Bridging the Innovation Gap - How Regional Quality of Government shapes Innovation across Europe

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Heidelberg, den 29. Januar 2025



Gregor Louis Mas

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List of abbreviations

Abbreviation	Definition
2SLS	Two-Stage least squares
CATI	Computer-assisted telephone interviews
CIS	Community Innovation Survey
CRE	Correlated Random Effects
EIS	European Innovation Scoreboard
EMP	Unemployment rate
EQI	European Quality of Government Index
EU	European Union
FE	Fixed-Effects
GDP	Gross Domestic Product
IP	Intellectual Property
IV	Instrumental Variable
NUTS	Nomenclature of territorial units for statistics
OECD	Organisation for Economic Co-operation and Development
OLS	Ordinary least squares
POP	Population density
RE	Random Effects
R&D	Research and Development
RII	Regional Innovation Index
RIS	Regional Innovation Scoreboard
WGI	World Governance Indicators

1. Introduction

In September 2024, Mario Draghi released a report calling for urgent action to close Europe's "innovation gap" with global competitors like China and the United States. Draghi pointed to Europe's challenge not as a lack of ideas or skilled labor but as the result of "inconsistent and restrictive regulations" holding back innovation (Draghi, 2024). Around the same time, Daron Acemoglu, Simon Johnson, and James Robinson were awarded the Sveriges Riksbank Prize in Economic Sciences for their influential research on how institutions shape economic prosperity (Nobel Prize, 2024). Their work highlighted a powerful truth: strong institutions are a key driver of long-term economic success (Acemoglu et al., 2001). These two perspectives converge on a critical insight: institutions matter.

Building on this understanding, this study examines how regional quality of government influences innovation outcomes across European regions. Framework conditions and macroeconomic variables are spread unevenly within Europe, posing a formidable challenge to achieving sustained, widespread innovation. By focusing on regional variations, it provides a granular understanding of how institutions shape innovation and, ultimately, economic development. The central hypothesis is clear: robust institutions foster innovation, which in turn drives economic development. However, this relationship is far from uniform. Institutional quality may have disproportionate effects on poorer regions, where improvements in governance could yield transformative impacts. Conversely, in wealthier regions, the marginal returns to institutional improvements might be smaller, with economic output playing a more significant role in driving innovation. Addressing this heterogeneity is essential for crafting targeted policy interventions aimed at reducing regional disparities and enhancing Europe's overall innovative capacity.

This study expands on a growing body of literature highlighting the importance of governance quality in fostering innovation. Research suggests that stronger institutions — marked by reduced corruption and effective governance — drive higher levels of innovation, as shown by studies on patent activity and government accountability (Rodriguez-Pose and Di Cataldo, 2015; D'Ingiullo and Evangelista, 2020). Historical reforms, such as the Napoleonic Civil Code, further highlight how institutional improvements can sustain long-term innovation (Donges et al., 2023). Despite these findings, significant gaps remain. Much of the existing research relies on narrow proxies for innovation, such as

patent filings or research and development expenditure, which fail to capture its multidimensional nature. This study addresses these limitations by employing the Regional Innovation Scoreboard (RII), a comprehensive measure that reflects the diverse components of regional innovative capacity (European Commission, 2024).

The primary research question guiding this study is: "How does regional Quality of Government shape innovation outcomes across European regions?". In addressing this, the study also delves deeper into whether this relationship is linear or if improvements in institutional quality have a disproportionate impact on poorer regions. Additionally, it examines the complex interplay between regional economic output, institutional quality, and innovation, shedding light on the conditions under which these factors jointly influence regional innovation ecosystems.

Other than incorporating the more comprehensive and multidimensional RII, this research advances the field by addressing a key challenge in institutional research: endogeneity. Institutional quality and innovation are deeply interconnected, making it difficult to establish causality. This study adopts an instrumental variable approach to disentangle these effects, ensuring more robust and reliable findings (Zhang and Rodríguez-Pose, 2024). Additionally, it incorporates a Correlated Random Effects model to account for unobserved heterogeneity across regions, providing a more nuanced understanding of the interplay between governance, economic output, and innovation.

The key findings contribute significantly to existing literature. First, they confirm that institutional quality consistently drives regional innovation in Europe. Second, they provide compelling evidence of diminishing returns to institutional quality, where governance improvements yield greater benefits in less-developed regions. Third, the results suggest a threshold effect: in poorer regions, increases in income alone do not translate into higher levels of innovation unless institutional frameworks are sufficiently robust. Conversely, in wealthier regions, economic output plays a more significant role, with governance quality complementing innovation independently on a less pronounced level.

The paper is organized as follows: A theoretical framework (Chapter 2) explores the conceptual links between institutions, innovation, and economic growth, grounding the research in existing literature. Chapter 3 describes the dataset, key variables, and econometric methods employed, highlighting the rationale for using the Correlated Random Effects model and an instrumental variable approach. The main findings, including base model outputs, subsample analyses, and robustness tests are presented in Chapter 4. The discussion formally interprets the results in the context of broader literature, emphasizing the practical implications. Finally, the conclusion summarizes key findings, highlights policy recommendations, and suggests avenues for future research.

2. Theoretical Framework

For many years, one of the main goals of economic study has been to comprehend the causes of income inequality (Acemoglu et al., 2004). Innovation and technological progress have long been central to economic growth theories. Since Schumpeter's seminal work on creative destruction (Shumpeter, 1911), advancements in technology have been considered essential to sustain long-term prosperity (Solow, 1957; Romer, 1986). Endogenous growth models further highlight how innovation-driven technological advancements are not merely external forces but are shaped by intentional investments in research and development (R&D) and human capital (Romer, 1986). The ability of firms and economies to innovate has thus become a defining factor in explaining persistent differences in income levels across countries, reflecting varying capacities to generate, adapt, and diffuse new technologies (Kogan et al., 2017).

More recently, research has moved toward examining the social and institutional frameworks that enable innovation (Zhang and Rodríguez-Pose, 2024). Scholars emphasize the role of institutions in fostering environments conducive to technological progress (Acemoglu et al., 2001, 2004). As the "rules of the game" (North, 1990), institutions shape incentives, reduce uncertainty, and promote stability, laying the foundation for technological progress, and ultimately, economic development. Well-functioning institutions encourage investment, innovation, and productive activity, while weak institutions hinder progress through inefficiency and rent-seeking behavior (Acemoglu et al., 2001; Rodriguez-Pose and Di Cataldo, 2015). Conversely, traditional drivers of innovation, such as R&D-spending and human capital, are themselves strongly influenced by the broader institutional environment (Zhang and Rodríguez-Pose, 2024). Government institutions play a critical role by managing economic uncertainty, facilitating coordination among actors, and shaping collective decision-making processes (Rodriguez-Pose and Di Cataldo, 2015).

2.1. Institutions, Innovation, and Growth: The Mechnanisms

North (1990) defines institutions as "the rules of the game in a society or, more formally, the humanly devised constraints that shape human interaction." He emphasizes that insti-

tutions "structure incentives in human exchange, whether political, social, or economic," highlighting their role in shaping behavior and reducing uncertainty in collective decision-making processes.

Similarly, in the latest edition of the Oslo Manual (OECD and Eurostat, 2018), innovation is defined as "a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process)." This definition underscores three critical dimensions of innovation: knowledge as its foundation, novelty as its distinguishing characteristic, and value creation or preservation as its intended goal. Crucially, the requirement for implementation distinguishes innovation from mere invention, as innovation must be applied or made accessible to others to have a meaningful impact. The term 'innovation' encompasses both the process and the resulting outcomes. Building on Zhang and Rodríguez-Pose's (2024) perspective, several channels can be identified through which institutions shape and influence innovation.

In short, strong institutions are essential because they:

1. Protect intellectual property rights, ensuring firms can profit from R&D investments (Lai, 1998; Sweet and Eterovic Maggio, 2015).
2. Combat corruption, reducing market distortions (Anokhin and Schulze, 2009; Zhang and Rodríguez-Pose, 2024).
3. Reduce bureaucracy, lowering administrative costs and simplifying business operations (Alam et al., 2019; Jiao et al., 2015).
4. Enable efficient policy implementation, promoting innovation incentives (Alam et al., 2019; Zhang and Rodríguez-Pose, 2024).
5. Facilitate learning effects, encouraging spillovers and cooperation (Morgan, 2007; Rodríguez-Pose and Storper, 2006).

Weak institutions create significant barriers to innovation by undermining economic processes and failing to create strong incentives for investments in innovation. A major challenge is the lack of intellectual property (IP) protections and legal enforcement, discouraging economic actors from engaging in innovative activities (Zhang and Rodríguez-Pose, 2024). The inability to protect IP rights inhibits technology transfer and undermines knowledge markets (Lai, 1998; Sweet and Eterovic Maggio, 2015). Since high-risk innovation often relies on the prospect of monopoly-like returns from new products or services, strong IP protection and effective measures against counterfeiting are essential for sustaining R&D investments (Sweet and Eterovic Maggio, 2015). Furthermore, evidence suggests a strong relationship between the rule of law and innovation, showing that reliable courts and efficient legal systems are crucial to fostering innovative capacities (Caselli and Coleman, 2001; Seitz and Watzinger, 2017).

Another critical barrier is corruption, which erodes institutional trust obligatory for innovation (Anokhin and Schulze, 2009). Corrupt institutions may lead to a situation in which well-connected enterprises are unfairly advantaged over emerging, more innovative ones, which in turn weakens incentives for entrepreneurship and investments in innovation (Zhang and Rodríguez-Pose, 2024). Finally, corruption increases operational costs and decreases market transparency, reducing the natural flow of new products and technologies (Anokhin and Schulze, 2009; Alam et al., 2019).

Bureaucratic inefficiency is another factor that hampers innovation. Excessive administrative processes, such as lengthy licensing procedures or complex patent registration, divert resources away from innovation and obscure business operations (Anokhin and Schulze, 2009; Alam et al., 2019; Jiao et al., 2015). Unsustainable levels of bureaucracy increase agency and transaction costs, making investments in innovative projects less attractive due to limited returns and uncertain planning (Zhang and Rodríguez-Pose, 2024; Anokhin and Schulze, 2009).

Policy instability also undermines innovation by creating regulatory uncertainty. Frequent changes in policies, unclear regulations, and inconsistent enforcement increase compliance costs and reduce firms' willingness to invest in long-term R&D (Zhang and Rodríguez-Pose, 2024; Rodríguez-Pose and Storper, 2006). Strong institutions enable a transparent, well-designed regulatory environment that supports innovation incentives (Alam et al., 2019).

Lastly, weak governance affects regional learning, knowledge-sharing networks, and entrepreneurial ecosystems, thereby limiting a region's capacity to learn and adapt (Rodríguez-Pose and Storper, 2006; Morgan, 2007). Strong institutions, on the contrary, enable inter-firm cooperation and knowledge spillovers, driving innovation (D'Ingiullo and Evangelista, 2020; Rodríguez-Pose and Storper, 2006).

2.2. Regional Innovation and Institutions: The Evidence

Research has consistently shown the positive impact of institutional quality on innovation. In Europe, Rodríguez-Pose and Di Cataldo (2015) found that regions with higher institutional quality - characterized by reduced corruption and stronger law enforcement - exhibited significantly greater patenting activity, using historic literacy rates as an instrumental variable. In the same vein, D´Ingiullo and Evangelista (2020) demonstrated that innovative output in Italian provinces had been increased due to enhanced government accountability, regulatory quality, and overall institutional effectiveness. Historical reforms also provide compelling evidence of how institutional quality fosters long-term innovation. For example, Donges et al. (2023) demonstrated how the introduction of the Napoleonic Civil Code in parts of Germany modernized administrative and legal institutions, leading to enduring innovation-driven growth.

Beyond Europe, global research has further emphasized the critical role of institutions in driving local innovation. In China, local government reforms in urban regions have improved the quality of government, leading to increased innovative activity (Zhang and Rodríguez-Pose, 2024). In Africa, Iddawela et al. (2021) identified a positive correlation between sub-national governance quality and regional economic growth in 22 countries, highlighting the institutional foundation required for technological and economic advancements.

At the firm level, institutions also play a crucial role in enabling corporate innovation. Mahendra et al. (2015) demonstrated that reducing bureaucratic burdens and strengthening contract enforcement improved firms´ ability to invest in R&D and pursue innovation.

