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Papers in Evolutionary Economic Geography

22.03

Utrecht University

Human Geography and Planning

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Abstract. We quantify the general equilibrium effects on economic growth of improving the quality of institutions at the regional level in the context of the implementation of the European Cohesion Policy for the European Union and the UK. The direct impact of changes in the quality of government is integrated in a general equilibrium model to analyse the system-wide economic effects resulting from additional endogenous mechanisms and feedback effects. The results reveal a significant direct effect as well as considerable system-wide benefits from improved government quality on economic growth. A small 5% increase in government quality across European Union regions increases the impact of Cohesion investment by up to 7% in the short run and 3% in the long run. The exact magnitude of the gains depends on various local factors, including the initial endowments of public capital, the level of government quality, and the degree of persistence over time.

Keywords: government quality, cohesion, economic growth, public investment, regions, EU

JEL codes: C68, O17, R13, R15

Introduction

The role of government quality as a driver of economic development at subnational level has come under considerable scrutiny in recent years. The majority of the research on the topic has focused on the European Union (EU), where it has been found that regional differences in government quality impinge on a wide range of socio-economic and political outcomes, including the delivery and efficiency of public investment. Variations in regional government quality across the EU significantly affect both economic growth and powerfully mediate the returns to investment under virtually all public policies, including major funding programmes such as the European Structural and Investment Funds (ESIF). "The quality of government becomes — for the large majority of regions — the basic factor determining why a region grows. In many of the regions receiving the bulk of Structural Funds, greater levels of cohesion expenditure would, in the best-case scenario, only lead to a marginal improvement in economic growth, unless the quality of the government is significantly improved" (Rodríguez-Pose and Garcilazo, 2015, p. 1288).

In this paper, we revisit in far greater detail than hitherto — by means of newly developed datasets and a variety of advanced econometric methods — the issue of the impact of regional quality of government on the returns to European Cohesion investments. We move away from the partial equilibrium setting, which has until now dominated research (e.g., Rodríguez-Pose and Garcilazo, 2015; Rodríguez-Pose and Ketterer, 2020), and use a dynamic spatial computable general equilibrium (CGE) model (Lecca et al., 2018 and 2020), to assess the system-wide effects of improvements in regional government quality across EU regions. This yields a unique and broader perspective on the topic that has been missing in the literature so far. To our knowledge, no previous attempts have been made to assess quality of government in a broader (and regional) general equilibrium setting.

Our econometric estimates confirm the existence of a positive and significant relationship between government quality and GDP growth at a regional level in the EU. We use this evidence in general equilibrium modelling simulations to show that the GDP gains generated by the public capital investments of the 2014-2020 European Structural and Investment Funds (ESIF) —amounting to roughly 50% of the overall expenditure in Cohesion policy — may be considerably enhanced by improvements in government quality. Modelling simulations assuming a full absorption of the policy investments suggest that a relatively small 5% increase in government quality across EU regions can lead to increase the impact of ESIF investment by up to 7% in the short run and 3% in the long run. Substantial economic gains can therefore be accomplished by paying greater attention to institutional bottlenecks and improving quality of government.

Quality of government and economic growth

Until now, most scientific research dealing with economic growth at subnational level has struggled to assess how and to what extent investment in regional development is transformed into economic growth. In particular, an ever growing volume of research focusing on the link between European Cohesion Policy investments and regional growth keeps on producing diverse results that make finding a common ground on the convenience and adequacy of the European Cohesion Policy hard to reach. One of the potential reasons for this lack of consensus is that most of this research has neglected until relatively recently the role of institutions on the economic dynamism of different regions. More importantly, it also has overlooked how variations in institutional quality across space mediate the returns of public policies, in general, and the European Cohesion effort, in particular (Rodríguez-Pose, 2013).

A recent spate of research has changed this panorama. Using the data on subnational government quality produced by Charron et al. (2014, 2015), the volume of work shedding

light on how government quality affects economic development at a regional level has not ceased to increase. Most of this literature has covered regions in the EU. In addition to the research on government quality and the returns of European Cohesion policy by Rodríguez-Pose and Garcilazo (2015), several contributions have shown that local institutional quality impinges on economic growth through its effect on different policies and investments, such as interventions to promote entrepreneurship (Nistotskaya et al., 2015; Aparicio et al., 2016; Huggins and Thompson, 2016), regional competitiveness (Annoni and Dijkstra, 2017), innovation (Rodríguez-Pose and Di Cataldo, 2015), productivity (Kaasa, 2016), industrial diversification (Cortinovis et al., 2017), resilience (Ezcurra and Ríos, 2019), or infrastructure (Crescenzi et al., 2016). Similar work has been carried out outside Europe (e.g., Rodríguez-Pose and Zhang, 2019; Iddawela et al., 2021). Overall, the bulk of this literature highlights that local government quality is a fundamental shaper of economic growth (Ketterer and Rodríguez-Pose, 2018) and that the connection between the quality of local institutions and economic performance is achieved both directly and indirectly, through how variations in government quality shape the design, implementation, and monitoring of public policies.

However, the majority of existing research on the topic — with the exception of Rodríguez-Pose and Garcilazo (2015) — does not quantify the potential impact of weak institutional ecosystems on the economic growth impact of different policies. This has made it difficult to go beyond the statement that institutions and government quality matter for regional development.

