in Table 6.

Despite the introduction of spatial autocorrelation of regional growth rates and growth determinants, previous findings remain largely robust to these changes. Initial income is again found to be highly significant and negatively related to the economic growth rates which is in line with the concept of conditional convergence. Investments and their associated interaction effects, however, do no longer exert any significant influence on the spatially augmented regional growth process. The same loss of significance can be observed in the degree of rurality and the social capital variables that fail to transmit their significance to the all-inclusive regression in column 6. The effects of human capital on the other hand, remain in line with the previous estimations, supporting the negative interaction effect of tertiary education with rurality and the positive one of the share of scientists and engineers in the total population.

When compared to the estimation of the growth processes within countries, the regional economic structure plays a more significant role if spatial spillover effects are specifically accounted for. The share of the agricultural sector exerts a negative influence on the growth rates of more urban regions whereas the effect turns positive the more rural an area is classified as. The service sector is found to have a positive relationship with the growth rates in urban and rural countries with a positive albeit insignificant interaction term. Finally, the structural labour market is accounted for by finding a significantly adverse link between a region's economic growth and its unemployment rate, although the spatially augmented regression does not detect any significant interaction effects. Geographic variables are yet again not significant with the already previously established exception of the number of cooling degree days.

Another critical part of this spatial analysis are the spillover effects and the degree of spatial autocorrelation of the growth determinants. Several variables are estimated to have a significant spatial impact on economic growth. Intuitively and in line with Ketterer and Rodríguez-Pose (2018), environmental spillover effects are excluded. The initial level of GDP per capita, especially in neighbouring rural regions, appears to lead to positive regional growth effects that are however not consistently significant. Population change spillovers from rural regions appear to be negative but remain insignificant. Moreover, the coefficients for capital investments are positive and significant to some degree, yet the interaction variable shows a negative sign and is of high significance indicating that investments in neighbouring rural regions are detrimental to local economic growth rates.

The spillover analysis for the human capital variables reveals that the level of tertiary education in other regions positively affects growth whereas its spillover effects from rural regions in total are close to zero. The human resources employed in science and technology fields in surrounding areas affect the growth rates negatively while their spillovers from rural regions appear to be more positive. An interesting observation can be made when looking at the share of the population that is of a "working age" (15-64) which has a highly significant positive spillover effect coming from predominantly rural areas. A possible explanation for this phenomenon might be found in commuters and migratory patterns as the effects appear to be negative with more urban neighbouring regions.

Social capital is found not to exert any significant spillover effects when accounting for all variables (column 6) whereas the economic structure of surrounding regions does possess some significant spatial autocorrelation effects. The spatial externalities of shares of the agricultural and service sector are found to be negative. Significant rural interaction effects however, are not determined. Finally, the economic growth rates of neighbouring regions are highly significant and positively affect local GDP growth which is a clear sign of present growth spillovers.

Table 5: Spatially augmented autoregressive parameter estimation.