Despite these findings, the role of regional institutions in fostering innovation remains under-explored. Except for the aforementioned works (Rodriguez-Pose and Di Cataldo, 2015; Zhang and Rodríguez-Pose, 2024) and a few others, the institutional dynamics driving local innovation have yet to become a central focus in economic research.

3. Methodology and Data

3.1. Methodological Framework

This study investigates the relationship between institutional quality and regional innovation using a balanced panel dataset of 125 European regions from 19 countries over the period 2016-2022.[1] To ensure robust insights, the analysis employs four econometric models: Correlated Random Effects (CRE), Instrumental Variables (IV), Fixed Effects (FE), and a pooled OLS. The primary focus is on the CRE and IV models, as they address different core aspects of the research question, while the FE model serves as a quasi-robustness check. The pooled OLS is conducted on a national-level panel. It serves as a test for the external validity of regional-level findings. Institutional quality, the independent variable, is measured by the European Quality of Government Index (EQI), developed by the University of Gothenburg (Charron et al., 2024). The dependent variable, regional innovative capacity, is measured by the Regional Innovation Index (RII) from the Regional Innovation Scoreboard (European Commission, 2024). Due to data availability constraints, the sample includes only regions with complete records for the dependent, independent, and control variables.

The CRE model is well-suited for the panel dataset's structure, which features a relatively large number of cross-sectional units ($N = 125$) compared to time periods ($T = 7$). It allows for capturing both within-region and between-region variation while addressing unobserved heterogeneity through the inclusion of regional means of time-varying explanatory variables (Wooldridge, 2019). By balancing these dimensions, the CRE model provides an effective framework for exploring the role of institutional quality across regions.

However, the potential for endogeneity necessitates an additional, more robust approach. In this context, endogeneity means that institutional quality may be influenced by regional innovation, causing reverse causality or simultaneity (Angrist and Pischke, 2009). To address this concern, the study employs an IV regression using historical education levels from 1900 as an instrument for institutional quality. Historical education plausibly

[1] For a complete overview of the panel, please refer to table A.3 in the Appendix.

influences long-term governance structures but is unlikely to directly affect contemporary regional innovation capacities, thereby satisfying the exclusion restriction (Bowden and Turkington, 1990; Rodriguez-Pose and Di Cataldo, 2015). The IV regression captures causal relationships more reliably by isolating the effect of institutional quality on innovation from potential reverse causality.

The FE model is used as a quasi-robustness check, isolating within-region variation by accounting for time-invariant regional characteristics. While it provides valuable insights into regional dynamics, it does not allow for exploring between-region effects and cannot address endogeneity concerns.

This methodological framework ensures a comprehensive analysis of the institutional determinants of regional innovation. The subsequent sections detail the implementation of these methods, along with the rationale for emphasizing CRE and IV approaches as the primary analytical tools.

3.1.1. Core Model: Correlated Random Effects

The **CRE model**, as described by Wooldridge (2019), serves as a core estimation model. It addresses unobserved heterogeneity by incorporating regional averages of time-varying explanatory variables. This model balances within-region and between-region information while avoiding the degrees-of-freedom loss typical of an FE model in panels with limited time periods. This makes it a suitable, and more robust alternative to a Random Effects (RE) or FE model (Wooldridge, 2019).

The CRE model is specified as follows:

$$RII_{it} = \beta_0 + \beta_1 EQI_{it} + \beta_2 \log(GDP)_{it} + \beta_3 \log(POP)_{it} + \beta_4 EMP_{it} + \theta_i + \epsilon_{it} \quad (1)$$

Where RII_{it} represents the Regional Innovation Index of region i at time t, and EQI_{it} is the institutional quality index. The control variables $\log(GDP)_{it}$, $\log(POP)_{it}$, and EMP_{it} reflect regional economic development, population density, and employment levels, respectively. θ_i represents unobserved regional effect, which is fixed across time but different for each region. Finally, ϵ_{it} describes the idiosyncratic error term. Logarithmic transformations are applied to GDP per capita and population density to ensure a more normalized variable distribution.

As previously mentioned, the CRE model includes region-level averages of key explanatory variables, namely EQI_{it} and $\log(GDP)_{it}$ as additional regressors. These averages are calculated over the entire time period (2016-2022) to address potential endogeneity due

to the correlation between institutional quality and unobserved regional characteristics:

$$\text{Mean}_i(X) = \frac{1}{T_i} \sum_{t=1}^{T_i} X_{it}$$

Where X is a time-varying explanatory variable, such as EQI or $log(GDP)$ and T_i is the number of observed time periods for region i. These measures reduce the bias from unobserved time-invariant factors, improving the reliability of the model.

3.1.2. Addressing Endogeneity: IV Regression

Endogeneity and reverse causality arise, when explanatory variables, such as the EQI, are correlated with the error term, or themselves influenced by the dependent variable (Bowden and Turkington, 1990). In this case, it can be argued, that regions exerting high innovative capacities may in turn improve institutional quality. To correct for potential endogeneity, an **IV Regression** is applied using historical education levels from 1900 as an instrument for EQI. Historical education plausibly influences institutional quality by shaping long-term governance structures and societal norms. At the same time, it is unlikely to have a direct effect on contemporary regional innovative capacities, satisfying the exclusion restriction criterion for a valid instrument (Bowden and Turkington, 1990; Greene, 2019).
The IV model follows a Two-Stage Least Squares (2SLS) approach:
First Stage:

$$EQI_{it} = \gamma_0 + \gamma_1 \text{Historical Education}_i + \gamma_2 \log(GDP)_{it} + \gamma_3 \log(POP)_{it} + \gamma_4 EMP_{it} + \epsilon_{it} \quad (2)$$

Second Stage:

$$RII_{it} = \beta_0 + \beta_1 \widehat{EQI}_{it} + \beta_2 \log(GDP)_{it} + \beta_3 \log(POP)_{it} + \beta_4 EMP_{it} + \theta_i + \epsilon_{it} \quad (3)$$

Where $\widehat{EQI}_{it}$ represents the predicted institutional quality from the first stage.
This approach is employed to isolate the causal relationship between institutional quality and innovation while mitigating bias from omitted variables or reverse causality (Angrist and Pischke, 2009; Wooldridge, 2010).

3.1.3. Additional Model: Fixed-Effects and Pooled OLS

Two supplementary models are employed as quasi-robustness checks to complement the primary analysis: Firstly, a **Fixed-Effects (FE) Model** is used for the regional panel.

Secondly, a **pooled Ordinary Least Squares (OLS) Model** is employed for an additional national panel, which utilizes national-level data for the 27 EU member states. The FE model is estimated to account for unobserved, time-invariant regional characteristics such as historical, geographical, or cultural factors. This approach is particularly useful for isolating within-region variations in innovation over time, independent of static regional attributes (Baltagi, 2021). The FE model is specified as:

$$RII_{it} = \beta_1 EQI_{it} + \beta_2 \log(GDP)_{it} + \beta_3 \log(POP)_{it} + \beta_4 EMP_{it} + \alpha_i + \epsilon_{it} \tag{4}$$

Where α_i represents time-invariant regional fixed effects.
In addition, a pooled OLS Model is applied to analyze a national panel of 27 EU-countries over two time periods (2017 and 2021). This model assesses whether the relationships observed at the regional level hold at the national scale. The pooled OLS specification is similar to the regional models but is applied to national averages, providing a complementary perspective on the role of institutional quality, economic output, population density, and employment rates. Given the small sample size ($N = 27, T = 2$), this model serves as a descriptive robustness check rather than a causal framework.

3.1.4. Addressing Key Issues: Model Extensions

In order to ensure the robustness of the results, several methodological adjustments are employed. Three model specifications are employed to ensure the reliability and robustness of the results. First, a base model is employed to establish a baseline for the econometric analysis. Second, the models are extended with an interaction term ($EQI_{it} \times \log(GDP)_{it}$) to test for heterogeneous effects of institutional quality depending on regional economic development. This specification explores potential non-linearities and interaction effects in the relationship between governance and innovation (Greene, 2019). Secondly, spatial lags are incorporated to account for spatial dependence. Third, a spatial lag term $W \cdot RII_{it}$ is added using a spatial weights matrix constructed from geographic distances between regions. This extension accounts for potential knowledge spillovers between neighboring regions (LeSage and Pace, 2009). Collectively, these specifications ensure that key relationships are not driven by a specific model choice or data transformation (Baltagi, 2021). To ensure valid statistical inference, robust clustered standard errors are used throughout all specifications. This adjustment accounts for potential heteroskedasticity and serial correlation, common issues in panel data analysis, ensuring that the estimated coefficients remain consistent and interpretable even when standard assumptions about error terms are violated.

3.1.5. Robustness Checks

To ensure the validity and reliability of the results, the most comprehensive models are subjected to robustness checks. These checks focus on two key objectives: evaluating whether endogeneity persists and assessing the efficacy of the IV approach in addressing this issue. To this end, a subsample analysis is conducted using the CRE and IV models to compare results across regions with differing economic performance. Specifically, the analysis contrasts the poorest 20th percentile and the wealthiest 80th percentile of regions, as measured by GDP per capita. This approach tests whether the models yield consistent conclusions or diverge in their evaluations across economic contexts. To further enhance the robustness of the analysis and to compare the CRE and IV approaches, the analysis examines the marginal effect of EQI on RII across varying levels of GDP per capita. This enables an estimation of how institutional quality influences regional innovation at different stages of economic development. The marginal effect is derived as:

$$\frac{\partial RII}{\partial EQI} = \beta_{EQI} + \beta_{EQI \cdot \log_{GDP}} \cdot \log(\text{GDP}).$$

To ensure that the observed relationships in the primary models are not artifacts of random correlations or omitted variable bias, a placebo test is conducted (Angrist and Pischke, 2009). In this test, the actual dependent variable (RII) is replaced with a randomly generated dependent variable to evaluate the presence of spurious correlations. Finally, model diagnostics are reported to assess robustness and reliability of results. The Sargan-Hansen test evaluates the validity of the instrumental variables and tests for endogeneity in the IV model (Kiviet and Kripfganz, 2021), while other diagnostic measures verify model performance and reliability across specifications.

3.2. Data

3.2.1. Independent Variable: Quality of Government

One major challenge in measuring the relationship between formal government institutions and local innovative capacities is the operationalization of institutional quality (Zhang and Rodríguez-Pose, 2024). The present study builds on previous research (D'Ingiullo and Evangelista, 2020; Rodriguez-Pose and Di Cataldo, 2015), using the Quality of Government Index developed by the University of Gothenburg (Charron et al., 2024) to measure regional government quality.

The EQI measures sub-national quality of government across 242 regions in 31 European countries. The score evaluates how well local institutions function by assessing public service quality, impartiality, and corruption control as experienced by citizens. This

particular regional focus makes the EQI a valuable tool for analyzing institutional performance beyond national-level indicators.
Its structure is based on three core dimensions, so-called "pillars"; Quality of Public Services, Impartiality and Control of Corruption. Quality of Public Services measures the effectiveness and availability of essential services such as law enforcement, education, and healthcare. Impartiality evaluates whether public services are delivered fairly and consistently. Control of Corruption assesses the extent to which corruption, favoritism, bribery, and misuse of public office are prevented in public administration.
Data for the EQI is collected through survey-based methodologies, namely computer-assisted telephone interviews (CATI) and online questionnaires. Respondents in each NUTS 2 region deliver feedback on experienced public service quality, fairness, and corruption control. The data is aggregated at the regional level, leveraging several weights to ensure cross-region comparability.
To ensure cross-country comparability, the EQI integrates the World Governance Indicators (WGI), developed by the World Bank (World Bank, 2024), which provide a national benchmark for governmental quality. It covers six dimensions of governance: Voice and Accountability, Political Stability and Absence of Violence, Government Effectiveness, Regulatory Quality, Rule of Law, and Control of Corruption. Regional EQI scores are standardized by centering them around the corresponding WGI average, preserving international comparability while enabling the identification of within-country disparities.
Final EQI scores are calculated by aggregating standardized responses from the three core pillars using z-scores. The resulting scores reflect both relative regional performance and absolute institutional quality. Therefore, the EQI is an essential and suited tool for analyzing sub-national disparities in institutional quality.[2]

3.2.2. Dependent Variable: Regional Innovative Capacities

Similarly, scholars have faced challenges in identifying reliable indicators for innovation. Economic literature frequently uses patent applications, R&D expenditures, and R&D employment levels as proxies for innovation (Rodriguez-Pose and Di Cataldo, 2015; Crosby, 2000; Crescenzi et al., 2007). However, these indicators have limitations when capturing the complexity of innovation. In response, this study seeks to strengthen the measurement approach by employing the Regional Innovation Scoreboard (RIS) produced by the European Commission (European Commission, 2024).
The RIS delivers a measurement of the innovative capacities in European Regions by com-

[2]For a visual representation of how the EQI is constructed, please refer to figure A.1 in the Appendix.

bining a comprehensive set of relevant indicators. It extends the framework of the annual national European Innovation Scoreboard (EIS) to a local level, covering 239 NUTS 2 and NUTS 1 Regions across 31 countries, including all EU-members and some associated countries such as Norway and Switzerland.

The RIS framework is built around 21 indicators organized into twelve dimensions, which are further aggregated into four key categories: Framework Conditions, Investments, Innovation Activities, and Impacts. This way, the scoreboard aims to describe local innovative ecosystems, rather than just observing innovative outcomes. Framework Conditions include factors such as availability of highly educated workforce and access to scientific knowledge. Investments include government subsidies, as well as public and private R&D expenditures. Innovative Activities evaluate the degree to which businesses actively engage in innovation through product development, research collaborations, and patent applications. Lastly, Impact variables measure economic outcomes such as high-tech employment, exports, and revenue from innovation-driven products.

Data are sourced from Eurostat, the Community Innovation Survey (CIS), and the OECD REGPAT database. In order to ensure comparability, the data are standardized using z-values and min-max scaling.[3]

By including a wide array of indicators and applying rigorous statistical methodology, the RIS provides a robust and comparable metric for assessing regional innovative capacities, a fundamental premise on which the present study is predicated.

3.2.3. Control Variables and Instrument

Regional economic output (GDP), population density (POP), and employment levels (EMP) have all been retrieved from Eurostat (2024a) for the corresponding regions. GDP measures the total economic output (Gross Domestic Product) of a region per inhabitant, adjusted for purchasing power standards (PPS) to eliminate price level differences and allow for meaningful comparisons across regions (Eurostat, 2024c). POP is the variable representing population density, that is, the average number of inhabitants per unit of land area, calculated as the ratio of a region´s population to its land era (Eurostat, 2024b). EMP defines the unemployment rate (Eurostat, 2024d). It represents unemployed persons as a share of the economically active population (aged 15–64), based on the EU Labor Force Survey. The choice of the instrumental variable, historical education levels, needs careful justification. This data, sourced from the Clio Infra project (2015), reflects the historical average years of education at the national level in 1900.

[3]For a full list of the indicators used in the RIS, please refer to table A.2 in the Appendix.

Due to data availability constraints, regional historical education data was not accessible. Consequently, this study assumes that national historical average education levels are relatively homogeneous within country borders, making them a suitable instrument for regional quality of government. It can be plausibly argued that historical education levels exert a significant influence on regional institutional quality, as they shape governance structures and societal development over time. At the same time, they are unlikely to directly affect contemporary regional innovative capacities, thus satisfying the exclusion restriction and serving as a valid instrument (Greene, 2019). The choice of this instrument is in line with previous research, with Rodríguez-Pose and Di Cataldo using historical literacy rates in the 19th century, following a similar train of thought Rodriguez-Pose and Di Cataldo (2015).

The panel dataset for this study has been compiled using the aforementioned data sources and indices. For the EQI, data was only available for the years 2017 and 2021 within the study's time frame, with additional data for 2013 and 2024 outside this period due to its four-year publication cycle. To create a balanced panel, linear interpolation was employed to estimate intermediate values. This approach does not compromise data quality, particularly given that the CRE model used in this study is designed to perform well with shorter time frames. Similarly, missing values for regional control variables were interpolated using the same method, ensuring consistency and robustness in the dataset.

3.2.4. Descriptive Statistics and Spatial Distribution

Innovation across European regions is shaped by a variety of structural factors, with institutional quality playing a central role. To better understand the regional disparities in innovative environments, it is essential to first examine the spatial distribution of key variables. This geographical overview provides a foundation for analyzing how institutional quality and other regional characteristics contribute to differences in innovative capacity. By mapping these variables, the analysis highlights patterns and potential hot spots of innovation or institutional challenges, allowing for the subsequent econometric evaluation.

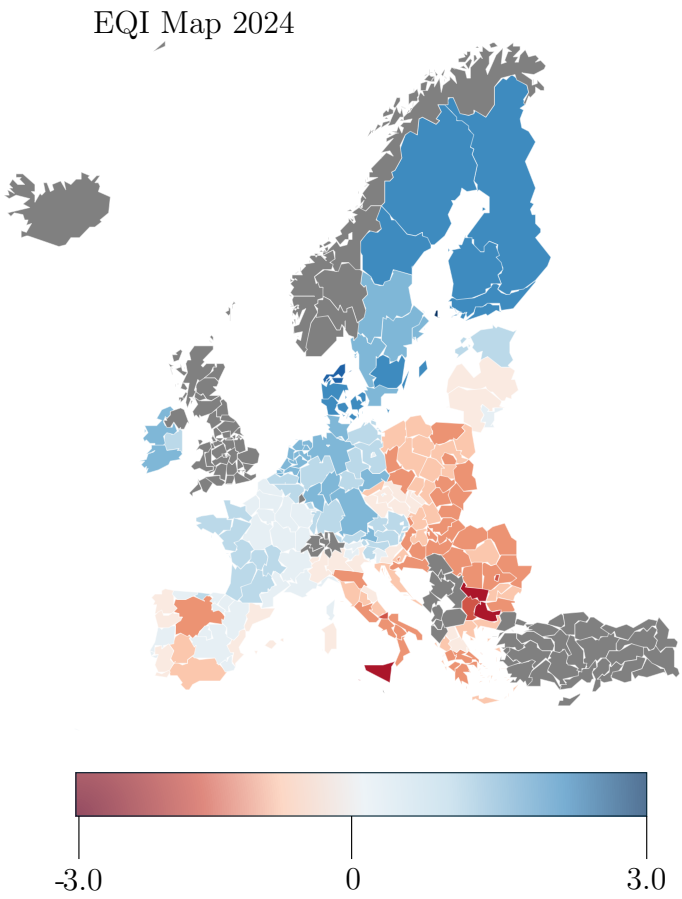


Figure 3.1.: EQI Data 2024

Figure 3.1 illustrates the spatial distribution of the *EQI* for 2024 (Charron et al., 2024). Institutional quality is represented on a scale ranging from -3.0 to 3.0, with higher values (indicating better institutional quality) shown in shades of blue and lower values (indicating poorer institutional quality) depicted in shades of red. A pronounced geographical divide is evident, with higher *EQI* values predominantly concentrated in Northern and Western Europe, particularly in Scandinavian countries. In contrast, lower *EQI* values are observed across regions in Eastern and Southern Europe. These regional disparities provide a crucial backdrop for understanding the relationship between institutional quality and regional innovation outcomes.

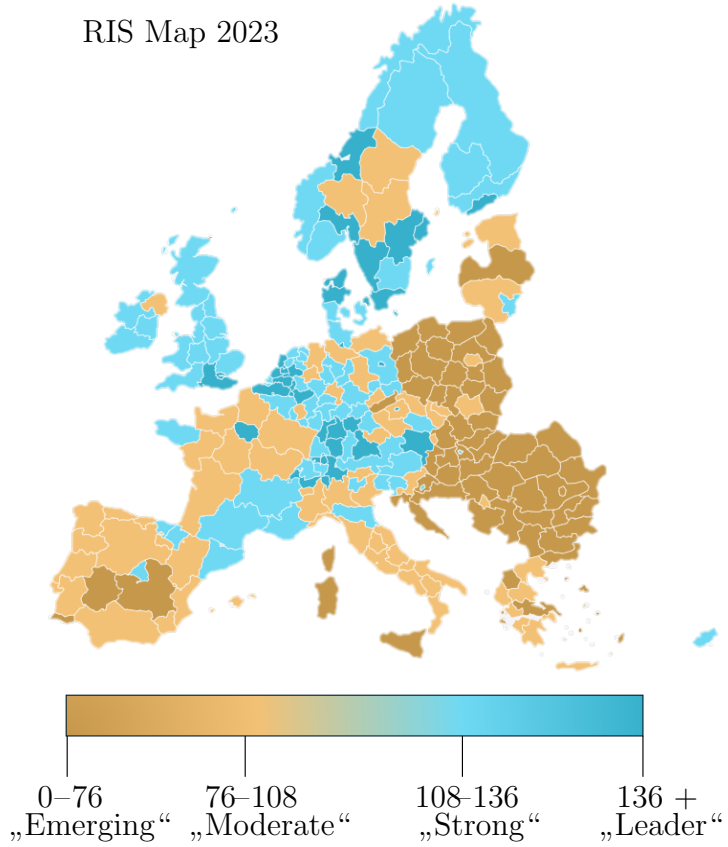


Figure 3.2.: RIS Data 2024

Figure 3.2 represents the geographical variation in regional innovation capabilities across European regions in 2023, based on the Regional Innovation Scoreboard. Regional innovation performance is evaluated relative to the EU's 2017 average and is expressed as an indexed value. The observed range spans from 20.6 in Southeastern Romania to 169.5 in Hovedstaden, Denmark. A clear spatial divide emerges, with Central and Northern Europe hosting regions classified as "Strong" or "Leader," indicated by light shades of blue, reflecting innovation outcomes well above the EU average in 2017. Conversely, regions in Eastern and Southern Europe, as well as parts of Western Europe (notably Northern France, Spain, and Portugal), exhibit less favorable outcomes. These regions are classified as "Emerging" or "Moderate," highlighted in darker shades of yellow. This disparity underscores significant structural differences in innovation capacities across European regions.

When comparing both maps, clear overlaps are evident, particularly in Southeastern Europe, where regions with lower institutional quality align with weaker innovation outcomes. In Central and Northern Europe, regions frequently emerge as "Leaders", excelling in both institutional quality and innovation capacity. This observed relationship forms

the central focus of the subsequent regression analyses, which aim to examine the extent and nature of this connection. Figure 3.3 represents this relationship visually with a scatterplot, showing the regional averages for EQI and RII. [4]

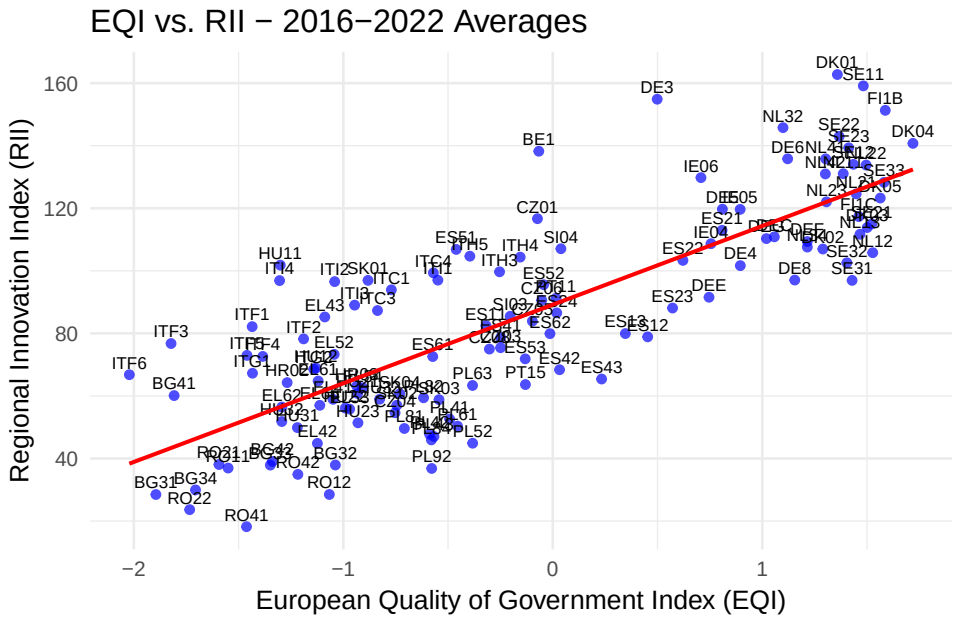


Figure 3.3.: Scatterplot of EQI vs. RII

The panel data used in this research combines both indices, enabling a comparative analysis across 125 overlapping regions. Table 3.1 provides a concise overview of the key descriptive statistics of the variables used in this study. The Regional Innovation Index has a mean value of 85.23, with a standard deviation of 33.35, indicating substantial variation in European regions. The highest RII value is 167.57, while the lowest is 15.56, reflecting a broad spectrum of regional innovation capacities. The European Quality of Government Index has a mean of -0.17 in this panel, with values ranging from -2.15 to 1.80. The relatively high standard deviation of 1.06 underscores notable regional differences in governance quality. Similarly, the control variables exhibit considerable variation. For instance, GDP per Capita in PPS ranges from 8,500 at the minimum to a maximum of 101,200 in PPS, highlighting regional income inequalities. This descriptive overview provides a foundation for understanding the importance of accounting for these variations in the subsequent econometric analysis.