2000-2019	Economic capital	Human capital	Social capital	Economic structure	Environmental capital	Total
	(1)	(2)	(3)	(4)	(5)	(6)
RID	0.0337	0.120	0.0986	-0.0442	0.0946	-0.150
	(0.0575)	(0.0849)	(0.0612)	(0.0767)	(0.0667)	(0.101)
Initial income	-0.0449***	-0.0596***	-0.0514***	-0.0734***	-0.0390***	-0.0937***
	(0.00922)	(0.0106)	(0.00973)	(0.0131)	(0.00862)	(0.0132)
Initial income × RID	-0.0106	0.00222	-0.0260*	0.00885	-0.0206*	0.00436
	(0.0126)	(0.0148)	(0.0135)	(0.0178)	(0.0122)	(0.0183)
Pop. change	-0.426***	-0.492***	-0.408**	-0.483***	-0.398**	-0.430***
	(0.162)	(0.157)	(0.162)	(0.161)	(0.161)	(0.158)
Pop. change × RID	0.570**	0.519**	0.555**	0.597**	0.596**	0.496**
	(0.255)	(0.245)	(0.254)	(0.256)	(0.251)	(0.245)
Investment	0.0183	0.0129	0.0245	0.0283	0.0223	0.00961
	(0.0210)	(0.0202)	(0.0208)	(0.0224)	(0.0203)	(0.0206)
Investment × RID	-0.00712	-0.0215	-0.0236	-0.0372	-0.0249	-0.0373
	(0.0354)	(0.0342)	(0.0350)	(0.0377)	(0.0345)	(0.0343)
Tertiary education		0.000588***				0.000745***
		(0.000221)				(0.000223)
Tert. education × RID		-0.00135***				-0.00149***
		(0.000355)				(0.000358)
HRST		0.00114				-0.000787
		(0.00137)				(0.00137)
HRST × RID		0.00626***				0.00711***
		(0.00217)				(0.00215)
GERD		-0.00208				-0.00105
		(0.00145)				(0.00152)
GERD × RID		0.00352				0.00157
		(0.00234)				(0.00242)
Age		0.188***				0.129**
		(0.0577)				(0.0578)
Age × RID		-0.110				-0.0508
		(0.0823)				(0.0878)
EQI			-0.00165			-0.00149
			(0.00196)			(0.00204)
EQI × RID			0.00739***			-7.32e-05
			(0.00271)			(0.00303)
Fund			-2.73e-05***			-1.02e-05
			(9.85e-06)			(8.64e-06)
Fund × RID			4.46e-05***			2.03e-05
			(1.51e-05)			(1.40e-05)
Unemployment				-0.000204		-0.000691**
				(0.000254)		(0.000273)
Unemployment × RID				-0.000650		0.000260
				(0.000401)		(0.000416)
Agriculture				-0.232***		-0.182***
				(0.0781)		(0.0697)
Agriculture × RID				0.286***		0.294***
				(0.109)		(0.0973)
Services				0.0494*		0.0563**
				(0.0296)		(0.0261)
Services × RID				0.00845		0.0396
				(0.0498)		(0.0451)
CDD					1.69e-05	2.99e-05**
					(1.33e-05)	(1.27e-05)
CDD × RID					-5.29e-05**	-3.38e-05**
					(2.25e-05)	(1.12e-05)
HDD					5.17e-06**	5.62e-06
					(2.23e-06)	(3.24e-06)
HDD × RID					-2.81e-06	-2.83e-06
					(3.42e-06)	(3.37e-06)
Longitude					-0.000138	-0.000293
					(0.000202)	(0.000208)
Longitude × RID					-7.42e-05	0.000118
					(0.000299)	(0.000286)
Constant	0.217***	0.143**	0.248***	0.339***	0.181***	0.319***
	(0.0418)	(0.0575)	(0.0441)	(0.0562)	(0.0400)	(0.0676)
Observations	904	904	904	904	904	904
R-squared	0.358	0.473	0.401	0.355	0.418	0.521
Heterogeneity (p-value)	0.000	0.000	0.000	0.000	0.000	0.000

Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1. Interaction effects with the degree of rurality are highlighted.

Table 6: Degrees of spatial autocorrelation – Estimated parameters of the weight matrix.