[4] See figures A.2 and A.3 in the Appendix for additional scatterplots.

Table 3.1.: Summary Statistics of Key Variables

Variable	**Mean**	**SD**	**Min**	**Max**
Regional Innovation Index	85.23	33.35	15.56	167.57
European Quality of Government Index	-0.17	1.06	-2.15	1.80
GDP per Capita in PPS	27,402.01	12,231.05	8,500	101,200
Population density	313.82	875.80	3.4	7,660
Unemployment rate	8.10	5.38	1.3	31.3

4. Empirical Findings

4.1. CRE Results

Table 4.1 presents the results of the Correlated Random Effects estimation, the primary regression model used in this study to explore the relationship between institutional quality (EQI) and regional innovation (RII). The CRE approach is particularly suited for panel data with significant heterogeneity, as it accounts for time-invariant effects and potential correlations between unobserved factors and explanatory variables. By including within-region means, such as $mean_EQI$, the CRE model allows for a more structural analysis of the effects of institutional quality. Three specifications are reported: the base model (i), a model with an interaction term between EQI and $\log(GDP)$ (ii), and a spatial lag model including lagged RII (iii).

The key variable, EQI, is examined through three components. First, EQI represents the baseline institutional quality variable for region i. Second, $EQI \times \log(GDP)$ captures the interaction between institutional quality and regional economic output. Lastly, $mean_EQI$ reflects the within-region average of institutional quality across years, capturing the structural, long-term impacts of governance quality. The results reveal the following:

EQI is positive and statistically significant ($p<0.01$) in models (i) and (iii) (coefficients 6.838 and 6.817 respectively), suggesting a direct positive effect of institutional quality on innovation. In model (ii), which includes the interaction term, the effect for EQI turns negative (coefficient: -37.752, $p<0.1$). However, the interaction term $EQI \times \log(GDP)$ is positive and highly significant (coefficient: 4.461, $p < 0.05$). This suggests that the impact of institutional quality on innovation is conditional on regional economic development, with stronger effects observed in regions with higher GDP levels. The inclusion of the interaction term introduces multicollinearity between the main effect EQI and the interaction term, as they are inherently correlated. This explains the increase in standard errors, highlighting increased uncertainty in the estimation of EQI´s direct effect when the interaction term is included. This highlights that its impact cannot be interpreted in isolation. Instead, it is contingent on other factors, such as regional economic output, captured by the interaction term. The coefficient for $mean_EQI$ switches from positive in

models (i) and (ii) to negative in the spatial lag model (iii). This change does not imply that institutional quality negatively impacts innovation. Instead, it reflects how the inclusion of *spatial_RII* redistributes explanatory power. In model (iii), the positive effects of institutional quality may now be captured indirectly through innovation spillovers. As a result, the direct effect of *mean_EQI* within the region diminishes and appears negative. This finding highlights the importance of considering both direct and spillover effects of institutional quality when interpreting its relationship with innovation.

Control variables display consistent results across specifications. The logarithmic value of GDP is positive and highly significant in all models, with values around 16-22 ($p<0.01$), implying that a 1% increase in regional economic output per capita leads to an increase in the Regional Innovation Score of over 0.16. This suggests that higher economic output is strongly associated with increased regional outcomes. The coefficient for population density is also positive and highly statistically significant in models (i) and (ii), with values around 6 ($p<0.01$). This points to densely populated areas exhibiting higher levels of innovation. However, it becomes insignificant in the spatial lag model (iii), possibly because the spillover effects captured by *spatial_RII* account for much of the agglomeration benefits previously attributed to population density. Similarly, the unemployment rate EMP has a significant coefficient; however, it is negative in all specifications (coefficients: -0.714 to -0.778, $p<0.01$). This would suggest that higher unemployment negatively influences innovation, aligning with expectations. The spatial lag variable (*spatial_RII*), included in model (iii), is positive and highly significant (coefficient: 0.810, $p<0.01$). This highlights the importance of regional spillovers in driving local innovation. It suggests that innovation in neighboring regions enhances a region's innovation performance through shared knowledge, collaborative networks, and cross-regional market dynamics.

For all models, clustered robust standard errors are employed to address potential heteroskedasticity and autocorrelation within regions over time. This adjustment is particularly important for panel data, where observations are not independent within regions. With this in mind, among the four models, the spatial lag model (iii) emerges as the most comprehensive and robust. It achieves the lowest AIC (Akaike Information Criterion) value (6758.9), indicating a good trade-off between model fit and complexity. The AIC favors prudent models that explain the data well without overfitting by penalizing overly complex specifications. Similarly, the Bayesian Information Criterion (BIC), which applies a stricter penalty for additional parameters, also identifies model (iii) as the best-performing specification. With the lowest BIC value, it reaffirms the model's capacity to balance complexity and predictive accuracy effectively. The Root Mean Squared Error (RMSE) also reaches its lowest value in the combined model specification (4.525). These values indicate the best balance of explanatory power, simplicity, and predictive accuracy.

Additionally, it achieves the highest adjusted R^2 value (0.667), explaining 66.7% of the variance in regional innovation outcomes while accounting for the number of predictors. This shows that the addition of interaction terms and spatial dependencies contributes meaningfully to the model's explanatory strength. Collectively, these metrics confirm the combined model's robustness and reliability in capturing the nuanced relationship between institutional quality and innovation.

Table 4.1.: CRE Regression Results

	i Base	**ii** Interaction	**iii** Spatial Lag
EQI	6.838***	-37.752*	6.656***
	(2.320)	(19.668)	(2.328)
EQI × log(GDP)		4.461**	
		(1.980)	
mean_EQI	11.728***	10.599***	-6.210**
	(3.184)	(3.020)	(2.702)
log(GDP)	20.604***	22.741***	16.468***
	(2.759)	(2.490)	(2.633)
log(POP)	6.283***	6.033***	1.436
	(1.264)	(1.213)	(1.101)
EMP	-0.714***	-0.706***	-0.778***
	(0.138)	(0.142)	(0.133)
spatial_RII			0.810***
			(0.067)
(Intercept)	-144.758***	-166.573***	-150.586***
	(26.273)	(24.693)	(23.820)
Num.Obs.	862	862	862
AIC	6797.2	6786.5	6758.9
BIC	10871.1	10855.6	10828.0
R^2	0.519	0.526	0.669
R^2 Adj.	0.515	0.522	0.667
RMSE	4.621	4.598	4.525

Note: Clustered robust standard errors in parenthesis.
***p<0.01, **p<0.05, *p<0.1.

4.2. IV Results

Table 4.2 addresses the issue of endogeneity, which remains largely unaddressed in Table 4.1. The IV approach, specifically a Two-Stage Least Squares (2SLS) method, is employed to provide a more robust and causal interpretation of the relationship between

institutional quality and regional innovation. Historical education levels, measured as the average years of education in country i for 1900, serve as an instrument for EQI, addressing concerns of reverse causality and omitted variable bias. This approach enables a clearer distinction between the effects of institutional quality and potential confounding influences.

The IV results differ substantially from the CRE findings in Table 4.1. EQI remains statistically significant in all specifications, with effect sizes of approximately 18 in model (i) ($p<0.01$), 67 in model (ii) ($p<0.01$), and 4 in model (iii) ($p<0.05$). This variation reflects the redistribution of explanatory power when including the interaction term ($EQI \times \log(GDP)$) in model (ii) and the spatial lag variable ($lag_R II$) in model (iii). Despite these changes, EQI consistently contributes to regional innovation outcomes, highlighting its robust importance. In model (ii), which includes an interaction term between EQI and $\log(GDP)$, the high coefficient for EQI (67.037) is paired with a large standard error, likely reflecting multicollinearity between the main effect and the interaction term. Consequently, the standalone interpretation of EQI in this specification is less reliable. Instead, the interaction term ($EQI \times \log(GDP)$), with a negative coefficient (-4.745, p ¡ 0.05), provides deeper insights. It indicates that the marginal effect of institutional quality on innovation diminishes as regional economic output increases, pointing to potential diminishing returns in wealthier regions. This stands in contrasts to the positive interaction observed in the CRE models, which suggested stronger effects of EQI in high-GDP regions. However, the IV results imply that poorer regions benefit more from improvements in institutional quality. By addressing endogeneity, the IV approach corrects potential biases and offers a more refined understanding of the relationship between institutional quality, economic performance, and innovation.

Control variables exhibit consistent significance across all IV model specifications. Economic output ($\log(GDP)$) remains influential, with coefficients ranging from 14.048 to 31.688 ($p<0.01$), confirming its strong association with regional innovation. Population density ($\log(POP)$) remains positive and significant, with values ranging from 3.148 to 6.132, highlighting the importance of densely populated regions in fostering innovation. The unemployment rate (EMP) shows positive and significant effects in models (i) and (ii), thereby suggesting a nuanced relationship between labor market dynamics and innovation. However, EMP becomes insignificant in the spatial lag model (iii), where much of its explanatory power may be absorbed by the spatial spillover term ($spatial_RII$). The perhaps counterintuitive relationship in models (i) and (ii) might represent a trade-off between employment levels and innovation intensity. Regions with very high employment rates may focus on traditional industries with lower innovation potential, while regions with lower employment may channel more resources into innovative, capital-intensive sec-

tors, relying on a more mobile workforce. The interpretation of EMP differs from the CRE results, as it is now positive. The spatial lag term ($spatial_RII$) itself, is highly significant and positive. This once again emphasizes the role of regional spillovers in fostering innovation.

Among the IV models, the spatial lag specification (ii) achieves the highest adjusted R^2 (0.916). It also exhibits the best values for AIC (6656.3), BIC (9853.6), and RMSE (9.94) This suggests that the added complexity by including $spatial_RII$ yields substantial improvements in predictive performance. Despite this, the inclusion of interaction terms raises important theoretical questions about the interplay between regional income, institutional quality, and innovation.

Overall, the IV approach consistently outperforms the CRE model in terms of R^2 and adjusted R^2. For instance, adjusted R^2 for model (iii) is 0.916 in the IV framework, compared to 0.667 for the corresponding CRE model. However, there is some ambiguity regarding the goodness-of-fit measures. While the IV models achieve lower BIC values, suggesting a better trade-off between fit and complexity, they tend to have higher AIC values and worse RMSE compared to the CRE models. This mixed performance leaves some uncertainty as to which approach is definitively superior.

Table 4.2.: IV Regression Results

	i Base	**ii** Interaction	**iii** Spatial Lag
EQI	18.131***	67.037***	4.046**
	(1.089)	(20.173)	(1.783)
EQI × log(GDP)		-4.745**	
		(1.952)	
log(GDP)	31.688***	28.461***	14.048***
	(2.545)	(2.875)	(1.810)
log(POP)	5.886***	6.132***	3.148***
	(0.657)	(0.662)	(0.646)
EMP	0.598***	0.566***	0.074
	(0.104)	(0.106)	(0.086)
spatial_RII			0.726***
			(0.066)
(Intercept)	-264.384***	-230.971***	-133.037***
	(23.172)	(26.965)	(16.157)
Num.Obs.	707	707	707
AIC	7092.4	7125.0	6656.3
BIC	10294.3	10322.3	9853.6
R^2	0.846	0.838	0.917
R^2 Adj.	0.845	0.837	0.916
RMSE	13.52	13.85	9.94

Note: Clustered robust standard errors in parenthesis.
Instrument relevance from first-stage F-statistic: $F = 612.97$, p<0.001.
***p<0.01, **p<0.05, *p<0.1.

4.3. Additional Model Results

The Fixed-Effects approach was initially included as a first robustness test to assess the adequacy of the CRE. Additionally, the FE model also isolates within-region variation, providing specific insights into how institutional quality impacts innovation independently of time-invariant regional characteristics. Table 4.3 highlights the results of the FE regressions. Here, the FE approach is limited to two model specifications (base and interaction), since Fixed-Effects models can inherently not account for spatial lags due to their limitation to within-region variation.

As evidenced by the CRE results presented in table 4.1, the coefficient for regional quality of government (EQI) is statistically significant and switches signs when interaction terms are included. The interaction term $EQI \times \log(GDP)$, conversely, is positive and significant (p<0.05), suggesting the same inference as in table 4.1.

The control variables reveal consistent patterns with some key distinctions. Regional in-

come ($\log(GDP)$) remains a positive and highly significant predictor of innovation, with coefficients of 14.338 and 16.243 in the base and interaction models, respectively. This may indicate that, within regions, year-to-year fluctuations in population density do not meaningfully affect innovation, unlike cross-regional differences where agglomeration effects are more pronounced. Since the FE model isolates within-region variation over time, the benefits of agglomeration that population density typically represents may already be reflected in stable, time-invariant regional characteristics, such as infrastructure or industrial clusters, which are absorbed by the fixed effects. Finally, EMP is consistently negative and statistically significant, aligning with the CRE findings. This relationship suggests that regions experiencing high levels of unemployment may encounter structural challenges - such as diminished economic activity or rigid labor markets - that constrain their ability to foster innovation effectively.
In terms of model performance, the FE approach yields substantially lower R^2 and adjusted R^2 values compared to the CRE and IV models, indicating less reliable predictive power. This is expected, as FE models exclude between-region variation and focus solely on within-region dynamics. Model (ii) achieves a higher adjusted R^2 than the base model and the inclusion of interaction terms appears to enhance model fit without adding excessive complexity.
Overall, while the FE results provide valuable robustness checks, they are less suited for interpreting the underlying relationships due to their limited ability to capture between-regions effects. These findings support the use of CRE and IV models as primary tools in this study.

To complement the regional analysis, a pooled OLS model was employed on a national-level panel, incorporating data for all EU member states. The pooled OLS regression conducted on the national panel reinforces the regional findings. Institutional quality (EQI) remains a significant and positive determinant of innovation (RII), with an estimated effect size of 24.56 ($p < 0.001$). Population density and economic output also exhibit significant positive relationships with RII ($p < 0.05$).
These results suggest that institutional quality is a key driver of innovation across scales, consistent with regional-level conclusions. However, the national panel's limited sample size ($N = 27$) and short time dimension ($T = 2$) significantly restrict the robustness and reliability of these findings. As such, while the pooled OLS results lend support to the study's central hypothesis, they do not provide sufficient grounds for definitive inference. The regional analysis, with its richer dataset and methodological rigor, remains the primary focus.

Table 4.3.: Alternative Model Results

FE Model Results

	i Base	**ii** Interaction
EQI	5.953***	-54.536**
	(2.208)	(22.926)
EQI x log(GDP)		6.010**
		(2.341)
log(GDP)	14.338***	16.243***
	(2.826)	(2.724)
log(POP)	-2.360	-23.395
	(17.802)	(19.040)
EMP	-1.149***	-1.123***
	(0.174)	(0.181)
Num.Obs.	862	862
R^2	0.319	0.331
R^2 Adj.	0.316	0.327
AIC	6330.5	6312.9
BIC	9814.2	9791.9
RMSE	4.07	4.03

Note: Robust standard errors in parenthesis.
***p<0.01, **p<0.05, *p<0.1.

Pooled OLS Model Results

Variable	**Estimate**	**p-value**
EQI	24.564	<0.001***
log(GDP)	15.517	0.051*
log(POP)	4.174	0.025**
EMP	0.756	0.064*
(Intercept)	-1.706	0.960
Residual Std. Error	11.02 (df = 47)	
R^2	0.875	
Adj. R^2	0.865	
F-statistic	82.44 (p < 2.2e-16)	

Note: Signif. codes: ***p<0.01, **p<0.05, *p<0.1.

4.4. Robustness Checks

The ambiguous relationship between regional economic output, institutional quality, and innovation requires further clarification. Specifically, determining which model — IV or CRE — provides a more reliable interpretation, is a key objective. It is also important to assess whether institutional quality has a greater impact on wealthy regions or poorer ones. To address these questions, this study employs several robustness checks. The first test is a sub-sample analysis, using the base models for the CRE and IV approaches respectively. Including interaction-terms has proven to introduce substantial instability without providing meaningful insights when splitting the panel into two extremes. For this test, the wealthiest regions are defined as the 80th percentile of GDP per capita, while the poorest regions represent the bottom 20th percentile. This threshold was selected to create a stark contrast between extremes, allowing for a clearer evaluation of how institutional quality affects innovation across different economic contexts. Second, a marginal effect analysis is reported, to test the marginal effect of EQI on RII across all levels of regional economic output. Finally, this study conducts a placebo test using randomly generated

values for the dependent variable and reports several model diagnostics to ultimately assess which model is the most comprehensive and robust.

4.4.1. Subsample Analysis

Figure 4.1 presents the results of the subsample analysis for the base CRE regression, divided into two contrasting groups. The center points (dots) represent the estimated effect size of each variable within the respective subgroup, while the horizontal lines indicate confidence intervals, with the vertical endpoints representing the 90% confidence level. Narrower confidence intervals reflect more precise estimates. If the lines cross zero, the null hypothesis (that the variable has no effect) cannot be rejected at the 90% significance level.[5]

When subsampling the CRE results, much of the model's predictive capacity diminishes. For the poorest European regions, only the unemployment rate (EMP) exhibits a statistically significant negative effect (coefficient: -0.511, p-value: 0.036). This finding suggests that in regions with lower economic output, lower unemployment rates (i.e., higher employment) are positively associated with regional innovation. Interestingly, population density and economic output have the largest effect, while not being statistically significant in this subgroup.

For the wealthiest regions, $mean_EQI$, EMP, and $log(GDP)$ are all statistically significant drivers of regional innovation capacities. This implies that while labor market inefficiencies primarily hinder innovation in poorer regions, the wealthiest regions benefit significantly from structurally high institutional quality, greater economic output, and higher population density. These findings raise questions regarding the counterintuitive lack of significance for economic output and institutional quality in economically weaker regions, which may merit further investigation.

[5]For detailed subsample results, see table A.1 in the Appendix.

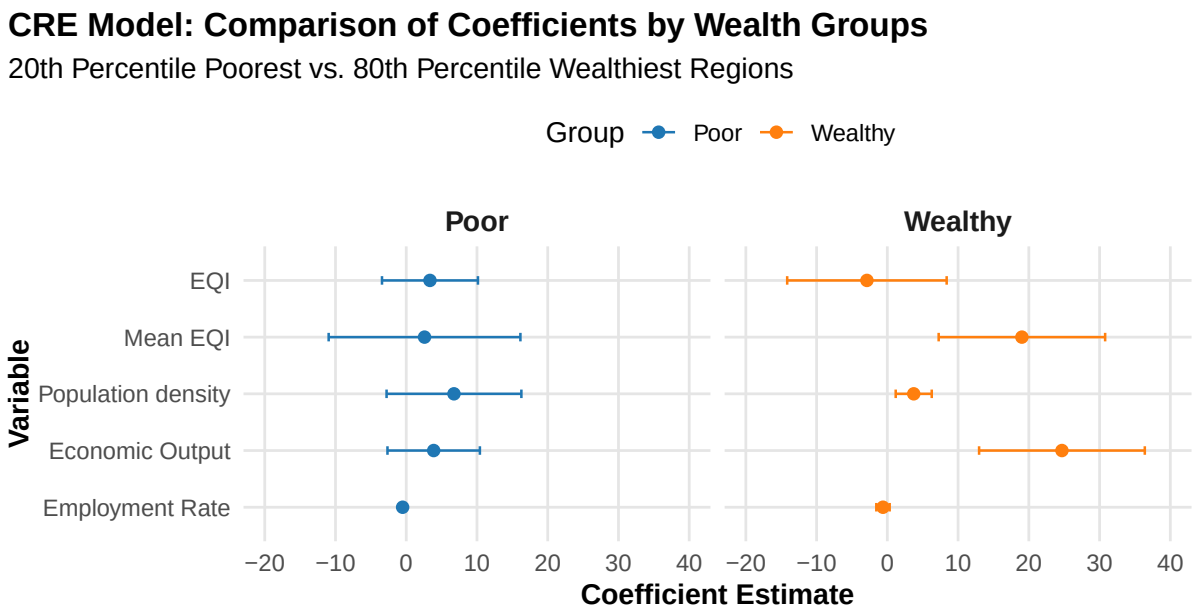


Figure 4.1.: Subsample Analysis: CRE

Figure 4.2 presents the subsample analysis for the IV approach, offering a more theoretically consistent perspective by addressing endogeneity and providing intuitive results. The analysis yields several significant findings for both subgroups. Improvements in institutional quality (EQI) have a notably stronger impact on the poorest regions than on the wealthiest. Specifically, the effect size for EQI in the poorest regions (coefficient: 58.4, $p<0.01$) is nearly three times that of the wealthiest regions (coefficient: 20.0, $p<0.01$). This finding aligns with the interaction effects observed in Table 4.2, where improvements in institutional quality were shown to have diminishing returns in wealthier regions with higher economic output.[6]

Population density also plays a more prominent role in poorer regions, although it remains a significant driver of innovation even in wealthier regions. This suggests that increased population density enhances regional innovation overall, consistent with previous theoretical expectations. However, the effect may be more pronounced in poorer regions, potentially due to the accompanying development of a more skilled labor market, increased competition, and innovation spillovers. In wealthier regions, where population density is already relatively high, these additional benefits may be less impactful.

Regional income exhibits a contrasting pattern between wealthier and poorer regions. In wealthy regions, $\log(GDP)$ has a much stronger and statistically significant effect on innovation (coefficient: 15.3, $p < 0.01$), likely reflecting the ability of higher economic output to support advanced RD, infrastructure development, and high-tech industries.

[6]For detailed subsample results, see table A.1 in the Appendix.

Conversely, in poorer regions, the effect size shrinks to 1.03 and becomes statistically insignificant, thereby suggesting that economic output in itself does not directly drive innovation. This may be due to a lack of complementary factors, such as institutional strength, skilled labor, and access to innovation networks.
Finally, higher employment rates are positively associated with innovation in both groups, however more significantly in the poorest 20th percentile. This finding contrasts with the CRE results, wherein EMP was found to exert a negative effect. In poorer regions, higher unemployment rates may reflect structural economic shifts, where traditional industries decline while innovation-intensive sectors emerge.

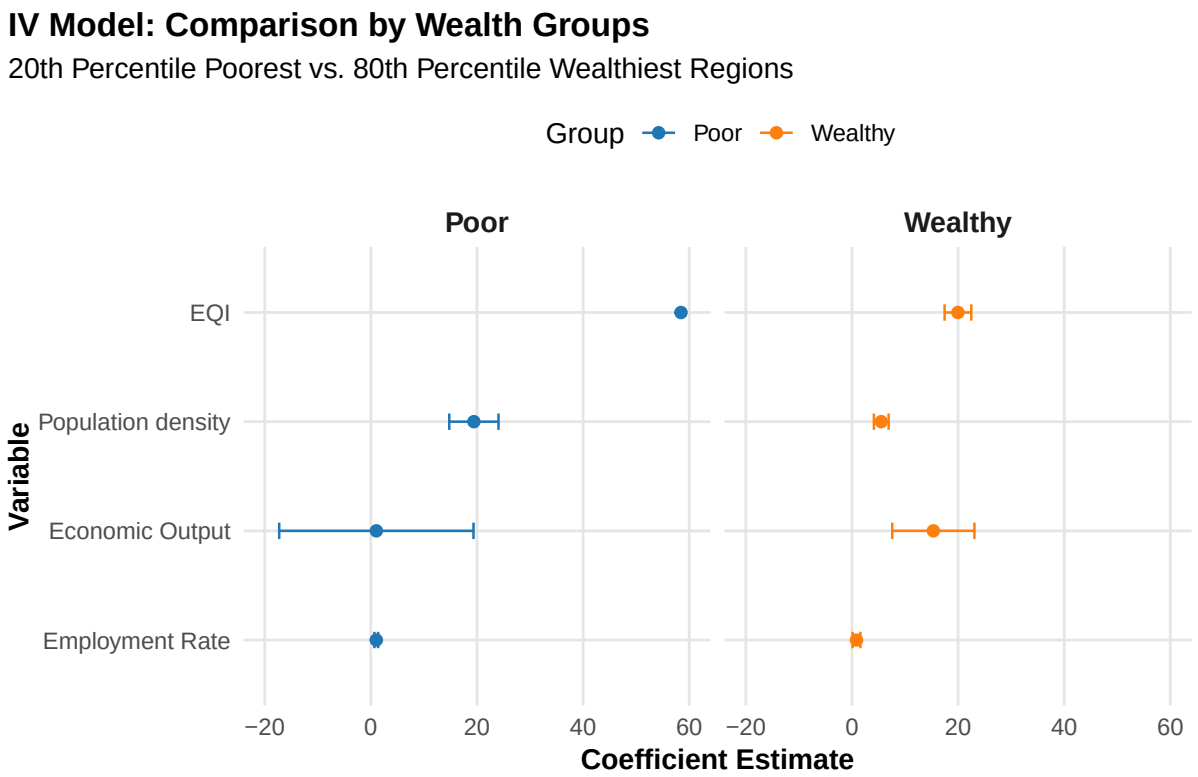


Figure 4.2.: Subsample Analysis: IV

4.4.2. Marginal Effect Analysis

While the subsample analysis offers valuable insights into the dynamics between regional economic output and institutional quality, it does not directly quantify their interaction. A marginal effect analysis using interaction terms of the CRE and IV provides a more detailed examination of this relationship.
Figure 4.3 illustrates how the effect of institutional quality on regional innovation outcomes varies with the level of economic development within the CRE framework. Here,

the marginal effect of EQI on RII increases as GDP per capita increases. This is evident from an upward-sloping curve and also in line with table 4.1, where $(EQI \times \log(GDP))$ is positive. These results imply that institutional quality exerts a stronger influence on innovation in regions with higher economic output, potentially due to better resource utilization, infrastructure, or complementary factors already present in wealthier areas.