2000-2019	Economic capital	Human capital	Social capital	Economic structure	Environmental capital	Total
	(1)	(2)	(3)	(4)	(5)	(6)
Initial income	-0.00680	-0.0132**	-0.0201**	0.0257	-0.0108	0.0628
	(0.00802)	(0.00514)	(0.00998)	(0.0231)	(0.00751)	(0.129)
Initial income × RID	0.0418***	0.0881**	0.0610***	0.0309	0.0491***	-0.151
	(0.0148)	(0.0419)	(0.0177)	(0.0397)	(0.0140)	(0.0975)
Pop. change	-0.984	0.212	-0.404	-0.579	0.00873	0.611
	(0.927)	(1.099)	(0.962)	(1.194)	(0.951)	(1.303)
Pop. change × RID	-0.597	0.418	-0.988	-1.600	-2.130	-1.272
	(1.758)	(2.063)	(1.970)	(2.178)	(1.844)	(2.661)
Investment	-0.0208	0.595***	0.0640	-0.148	0.0242	0.736***
	(0.151)	(0.181)	(0.161)	(0.169)	(0.141)	(0.213)
Investment × RID	-0.719***	-1.793***	-0.862***	-0.630**	-0.841***	-2.188***
	(0.270)	(0.322)	(0.284)	(0.295)	(0.254)	(0.376)
Tertiary education		0.00916***				0.0120***
		(0.00192)				(0.00235)
Tert. education × RID		-0.0158***				-0.0152***
		(0.00365)				(0.00492)
HRST		-0.0596***				-0.0663***
		(0.0104)				(0.0120)
HRST × RID		0.0910***				0.0657**
		(0.0216)				(0.0269)
GERD		0.00775				0.0207
		(0.0128)				(0.0143)
GERD × RID		0.0175				-0.0470
		(0.0267)				(0.0321)
Age		-1.217***				-1.577***
		(0.339)				(0.385)
Age × RID		1.980***				2.024***
		(0.537)				(0.604)
EQI			0.0283**			0.0206
			(0.0137)			(0.0149)
EQI × RID			-0.0262			-0.00831
			(0.0242)			(0.0301)
Fund			2.17e-05			-5.94e-05
			(9.77e-05)			(0.000113)
Fund × RID			4.65e-06			0.000109
			(0.000153)			(0.000179)
Unemployment				0.00236		0.00110
				(0.00174)		(0.00238)
Unemployment × RID				-0.00533*		-0.00583
				(0.00322)		(0.00459)
Agriculture				0.400		-0.879***
				(0.956)		(0.312)
Agriculture × RID				-1.012		-0.222
				(1.358)		(0.564)
Services				-0.478*		-0.575*
				(0.263)		(0.327)
Services × RID				0.131		-0.0210
				(0.494)		(0.613)
Economic growth	1.688***	1.921***	1.725***	1.770***	1.645***	2.669***
	(0.0748)	(0.0890)	(0.0786)	(0.0875)	(0.0754)	(0.140)
Observations	904	904	904	904	904	904
R-squared	0.358	0.473	0.401	0.355	0.418	0.521
Heterogeneity (p-value)	0.000	0.000	0.000	0.000	0.000	0.000

Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1. Interaction effects with degree of rurality are highlighted.

6 Conclusion

In this thesis I have investigated how the degree of rurality affects different determinants of economic growth in European regions. Data from between 2000 and 2019 of 226 NUTS-2 regions representing 26 different European Union member states was included in the study. The paper is addressing the issue of regional economic growth and rurality in Europe through an empirical analysis focused directly on the relevant interaction effects. Its findings are largely confirming economic intuition as differences in economic growth determination between rural and urban regions emerge. By highlighting the significant interaction effects of several commonly referred to categories of growth determinants and regional structural development it helps to explain the heterogeneous growth processes within the EU but also within its member states.

As a whole, the empirical results reflect the importance of a region's typology as several determinants are affecting economic growth significantly different in predominantly rural regions as they do in more urban areas. Capital investments, tertiary education, the level of initial income and the number of cooling degree days are found to have negative interaction effects with regional rurality, whereas the growth effects of population change, human resources in science and technology, the institutional quality, government funding and the agricultural sector appear to be positively affected by the degree of rurality. The classification of regions into rural and urban areas emerges as a fundamental factor for economic development in the EU. Interaction effects are present in all categories of capital but especially economic and human capital growth effects seem to be affected by the degree of rurality. Social capital and the regional economic structure also experience significant interaction effects to a certain degree while the environmental capital growth effects do not appear to vary a lot between rural and urban areas. These findings are corroborated by different model specifications and changes in the estimation techniques. By accounting for heteroskedasticity, country fixed effects, endogeneity and spatial autocorrelation the robustness of the results is confirmed.

Overall, my empirical findings highlight the heterogeneity in growth processes within the European Union but also within its member states through the importance of regional structural development in the form of its rural typology. This has significant implications for European cohesion and regional economic policies as the degree of a region's rurality has to be taken into account. Understanding these rural and urban discrepancies is vital to achieve a more comparable development of regional economic growth, fostering the convergence process. Knowing the interaction effects of the different growth determinant groups with regional development can help to forge more effective and efficient policies bolstering growth in structurally lagging regions.

The interaction effect approach used in this thesis allows for further analysis of growth heterogeneity in future research endeavours. One could include different variables or categories like cultural capital in the estimations of the effect of rurality. Alternatively, the implementation of other interaction variables allows for new perspectives on the growth processes in Europe or other regions in the world. Moreover, focusing on one of the previously analysed categories and adding more depth to it by introducing additional, more nuanced data could be another starting point for empirical investigations. In addition, further data availability or different model estimation techniques like a system-GMM might also warrant new topical approaches that reduce endogeneity concerns and enhance the robustness of the results.