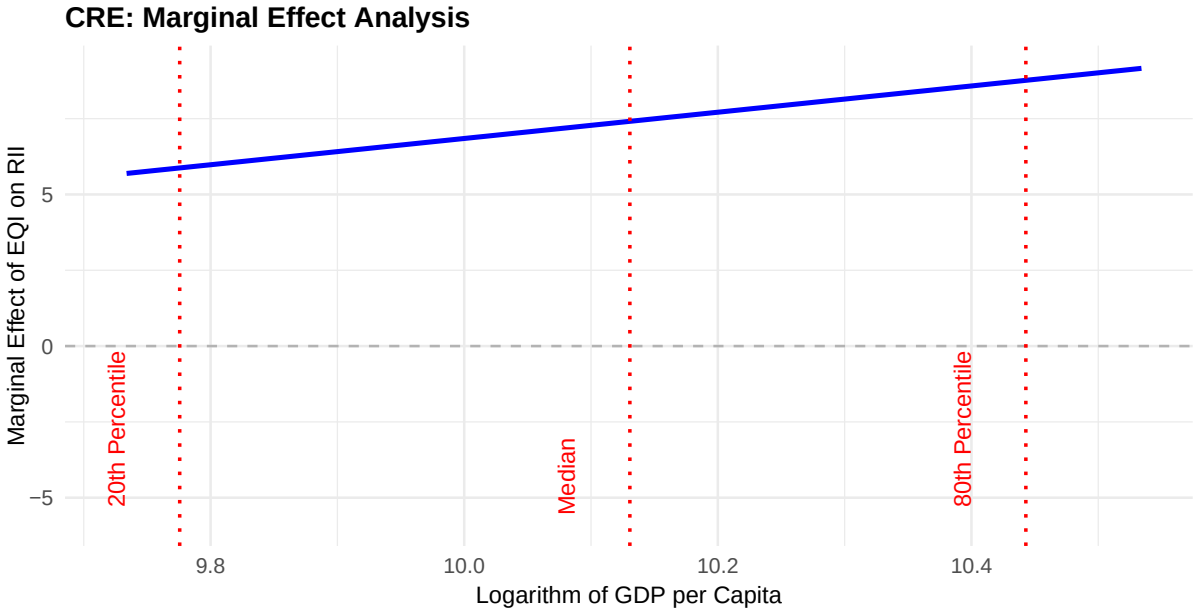


Figure 4.3.: Marginal Effect Analysis: CRE

The results portrayed in figure 4.4 are consistent with patterns observed in previous IV regressions and the subsample analysis. Unlike the CRE model, where the marginal effect of EQI on RII increases with GDP per capita, the IV results reveal a decreasing marginal effect of EQI. This downward-sloping curve aligns with both theoretical expectations and empirical findings, suggesting that institutional quality has a stronger impact in poorer regions compared to wealthier ones. Despite the decline in marginal effect at higher levels of GDP per capita, the positive marginal effect across all regions indicates that EQI consistently supports innovation. The decline in effect emphasizes the role of diminishing returns: regions with stronger economic output might already have institutional mechanisms in place, reducing the additional benefit from improvements in EQI. These results also improve this study´s understanding of the relationship between economic output, institutional quality, and regional innovation. The data supports the idea that economic output modulates the effectiveness of governance improvements.

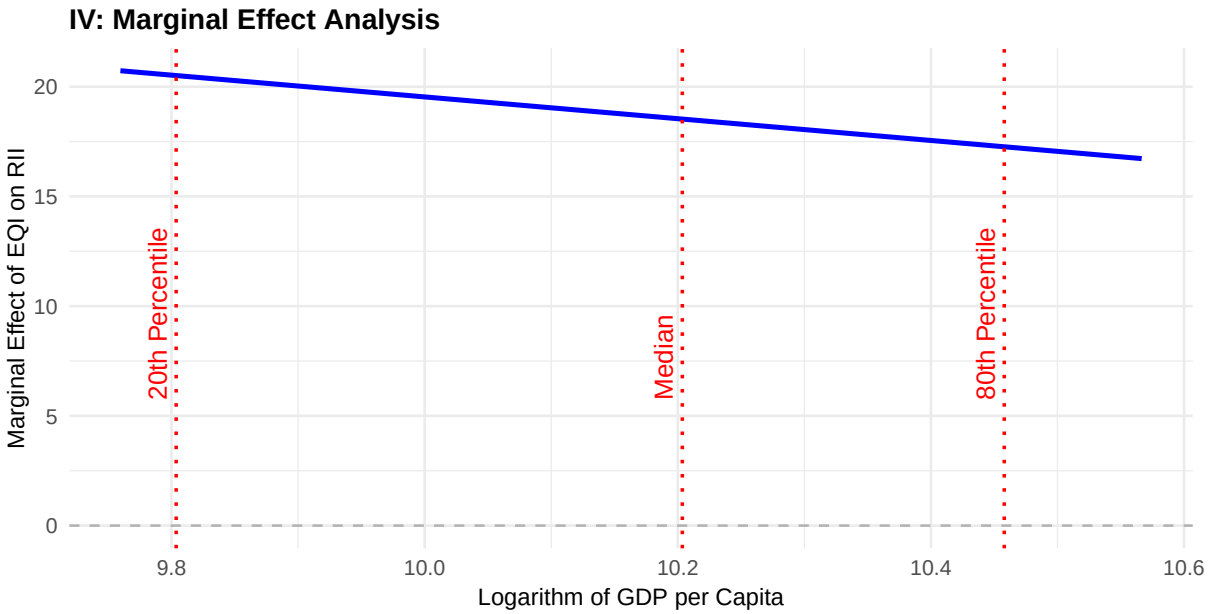


Figure 4.4.: Marginal Effect Analysis: IV

4.4.3. Model Diagnostics and Placebo Test

Thus far, model results and robustness checks have consistently indicated that the IV model is more intuitive and reliable compared to the CRE model. To formalize this conclusion, several diagnostic tests have been employed[7]. The Hausman Test is used to evaluate the consistency of the CRE model. It returns a highly significant chi-squared statistic ($\chi^2 = 199.86$, $p < 0.001$), rejecting the null hypothesis and indicating that the CRE model is inconsistent due to endogeneity. This finding underscores the necessity of an alternative approach to address potential biases. Additionally, the First-Stage F-Statistic is computed to evaluate the strength of the instruments used in the IV model. The resulting F-statistic of 509.79 far exceeds the critical threshold of 10, confirming that the instruments are both strong and reliable in addressing endogeneity concerns. The Weak Instruments Test strongly confirms the validity of the instrument, with a test statistic of 195.92 ($p<0.0001$), indicating that *Historical_Education* is highly relevant and not weak. The Wu-Hausman test, with a test statistic of 0.068 and a p-value of 0.794, suggests no significant endogeneity concerns in the IV model. This result highlights that while endogeneity might be problematic in models like CRE or OLS, the IV approach effectively addresses this issue through the instrument. Although the Sargan test could not be computed due to the model's just-identified structure, this does not undermine the reliability of the IV approach. In summary, the diagnostics provide compelling evidence for the robustness and validity of the IV specification. The results confirm the appropri-

[7]For detailed model diagnostics, please refer to table A.5 in the Appendix.

ateness of the instruments and demonstrate the reliability of the IV model in addressing endogeneity concerns. These findings reinforce the credibility of the conclusions drawn from the analysis.

Finally, to ensure that the model results are not driven by spurious correlations, placebo tests were performed for both the IV and CRE models. The dependent variable was replaced with randomly generated values, and the models were re-estimated to check for the absence of meaningful relationships. Table 4.4 provides an overview of this approach for the CRE and IV models with their most comprehensive specifications respectively (ii and iii). Crucially, in both models, the estimated coefficients for key variables EQI and its interaction term are statistically insignificant, with p-values well above standard thresholds for significance. The only variable exception is the spatial lag variable, which for the IV model, is statistically significant at the 90% confidence interval (p = 0.066). This suggests a potential weak relationship between the spatial lag of innovation and the randomly generated dependent variable. While the result is significant at a lower confidence level, it is not strong enough to question the robustness of the main results. Additionally, R^2 and adjusted R^2 are close to zero in both models, indicating that the models did not explain any meaningful variation in the randomized dependent variable. The non-significant p-value for the Wald Test additionally indicates that the included variables jointly have no explanatory power for the placebo-dependent variable. Collectively, these findings confirm that the observed relationships in the main models are not artifacts of model specification or random noise, as the placebo tests demonstrate an absence of spurious effects when the dependent variable is randomized.

Table 4.4.: Placebo Tests for CRE and IV Models

	CRE Model		**IV Model**	
Variable	**Interaction**	**Spatial Lag**	**Interaction**	**Spatial Lag**
QOG	-0.104	0.158	1.700	-0.119
	(0.919)	(0.575)	(0.241)	(0.421)
EQI x log(GDP	0.027		-0.169	
	(0.786)		(0.228)	
mean_EQI	-0.150	-0.204		
	(0.600)	(0.479)		
log(GDP)	-0.040	-0.157	-0.093	-0.070
	(0.774)	(0.309)	(0.652)	(0.680)
log(POP)	-0.027	-0.037	0.045	0.022
	(0.466)	(0.324)	(0.258)	(0.644)
EMP	-0.003	-0.006	0.004	0.002
	(0.690)	(0.401)	(0.618)	(0.811)
spatial_RII		0.004		0.726*
		(0.191)		(0.066)
(Intercept)	0.605	1.556	0.735	0.230
	(0.655)	(0.269)	(0.713)	(0.883)
R^2	0.002	0.004	0.009	0.004
Adj. R^2	-0.005	-0.003	0.002	-0.003
Wald Test (p-value)	0.924	0.732	0.425	0.610
Observations	862	862	707	707

Note: Estimates are followed by p-values in parentheses.

CRE models use random effects estimation; IV models use 2SLS estimation.