References

Acemoglu, Daron, Simon Johnson, and James A Robinson (2001). "The colonial origins of comparative development: An empirical investigation". In: *American economic review* 91.5, pp. 1369–1401.

Acemoglu, Daron, Suresh Naidu, et al. (2019). "Democracy does cause growth". In: *Journal of political economy* 127.1, pp. 47–100.

Agarwal, Sheela, Sanzidur Rahman, and Andrew Errington (2009). "Measuring the determinants of relative economic performance of rural areas". In: *Journal of Rural Studies* 25.3, pp. 309–321.

Aghion, Philippe and Peter Howitt (1992). "A Model of Growth Through Creative Destruction". In: *Econometrica* 60.323, p. 51.

Aghion, Philippe and Peter W Howitt (2008). *The economics of growth.* MIT press.

Alexiou, Constantinos (2009). "Government spending and economic growth: Econometric evidence from the South Eastern Europe (SEE)". In: *Journal of Economic and social research* 11.1, p. 1.

Armstrong, Harvey, Jim Taylor, and Jim Taylor (2000). "Regional economics and policy". In.

Artelaris, Panagiotis, Dimitris Kallioras, and George Petrakos (2010). "Regional inequalities and convergence clubs in the European Union new member-states". In: *Eastern Journal of European Studies* 1.1, p. 113.

Barkley, David L, Mark S Henry, and Haizhen Li (2004). *Does human capital affect rural economic growth? Evidence from the South.* Tech. rep.

Barro, R and Xavier Sala-i-Martin (2004). *Economic growth second edition.*

Barro, Robert J (1996). "Democracy and growth". In: *Journal of economic growth* 1.1, pp. 1–27.

Barro, Robert J et al. (2003). "Determinants of economic growth in a panel of countries". In: *Annals of economics and finance* 4, pp. 231–274.

Becker, Gary S (1964). *Human capital: A theoretical and empirical analysis, with special reference to education.* University of Chicago press.

Benos, Nikos, Stelios Karagiannis, and Sotiris Karkalakos (2015). "Proximity and growth spillovers in European regions: The role of geographical, economic and technological linkages". In: *Journal of Macroeconomics* 43, pp. 124–139.

Bisciari, Patrick, Dennis Essers, Evelien Vincent, et al. (2020). "Does the EU convergence machine still work?" In: *National Bank of Belgium Economic Review.*

Bruce, David et al. (2010). "Nurturing the animation sector in a peripheral economic region: the case of Miramichi, New Brunswick". In: *The next rural economies: Constructing rural place in global economies*, pp. 128–141.

Bryden, JM et al. (2004). "Scotland-North and South". In: *Why Local Economies Differ: The Dynamics of Rural Areas in Europe. Edwin-Mellen Press, Lampeter.*

Bryden, John and Keith Hart (2001). "Dynamics of rural areas (DORA): the international comparison". In: *Aberdeen. Available at: http://www. abdn. ac. uk/irr/arkleton/documents/icfinal. pdf (Accessed March 05 2013).*

— (2005). *Why local economies differ: the dynamics of rural areas in Europe.*

Bryden, John M and Shirley P Dawe (1998). "Development strategies for remote rural regions: what do we know so far". In: *Keynote Paper for the OECD International Conference on remote rural areas–developing through natural and cultural assets, Albarracin, Spain*, pp. 5–6.

Capello, Roberta (2009). "Spatial spillovers and regional growth: a cognitive approach". In: *European Planning Studies* 17.5, pp. 639–658.

Chand, Ramesh and SK Srivastava (2014). "Changes in the rural labour market and their implications for agriculture". In: *Economic and Political Weekly*, pp. 47–54.

Charron, Nicholas, Lewis Dijkstra, and Victor Lapuente (2015). "Mapping the regional divide in Europe: A measure for assessing quality of government in 206 European regions". In: *Social indicators research* 122.2, pp. 315–346.

Charron, Nicholas, Victor Lapuente, and Paola Annoni (2019). "Measuring quality of government in EU regions across space and time". In: *Papers in Regional Science* 98.5, pp. 1925–1953.

Charron, Nicholas, Victor Lapuente, and Monika Bauhr (2021). "Sub-national Quality of Government in EU Member States: Presenting the 2021 European Quality of Government Index and its relationship with Covid-19 indicators". In: *The QoG Working Paper Series* 4.

Charron, Nicholas, Victor Lapuente, and Lewis Dijkstra (2012). "Regional governance matters: A study on regional variation in quality of government within the EU". In: *Regional Studies* 48.1, pp. 68–90.

Ciccone, Antonio and Marek Jarocinski (2010). "Determinants of economic growth: will data tell?" In: *American Economic Journal: Macroeconomics* 2.4, pp. 222–46.

Cornett, Andreas P and Nils Karl Sørensen (2008). "International vs. intra-national convergence in Europe-An assessment of causes and evidence". In: *Investigaciones Regionales-Journal of Regional Research* 13, pp. 35–56.

Cuaresma, Jesús Crespo, Gernot Doppelhofer, and Martin Feldkircher (2014). "The determinants of economic growth in European regions". In: *Regional Studies* 48.1, pp. 44–67.

Dabson, Brian et al. (2001). "Supporting rural entrepreneurship". In: *Exploring policy options for a new rural America*, pp. 35–48.

Deller, Steven C et al. (2001). "The role of amenities and quality of life in rural economic growth". In: *American journal of agricultural economics* 83.2, pp. 352–365.

Diamond, Jared M and Doug Ordunio (1999). *Guns, germs, and steel.* Vol. 521. Books on Tape.

Dijkstra, Lewis, Enrique Garcilazo, and Philip McCann (2015). "The effects of the global financial crisis on European regions and cities". In: *Journal of Economic Geography* 15.5, pp. 935–949.

Dollar, David and Aart Kraay (2003). "Institutions, trade, and growth". In: *Journal of monetary economics* 50.1, pp. 133–162.

Ertur, Cem and Wilfried Koch (2007). "Growth, technological interdependence and spatial externalities: theory and evidence". In: *Journal of applied econometrics* 22.6, pp. 1033–1062.

European Commission (2021). *A long-term Vision for the EU's Rural Areas - Towards stronger, connected, resilient and prosperous rural areas by 2040.* Communication 345. Brussels: European Commission.

Fortunato, Michael William-Patrick (2014). "Supporting rural entrepreneurship: A review of conceptual developments from research to practice". In: *Community development* 45.4, pp. 387–408.

Freshwater, David (2016). "Economic Transformations: understanding the determinants of rural growth". In: *Routledge international handbook of rural studies.* Routledge, pp. 129–137.

Freshwater, David and Timothy J Wojan (2014). *User Entrepreneurship: Defining and Identifying Explicit Type of Innovation*. Tech. rep.

Gagliardi, Luisa and Marco Percoco (2017). "The impact of European Cohesion Policy in urban and rural regions". In: *Regional Studies* 51.6, pp. 857–868.

Gallup, John Luke, Jeffrey Sachs, and Andrew D Mellinger (1998). "Geography and economic growth". In.

Glaeser, Edward L et al. (2004). "Do institutions cause growth?" In: *Journal of economic Growth* 9.3, pp. 271–303.

Green, Anne (2016). "Changing dynamics of rural labour markets". In: *Routledge International Handbook of Rural Studies*, pp. 143–153.

Haaf, K and CJM Kool (2017). "Determinants of regional growth and convergence in Germany". In: *USE Discussion Paper Series* 17.12.

Hauk, William R and Romain Wacziarg (2009). "A Monte Carlo study of growth regressions". In: *Journal of Economic Growth* 14.2, pp. 103–147.

Hjaltadóttir, Rannveig Edda, Teemu Makkonen, and Timo Mitze (2020). "Inter-regional innovation cooperation and structural heterogeneity: Does being a rural, or border region, or both, make a difference?" In: *Journal of Rural Studies* 74, pp. 257–270.

Hsieh, Edward and Kon S Lai (1994). "Government spending and economic growth: the G-7 experience". In: *Applied Economics* 26.5, pp. 535–542.