***p<0.01, **p<0.05, *p<0.1.

5. Discussion

This study aimed to deepen the understanding of the relationship between institutional quality and innovation in contemporary economic research (Huang and Xu, 1999). Building on previous work, such as Rodriguez-Posé and Di Cataldo (2015), a large panel of European regions was constructed and analyzed using multiple econometric approaches. After extensive robustness testing and theoretical considerations, the IV approach emerged as the most reliable method for examining the relationship between regional institutional quality and innovation outcomes. Specifically, this approach confirmed that EQI has a strong and direct positive effect on regional innovation, as measured by RII. The effect size, however, warrants careful interpretation. In model (ii) for the IV approach - including the interaction term $EQI \times log(GDP)$ - a one-unit improvement in institutional quality is associated with a 67.037-point increase in the Regional Innovation Scoreboard. This aligns with previous research highlighting the positive impact of institutional quality on innovation outcomes (Rodriguez-Pose and Di Cataldo, 2015; Zhang and Rodríguez-Pose, 2024). For instance, Rodriguez-Posé and Di Cataldo (2015) found that a one-unit increase in the Quality of Government Index corresponds to a 105.3% to 111.9% increase in innovation, as measured in patent applications. However, this positive relationship appears to exhibit diminishing returns. The negative coefficient of the interaction term $EQI \times \log(GDP)$ suggests that the marginal benefits of institutional quality decrease with higher levels of regional economic development. This pattern is further supported by the subsample analysis, which reveals that EQI has a significantly greater effect in poorer regions compared to wealthier ones. For example, a one-unit improvement in EQI leads to a 58.4-point increase in RII for the bottom 20th percentile of regions by GDP per capita, compared to a 20-point increase for the wealthiest regions. This finding echoes Rodriguez-Posé and Di Cataldo's assertion that "relatively small improvements in government effectiveness or the control of corruption may yield substantial benefits for the creation of sound regional innovation systems and for new knowledge generation in the periphery of Europe. Conversely, improvements in government quality have only a small effect on the patenting capacity of core regions" (2015).
Economic output ($\log(GDP)$) also consistently emerges as a primary determinant of regional innovation across all model specifications. However, the subsample analysis reveals

that $\log(GDP)$ is statistically insignificant in poorer regions, suggesting the presence of a threshold effect. This implies that mediating factors, such as EQI, $\log(POP)$, and EMP, may need to reach critical levels before economic development translates into significant innovation outcomes. Similar findings in the context of the EU Structural and Cohesion Funds suggest that institutional quality improvements are more impactful than additional investments below a certain economic threshold (Rodríguez-Pose and Garcilazo, 2015).

Population density consistently demonstrates a positive effect on innovation in both CRE and IV models. In the IV approach, a one percent change in population density results in a 0.28 unit increase in the RII. This effect is particularly pronounced in poorer regions, where it likely facilitates competition, intra-regional spillovers, and access to broader talent pools, as reflected in Crescenzi et al. (2007).

The results for unemployment rates are less consistent across models. The IV regression suggests a positive relationship between higher unemployment and regional innovation outcomes, while the CRE model identifies a significant negative relationship. The CRE interpretation, which aligns with much of the existing literature, suggests that higher employment rates typically foster innovation by facilitating knowledge spillovers, increased collaboration, and a more dynamic economic environment. Crescenzi et al. (2007) similarly found that unemployment has a negative effect on production innovation in the US while showing no significant relationship in the EU. The IV results, on the other hand, propose a more unconventional dynamic, where higher unemployment may coincide with innovation in poorer regions due to structural shifts. These shifts could reflect the decline of labor-intensive industries and the rise of innovation-driven sectors that rely on capital-intensive production or highly skilled labor, which may not immediately absorb displaced workers. While this finding is intriguing, the CRE interpretation remains more consistent with the broader theoretical framework and empirical evidence.

The spatial lag variable is positive and significant in both the CRE and IV models, suggesting that innovation performance of neighboring regions enhances a region's innovation output. This finding aligns with previous studies, such as Crescenzi et al. (2007), who reported positive spatial spillovers in the EU, often extending up to 200–300 km. The observed positive spillover effect highlights the importance of collaboration and knowledge sharing in driving innovation. These results suggest that regions can benefit from their neighbors' innovative activities, fostering a network effect that amplifies overall regional innovation capacity. The robustness of this finding across models underscores the significance of spatial dependencies in understanding regional innovation dynamics.

Despite the robustness of the results, several methodological considerations warrant further discussion. The IV approach, while offering a theoretically sound and intuitive framework supported by valid and significant instruments, is constrained by data limitations.

Specifically, the exclusion of regions with missing historical education data reduced the sample size to 102 regions from the original 125 in the full panel. This reduction may affect the generalizability of the findings and potentially influence model fit, although the precise impact remains unclear. Additionally, the choice of the instrument, national average education years in 1900, assumes homogeneity within countries which may not fully account for subnational heterogeneity. Further studies could consider region-specific instruments, such as historical literacy rates or other regionally disaggregated data

The choice of the Regional Innovation Scoreboard (RII) as the primary measure of innovation also warrants reflection. While the RII provides a comprehensive view of innovation by integrating factors such as human capital, R&D expenditures, and business innovation activities, its multidimensional nature may obscure the specific influence of individual drivers like patent applications or R&D intensity. Nonetheless, its ability to capture the broader dynamics of regional innovation makes it well-suited to the study's objective of understanding innovation ecosystems in European regions. That said, the focus on regional disparities may underemphasize the role of national-level spillovers, such as cross-border funding or overarching policy frameworks.

Several technical limitations also constrain this study. First, this research does not provide any insight into which pillars of institutional quality are most influential in driving innovation. This reduces the ability to specify policy recommendations. Additionally, the relatively short time frame of the dataset limits the ability to capture the long-term effects of institutional reforms, which may require years to materialize.

Future research could address these gaps by disaggregating the EQI components to identify their individual contributions to innovation and extending the dataset to allow for the analysis of long-term reform impacts, particularly in lagging regions. Furthermore, studies should explore whether spatial spillovers reflect competitive dynamics or collaborative synergies, especially in regions with significant institutional disparities. This would provide a more nuanced understanding of inter-regional innovation dynamics and enhance the policy relevance of findings.

6. Conclusion

This study set out to answer the question, "How does regional institutional quality shape innovation across European regions?" By examining the relationship between two indices - the European Quality of Government Index (EQI) and the Regional Innovation Index (RII) - it aimed to uncover how institutional quality drives innovation across diverse economic contexts. The findings are both insightful and actionable.

Institutional quality, as captured by EQI´s three pillars (Quality of Public Sercives, Impartiality, or Control of Corruption), plays a pivotal role in shaping innovative environments across all European regions. In all base estimations, EQI shows a strong and consistent positive influence on RII. However, when the interaction term is included, the relationship becomes a bit more nuanced. The IV analysis revealed that institutional reforms have the greatest impact in poorer regions. In less developed regions, improvements in governance, corruption control, or public service quality might create substantial new opportunities for innovation by addressing fundamental inefficiencies or barriers to economic activity. In wealthier regions, institutional quality is likely already at a higher baseline, so additional improvements may yield smaller innovation gains. Additionally, the results highlight how economic output and institutional quality are deeply interconnected—regions with higher GDP often display stronger institutions, and vice versa.

This study also contributes to the field by adopting RII as a multidimensional measure of innovation. Unlike traditional metrics, such as patent application or R&D expenditure, RII captures a broader and more comprehensive view of regional innovation capacity. This approach allows for a more holistic understanding of how innovation develops across regions. At the same time, the study addresses the persistent challenge of endogeneity in these analyses by employing an instrumental variable (IV) approach. This method strengthens the reliability of the findings and provides deeper insights into the causal relationship between EQI and RII.

The findings carry important implications for policy-makers. Institutional reforms should prioritize less-developed regions, focusing on reducing corruption, improving public services, and enhancing transparency. These changes can provide the foundation for stronger innovation ecosystems. Meanwhile, wealthier regions may benefit from more targeted strategies.

Ultimately, this study sheds light on the significant role of institutional quality in shaping regional innovation. It also highlights the persistent regional divide in Europe, where regions with weaker institutions often lag in innovation. By addressing these disparities, policymakers can help create more equitable and innovative environments across the continent.

A. Appendix

Table A.1.: Subsample Analysis for CRE and IV Models

	CRE Model		**IV Model**	
Variable	**Poor**	**Wealthy**	**Poor**	**Wealthy**
QOG	3.35	-2.88	58.40***	20.00***
	(0.417)	(0.674)	(<0.001)	(<0.001)
log(GDP)	3.88	24.70***	1.03	15.30***
	(0.330)	(0.001)	(0.927)	(0.001)
mean_QOG	2.59	19.00***		
	(0.754)	(0.009)		
log(POP)	6.75	3.73**	19.40***	5.52***
	(0.246)	(0.017)	(<0.001)	(<0.001)
EMP	-0.511**	-0.615	1.02***	0.85*
	(0.036)	(0.285)	(<0.001)	(0.059)
(Intercept)	-5.71	-166.00**	22.40	-88.00
	(0.905)	(0.023)	(0.834)	(0.071)

Note: Estimates are followed by p-values in parentheses.

CRE models use random effects estimation; IV models use 2SLS estimation.

***p<0.01, **p<0.05, *p<0.1.

Table A.2.: RIS 2023 Indicators

Category	Indicators
Framework Conditions	**Human resources:** Percentage of population aged 25-34 having completed tertiary education; lifelong learning (share of population aged 25-64 in education/training).
	Attractive research systems: International scientific co-publications per million population; top-10% cited scientific publications.
	Digitalisation: Individuals with above-basic overall digital skills.
Investments	**Finance and support:** R&D expenditure in the public sector as a percentage of GDP.
	Firm investments: R&D expenditure in the business sector; non-R&D innovation expenditure as a percentage of turnover; innovation expenditures per employee in innovation-active enterprises.
	Use of information technologies: Employed ICT specialists.
Innovation Activities	**Innovators:** SMEs introducing product or business process innovations as a percentage of SMEs.
	Linkages: Innovative SMEs collaborating with others; public-private co-publications per million population.
	Intellectual assets: PCT patent, trademark, and design applications per billion GDP (Purchasing Power Standards).
Impacts	**Employment impacts:** Employment in medium-high and high-tech manufacturing; employment in innovative SMEs.
	Sales impacts: Sales to new-to-market or new-to-enterprise innovations as a percentage of SMEs' turnover.
	Environmental sustainability: Exposure to fine particulates (PM2.5).

Figure A.1.: Construction of the European Quality of Government Index (EQI).

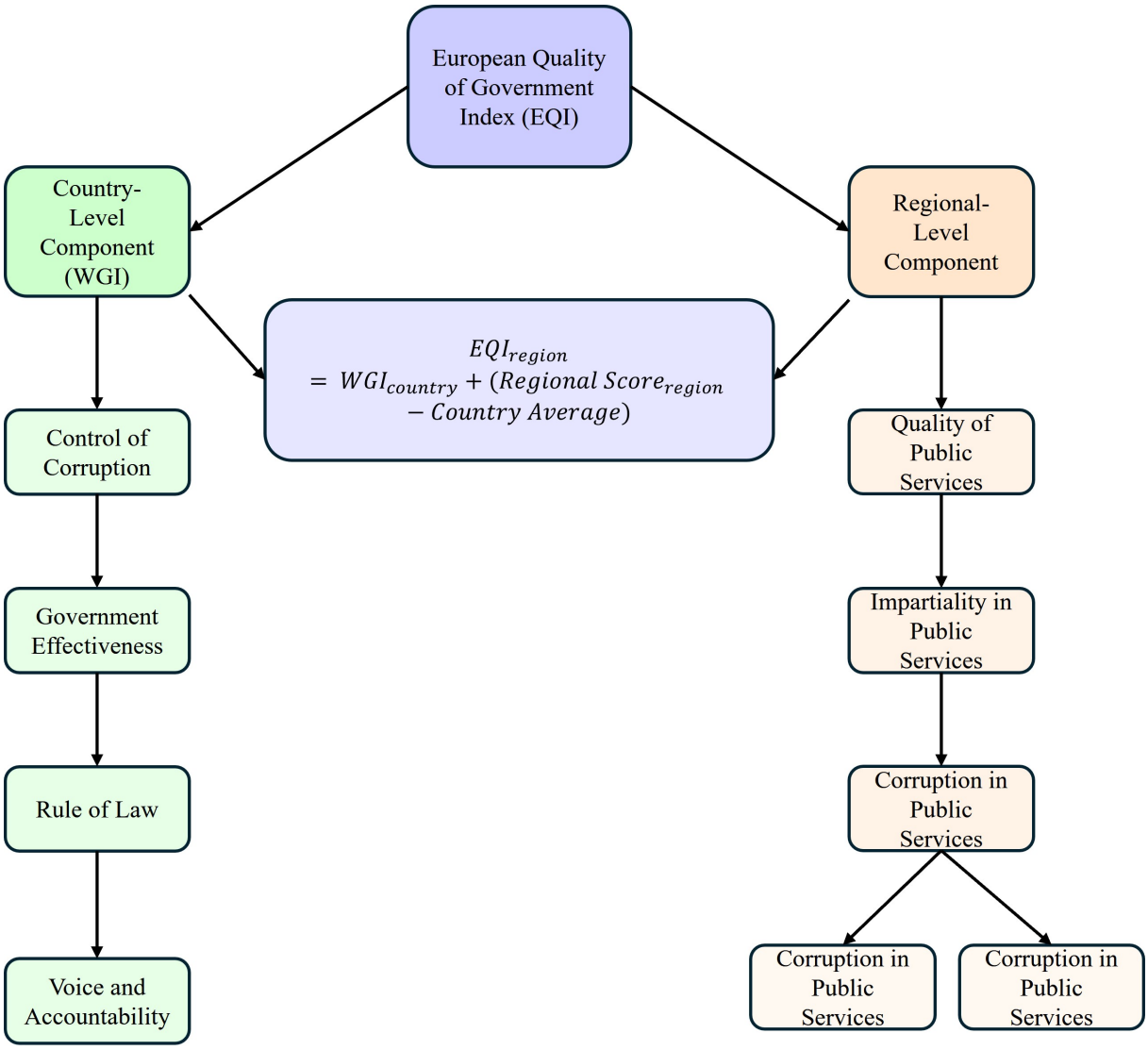


Table A.3.: Complete List of Regions

Region Code	**Region Name**	**Country Code**	**Country Name**
BE1	Région de Bruxelles-Capitale / Brussels Hoofdstedelijk Gewest	BE	Belgium
BG31	Severozapaden	BG	Bulgaria
BG32	Severen tsentralen	BG	Bulgaria
BG33	Severoiztochen	BG	Bulgaria
BG34	Yugoiztochen	BG	Bulgaria
BG41	Yugozapaden	BG	Bulgaria
BG42	Yuzhen tsentralen	BG	Bulgaria
CZ01	Praha	CZ	Czech Republic