Huang, Jikun, Qi Zhang, and Scott Rozelle (2007). "Determinants of rural poverty reduction and pro-poor economic growth in China". In: *conference on taking action for the world's poor and hungry people*, pp. 17–19.

Iverson, Roderick D and Catherine Maguire (2000). "The relationship between job and life satisfaction: Evidence from a remote mining community". In: *Human relations* 53.6, pp. 807–839.

Johnson, Bradley R (1990). "Toward a multidimensional model of entrepreneurship: The case of achievement motivation and the entrepreneur". In: *Entrepreneurship Theory and practice* 14.3, pp. 39–54.

Ketterer, Tobias D and Andrès Rodríguez-Pose (2018). "Institutions vs.'first-nature'geography: What drives economic growth in Europe's regions?" In: *Papers in Regional Science* 97, S25–S62.

Khan, Muhammad, Saqlain Raza, and Xuan Vinh Vo (2020). “Government spending and economic growth relationship: can a better institutional quality fix the outcomes?” In: *The Singapore Economic Review*, pp. 1–23.

Kramar, Hans (2015). “Regional convergence and economic development in the EU: the relation between national growth and regional disparities within the old and the new member states”. In.

McElwee, Gerard and Andrew Atherton (2021). “Rural entrepreneurship”. In: *World encyclopedia of entrepreneurship*. Edward Elgar Publishing.

Mitchell, Daniel J et al. (2005). “The impact of government spending on economic growth”. In: *The Heritage Foundation* 1813, pp. 1–18.

Mohl, Philipp and Tobias Hagen (2010). “Do EU structural funds promote regional growth? New evidence from various panel data approaches”. In: *Regional Science and Urban Economics* 40.5, pp. 353–365.

North, David and David Smallbone (1996). “Small business development in remote rural areas: the example of mature manufacturing firms in Northern England”. In: *Journal of Rural Studies* 12.2, pp. 151–167.

— (2006). “Developing entrepreneurship and enterprise in Europe’s peripheral rural areas: Some issues facing policy-makers”. In: *European Planning Studies* 14.1, pp. 41–60.

O’Hagan, Sean B and Ben P Cecil (2007). “A macro-level approach to examining Canada’s primary industry towns in a knowledge economy”. In: *Journal of rural and community development* 2.2.

OECD (2011). *Regions and Innovation Policy*. OECD Reviews of Regional Innovation, OECD Publishing.

Paci, Raffaele (1997). “More similar and less equal: economic growth in the European regions”. In: *Review of World Economics* 133.4, pp. 609–634.

Pinho, Carlos, Celeste Varum, and Micaela Antunes (2015). “Structural funds and European regional growth: Comparison of effects among different programming periods”. In: *European Planning Studies* 23.7, pp. 1302–1326.

Porter, Michael E (1996). “Competitive advantage, agglomeration economies, and regional policy”. In: *International regional science review* 19.1-2, pp. 85–90.

Rodríguez-Pose, Andrès and Riccardo Crescenzi (2008). "Research and development, spillovers, innovation systems, and the genesis of regional growth in Europe". In: *Regional studies* 42.1, pp. 51–67.

Rodríguez-Pose, Andrès and Roberto Ganau (2022). "Institutions and the productivity challenge for European regions". In: *Journal of Economic Geography* 22.1, pp. 1–25.

Romer, Paul M (1990). "Endogenous technological change". In: *Journal of political Economy* 98.5, Part 2, S71–S102.

Rupasingha, Anil, Stephan J Goetz, and David Freshwater (2002). "Social and institutional factors as determinants of economic growth: Evidence from the United States counties". In: *Papers in regional Science* 81.2, pp. 139–155.

Sachs, Jeffrey D and Andrew M Warner (2001). "The curse of natural resources". In: *European economic review* 45.4-6, pp. 827–838.

Solow, Robert M (1956). "A contribution to the theory of economic growth". In: *The quarterly journal of economics* 70.1, pp. 65–94.

Swan, Trevor W (1956). "Economic growth and capital accumulation". In: *Economic record* 32.2, pp. 334–361.

Van Der Gaag, Nicole and Joop De Beer (2015). "From Demographic Dividend to Demographic Burden: The Impact of Population Ageing on Economic Growth in E urope". In: *Tijdschrift voor economische en sociale geografie* 106.1, pp. 94–109.

Wu, Jie, Shuaihe Zhuo, and Zefu Wu (2017). "National innovation system, social entrepreneurship, and rural economic growth in China". In: *Technological Forecasting and Social Change* 121, pp. 238–250.

A Appendix

Table B.1: Sample of 226 European NUTS-2 regions used in the empirical analysis.

Austria		
Burgenland	Oberösterreich	Tirol
Kärnten	Salzburg	Wien
Niederösterreich	Steiermark	Vorarlberg
Belgium		
Prov. Antwerpen	Prov. Limburg (B)	Prov. Oost-Vlaanderen
Prov. Brabant Wallon	Région de Bruxelles-Capitale	Prov. Vlaams Brabant
Prov. Hainaut Prov.	Luxembourg (B)	Prov. West-Vlaanderen
Prov. Liége	Prov. Namur	
Bulgaria		
Severen tsentralen	Severozapaden	Yugozapaden
Severoiztochen	Yugoiztochen	Yuzhentsentralen
Croatia		
Jadranska Hrvatska		
Cyprus		
Cyprus		
Czech Republic		
Jihovychod	Praha	Jihozapad
Severozapad	Stredni Morava	Moravskoslezsko
Stredni Cechy	Severovychod	
Denmark		
Hovedstaden	Sjælland	Syddanmark
Midtjylland	Nordjylland	
Estonia		
Eesti		
Finland		
Itä-Suomi	Pohjois-Suomi	Etelä-Suomi
Länsi-Suomi		
France		
Ile-de-France	Centre — Val de Loire	Bourgogne
Franche-Comté	Basse-Normandie	Haute-Normandie
Nord-Pas de Calais	Picardie	Alsace
Champagne-Ardenne	Lorraine	Pays de la Loire
Bretagne	Aquitaine	Limousin
Poitou-Charentes	Languedoc-Roussillon	Midi-Pyrénées

Auvergne	Rhône-Alpes	Provence-Alpes-Côte d'Azur
Corse		
Germany		
Stuttgart	Karlsruhe	Freiburg
Tübingen	Oberbayern	Niederbayern
Oberpfalz	Oberfranken	Mittelfranken
Unterfranken	Schwaben	Berlin
Brandenburg	Bremen	Hamburg
Darmstadt	Gießen	Kassel
Mecklenburg-Vorpommern	Braunschweig	Hannover
Lüneburg	Weser-Ems	Düsseldorf
Köln	Münster	Detmold
Arnsberg	Koblenz	Trier
Rheinhessen-Pfalz	Saarland	Dresden
Chemnitz	Leipzig	Sachsen-Anhalt
Schleswig-Holstein	Thüringen	
Greece		
Attiki	Voreio Aigaio	Notio Aigaio
Kriti	Anatoliki Makedonia, Thraki	Kentriki Makedonia
Dytiki Makedonia	Ipeiros	Thessalia
Ionia Nisia	Dytiki Ellada	Sterea Ellada
Peloponnisos		
Hungary		
Közép-Dunántúl	Nyugat-Dunántúl	Dél-Dunántúl
Észak-Magyarország	Észak-Alföld	Dél-Alföld
Italy		
Piemonte	Valle d'Aosta/Vallée d'Aoste	Liguria
Lombardia	Abruzzo	Molise
Campania	Puglia	Basilicata
Calabria	Sicilia	Sardegna
Provincia Autonoma di Bolzano/Bozen	Provincia Autonoma di Trento	Veneto
Friuli-Venezia Giulia	Emilia-Romagna	Toscana
Umbria	Marche	Lazio
Latvia		
Latvija		
Lithuania		
Sostines regionas	Vidurio ir vakaru Lietuvos regionas	
Luxembourg		