Region Code	Region Name	Country Code	Country Name
CZ03	Jihozápad	CZ	Czech Republic
CZ04	Severozápad	CZ	Czech Republic
CZ05	Severovýchod	CZ	Czech Republic
CZ06	Jihovýchod	CZ	Czech Republic
CZ08	Moravskoslezsko	CZ	Czech Republic
DE3	Berlin	DE	Germany
DE4	Brandenburg	DE	Germany
DE5	Bremen	DE	Germany
DE6	Hamburg	DE	Germany
DE8	Mecklenburg-Vorpommern	DE	Germany
DEC	Saarland	DE	Germany
DEE	Sachsen-Anhalt	DE	Germany
DEF	Schleswig-Holstein	DE	Germany
DEG	Thüringen	DE	Germany
DK01	Hovestaden	DK	Denmark
DK02	Sjælland	DK	Denmark
DK03	Syddanmark	DK	Denmark
DK04	Midtjylland	DK	Denmark
EL41	Voreio Aigaio	EL	Greece
EL42	Notio Aigaio	EL	Greece
EL43	Kriti	EL	Greece
EL52	Kentriki Makedonia	EL	Greece
EL53	Dytiki Makedonia	EL	Greece
EL54	Ipeiros	EL	Greece
EL61	Thessalia	EL	Greece
EL62	Ionia Nisia	EL	Greece
EL65	Peloponnisos	EL	Greece
ES11	Galicia	ES	Spain
ES12	Principado de Asturias	ES	Spain
ES13	Cantabria	ES	Spain
ES21	País Vasco	ES	Spain
ES22	Comunidad Foral de Navarra	ES	Spain
ES23	La Rioja	ES	Spain
ES24	Aragón	ES	Spain
ES41	Castilla y León	ES	Spain
ES42	Castilla-la Mancha	ES	Spain
ES43	Extremadura	ES	Spain
ES51	Cataluña	ES	Spain
ES52	Comunitat Valenciana	ES	Spain
ES53	Illes Balears	ES	Spain
ES61	Andalucía	ES	Spain
ES62	Región de Murcia	ES	Spain
FI1B	Etelä-Suomi	FI	Finland

Region Code	**Region Name**	**Country Code**	**Country Name**
FI1C	Länsi-Suomi	FI	Finland
HR02	Panonska Hrvatska	HR	Croatia
HR03	Jadranska Hrvatska	HR	Croatia
HR05	Grad Zagreb	HR	Croatia
HR06	Sjeverna Hrvatska	HR	Croatia
HU11	Budapest	HU	Hungary
HU12	Pest	HU	Hungary
HU21	Közép-Dunántúl	HU	Hungary
HU22	Nyugat-Dunántúl	HU	Hungary
HU23	Dél-Dunántúl	HU	Hungary
HU31	Észak-Magyarország	HU	Hungary
HU32	Észak-Alföld	HU	Hungary
HU33	Dél-Alföld	HU	Hungary
IE04	Northern and Western	IE	Ireland
IE05	Southern	IE	Ireland
IE06	Eastern and Midland	IE	Ireland
ITC1	Piemonte	IT	Italy
ITC3	Liguria	IT	Italy
ITC4	Lombardia	IT	Italy
ITF1	Abruzzo	IT	Italy
ITF2	Molise	IT	Italy
ITF3	Campania	IT	Italy
ITF4	Puglia	IT	Italy
ITF5	Basilicata	IT	Italy
ITF6	Calabria	IT	Italy
ITG1	Sicilia	IT	Italy
ITG2	Sardegna	IT	Italy
ITH3	Veneto	IT	Italy
ITH4	Friuli-Venezia Giulia	IT	Italy
ITH5	Emilia-Romagna	IT	Italy
ITI1	Toscana	IT	Italy
ITI2	Umbria	IT	Italy
ITI3	Marche	IT	Italy
ITI4	Lazio	IT	Italy
NL11	Groningen	NL	Netherlands
NL12	Friesland (NL)	NL	Netherlands
NL13	Drenthe	NL	Netherlands
NL21	Overijssel	NL	Netherlands
NL22	Gelderland	NL	Netherlands
NL23	Flevoland	NL	Netherlands
NL32	Noord-Holland	NL	Netherlands
NL34	Zeeland	NL	Netherlands
NL41	Noord-Brabant	NL	Netherlands

Region Code	**Region Name**	**Country Code**	**Country Name**
NL42	Limburg (NL)	NL	Netherlands
PL41	Wielkopolskie	PL	Poland
PL42	Zachodniopomorskie	PL	Poland
PL43	Lubuskie	PL	Poland
PL52	Opolskie	PL	Poland
PL61	Kujawsko-Pomorskie	PL	Poland
PL63	Pomorskie	PL	Poland
PL81	Lubelskie	PL	Poland
PL82	Podkarpackie	PL	Poland
PL84	Podlaskie	PL	Poland
PL92	Mazowiecki regionalny	PL	Poland
PT11	Norte	PT	Portugal
PT15	Algarve	PT	Portugal
RO11	Nord-Vest	RO	Romania
RO12	Centru	RO	Romania
RO21	Nord-Est	RO	Romania
RO22	Sud-Est	RO	Romania
RO41	Sud-Vest Oltenia	RO	Romania
RO42	Vest	RO	Romania
SE11	Stockholm	SE	Sweden
SE12	Östra Mellansverige	SE	Sweden
SE21	Småland med öarna	SE	Sweden
SE22	Sydsverige	SE	Sweden
SE23	Västsverige	SE	Sweden
SE31	Norra Mellansverige	SE	Sweden
SE32	Mellersta Norrland	SE	Sweden
SE33	Övre Norrland	SE	Sweden
SI03	Vzhodna Slovenija	SI	Slovenia
SI04	Zahodna Slovenija	SI	Slovenia
SK01	Bratislavský kraj	SK	Slovakia
SK02	Západné Slovensko	SK	Slovakia
SK03	Stredné Slovensko	SK	Slovakia
SK04	Východné Slovensko	SK	Slovakia

Table A.5.: Summary of Model Diagnostics

Hausman Test (CRE vs. FE Base)	
Test Statistic (Chi-squared)	199.86
Degrees of Freedom	4
p-value	$< 2.2e\text{-}16$

First-Stage F-Statistic (IV Model)	
F-statistic	509.79
Numerator Degrees of Freedom	4
Denominator Degrees of Freedom	702

Sargan-Hansen Test (IV Model)		
Test	**Statistic**	**p-value**
Weak Instruments Test	195.92	$< 1.95e\text{-}39$
Wu-Hausman Test	0.068	0.794
Sargan Test	NA	NA

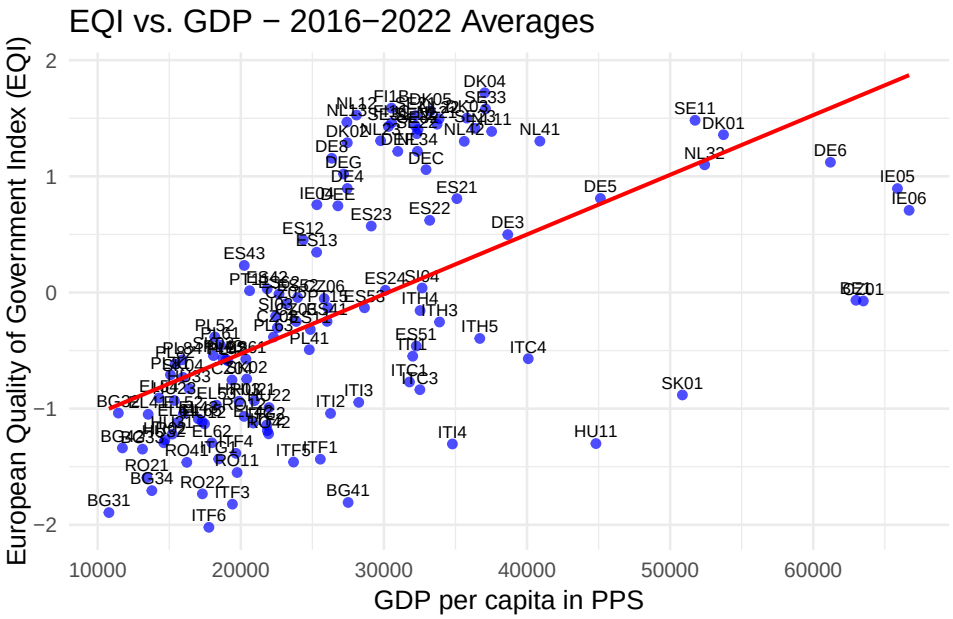


Figure A.2.: European Quality of Government Index (EQI) vs. Regional GDP per capita

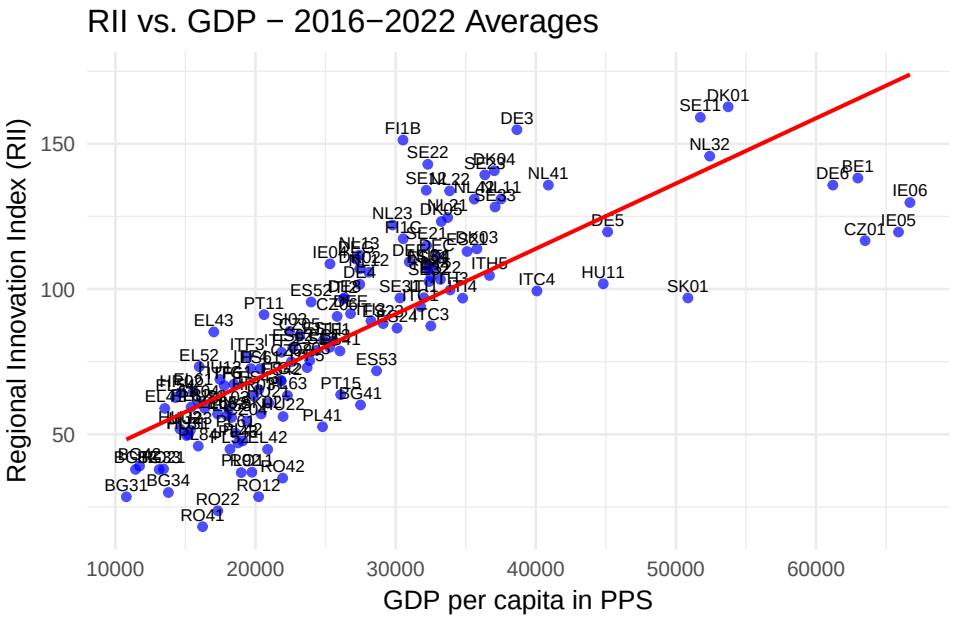


Figure A.3.: Regional Innovation Index (EQI) vs. Regional GDP per capita

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