Luxembourg (Grand-Duché)		
Malta		
Malta		
Netherlands		
Drenthe	Groningen	Overijssel
Flevoland	Limburg (NL)	Utrecht
Friesland	Noord-Brabant	Zeeland
Gelderland	Noord-Holland	Zuid-Holland
Poland		
Malopolskie	Slaskie	Wielkopolskie
Zachodniopomorskie	Lubuskie	Dolnoslaskie
Opolskie	Kujawsko-Pomorskie	Warminsko-Mazurskie
Pomorskie	Lódzkie	Swietokrzyskie
Lubelskie	Podkarpackie	Podlaskie
Warszawski stoleczny	Mazowiecki regionalny	
Portugal		
Norte	Algarve	Centro (PT)
Área Metropolitana de Lisboa	Alentejo	
Romania		
Nord-Vest	Centru	Nord-Est
Sud-Est	Sud - Muntenia	Bucuresti - Ilfov
Sud-Vest Oltenia	Vest	
Slovak Republic		
Bratislavský kraj	Západné Slovensko	Stredné Slovensko
Východné Slovensko		
Slovenia		
Vzhodna Slovenija	Zahodna Slovenija	
Spain		
Galicia	Principado de Asturias	Cantabria
País Vasco	Comunidad Foral de Navarra	La Rioja
Aragón	Comunidad de Madrid	Castilla y León
Castilla-La Mancha	Extremadura	Cataluña
Comunitat Valenciana	Illes Balears	Andalucía
Región de Murcia	Ciudad de Ceuta	Ciudad de Melilla
Sweden		
Stockholm	Östra Mellansverige	Småland med öarna
Sydsverige	Västsverige	Norra Mellansverige

Mellersta Norrland	Övre Norrland

Table B.2: Descriptive statistics of all the variables used in the empirical analysis.

Variable name	Description	Source	Min	Mean	Max
Dependent variable					
Economic growth	Growth rate of real GDP per capita in PPS	Eurostat, own computations	-0.039	0.030	0.124
Interaction variable					
RID	Degree of a region's rurality on an index scale	European Commission, own computations	0.000	0.555	1.000
1. Economic capital					
Initital income	Initial real GDP per capita in PPS	Eurostat, own computations	3.532	4.307	4.890
Population change	Growth rate of population	Eurostat	-0.056	0.002	0.039
Investment	Initial share of GFCF in GVA	ARDECO, Eurostat	0.080	0.250	0.500
2. Human capital					
Tertiary education	Share of population aged between 25-64 with a higher level of education	Eurostat	5.400	22.875	54.100
HRST	Share of total population that works as scientist and engineers	Eurostat	0.600	2.918	9.600
GERD	Share of GDP spent on Research & Development	Eurostat, OECD	0.000	1.430	9.350
Age	Share of total population aged 15 to 64	Eurostat	0.600	0.667	0.741
3. Social capital					
EQI	European Quality of Government Index	Charron et al. (2021) Charron et al. (2019) Charron et al. (2015)	-2.693	0.117	1.885

		Charron et al. (2012)			
Fund	Annual payments of European structural and investment funds as a share of GDP in PPS	European Commission	0.000	0.858	12.067
4. Economic structure					
Unemployment	Unemployment rate of population aged 15 to 74	Eurostat	1.900	9.648	34.000
Agriculture	Share of NACE A (Agriculture) of total GVA	ARDECO, Eurostat	-0.009	0.035	0.189
Services	Share of NACE K to N (Financial & Business Services) of total GVA	ARDECO, Eurostat	0.094	0.217	0.472
5. Environmental capital					
CDD	Cooling degree days	Eurostat	0.000	1.023	8.025
HDD	Heating degree days	Eurostat	0.341	26.906	69.522
Longitude	Distance from prime meridian measured in degrees	GISCO	-9.044	11.594	33.225
6. Historical instruments					
Roman Empire	Dummy variable indicating whether a region belonged to the Roman empire at its greatest extent in 117 AD	Ketterer et al. (2018), own computations	0.000	0.619	1.000
Charlemagne	Dummy variable indicating whether a region belonged to Charlemagne's empire at the time of his death in 814 AD	Ketterer et al. (2018), own computations	0.000	0.556	1.000

Table B.3: European Quality of Government Index (EQI) and economic growth. First stage

2000-2019	EQI
	(1)
Past initial income	2.230***
	(0.123)
Past investment	-0.444
	(0.433)
Dummy Roman Empire	-0.640***
	(0.0492)
Dummy Charlemagne	0.476***
	(0.0545)
Constant	-9.096***
	(0.510)
Observations	904
F-statistic of joint significance	203.78
F-statistic (p-value)	0.000
R-squared	0.476

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1