Quality of government in a partial equilibrium framework

Our aim is to overcome this shortcoming, by assessing in detail the extent to which regional variations in government quality across Europe lead to different economic impacts of Cohesion policy investment. We aim to quantify not only if such differences have an impact on the

returns of ESIF investment, but also whether changes in government quality in certain regions of Europe yield gains (or losses) in the form of changes in the returns of the European development effort. To do that, we investigate the role of quality of institutions within a partial equilibrium framework. Building on Rodríguez-Pose and Garcilazo (2015), we estimate the following panel model with growth of GDP per capita as the dependent variable, using data for EU regions:

$$\Delta GDPpc_{i,t} = \beta_0 + \beta_1 \ln GDPpc_{i,t-1} + \beta_2 \ln ESIFunds_{i,t} + \beta_3 q_{i,t} + \phi \boldsymbol{X}_{i,t} + \mu_i + \lambda_t + v_{i,t} \quad (1)$$

where $\Delta GDPpc_{i,t}$ is the annual growth rate of GDP per capita for region i between $t-1$ and t; $GDPpc_{i,t-1}$ represents the lag of GDP per capita for region i; $ESIFunds_{i,t}$ is the amount of Cohesion policy's ESIF per capita received by the region; and $q_{i,t}$ stands for the regional quality of government indicator. $\boldsymbol{X}_{i,t}$ denotes a vector of variables controlling for other factors —such as the level of primary and tertiary education, employment rate, employment density, and accessibility of the region— that may influence regional GDP per capita growth. The key parameter to be estimated in equation (1) is the elasticity of GDP per capita growth to changes in the regional quality of government: $\hat{\beta}_3$. This captures the direct effect of changes in the quality of government on economic growth.

Equation (1) is estimated using the following data. The regional quality of government index is taken from the European Quality of Government Index (Charron et al., 2014, 2015, and 2019). This index was only available for the years 2010, 2013, and 2017 at the time of writing. We converted it into a full time-variant variable for the period of analysis, by combining it with the World Bank's Worldwide Governance Indicators. In making this combination, we assume

that regional quality of governments varies in line with changes in government quality of the corresponding national governments.[1]

Data on the ESIF for the current programming period (2014-2020) come from the corresponding database provided by the European Commission Directorate General for Regional Policy (DG REGIO). The dataset contains the payments made by the European Commission to the Member States for each region, fund, and spending category for the 10 years over which the managing authorities are allowed to spend the money (up to 2023).[2]

Data for most of the control variables are taken from Eurostat. This is the case for GDP at current market prices, population aged 25-64 by educational attainment, employment rates, employment, and area by region (see Tables A1 and A2 of the Appendix for a description and for the descriptive statistics of the variables used in the estimations). The index for population road accessibility measures the number of inhabitants reachable within a 90-minute drive. It is constructed using information from the road transportation network in the EU for the years 2001, 2006, 2011 and 2014 (Dijkstra et al., 2019).[3]

The estimated coefficients of several specifications of model (1) are presented in Table 1. Columns 1 to 3 show the estimates of two-way fixed effects models with both region and time fixed effects. Column 1 contains the results of a parsimonious model, not including government quality or EU Cohesion funds among the explanatory variables. Columns 2 and 3 contain the results of the same model enriched first with EU Cohesion Funds, and then with government quality among the right-hand-side variables, respectively. We address the possible endogeneity

[1] Following Rodríguez-Pose and Ketterer (2020), we use an unweighted average of the Voice and Accountability (VA), Government Effectiveness (GE), Rule of Law (RL), and Control of Corruption (CC) indicators of the Worldwide Governance Indicators (WGI).

[2] More information available at https://cohesiondata.ec.europa.eu/browse?limitTo=datasets.

[3] Data for the rest of the years were extrapolated. The index was provided to us by DG REGIO.

of the latter variable by estimating an instrumental variable two-way fixed effects model in column (4). The government quality index is instrumented with the following variables: the level of regional development measured as regional GDP per capita over EU GDP per capita, two lags of the quality of government variable, two lags of the log ESIF variable, one lag of the log GDP growth variable, and one lag of the rest of the explanatory variables. Column (5) contains the estimated coefficients of the model including both EU Cohesion funds and government quality among the explanatory variables simultaneously. Finally, column (6) shows the instrumental variables estimates of that same model, with the same logic used for the choice of the instruments of these two variables, which, in this case, are both considered as potentially endogenous.

The results show that the European Cohesion funds had a positive and significant effect on regional economic growth at the European level. This is in line with the findings of Cappelen et al. (2003), Rodríguez-Pose and Fratesi (2004), Becker et al. (2012), Pellegrini et al. (2013); Crescenzi and Giua (2015), or Cerqua and Pellegrini (2018). The rest of the controls also show coefficients in line with those of the literature on the determinants of economic growth in Europe, e.g., positive and significant coefficients associated with employment and negative and significant ones for the initial level of GDP per capita and accessibility (Rodríguez-Pose and Ketterer, 2020).

Table 1. *Impact of quality of government on regional growth — equation (1)*

	(1) Two-way FE	(2) Two-way FE	(3) Two-way FE	(4) IV Two-way FE	(5) Two-way FE	(6) IV Two-way FE
GDP per capita (log)	-0.203***	-0.254***	-0.214***	-0.282***	-0.262***	-0.316***
	(-23.27)	(-16.83)	(-24.40)	(-23.77)	(-17.76)	(-14.63)
Quality of govt.			0.026***	0.040***	0.024***	0.038***
			(4.38)	(4.39)	(3.82)	(3.90)
ESIF (log)		0.013***			0.013***	0.010*
		(4.62)			(4.53)	(1.93)
Primary education	0.009	-0.015	-0.017	-0.088	-0.038	-0.093
	(0.16)	(-0.26)	(-0.27)	(-1.31)	(-0.59)	(-1.39)
Tertiary education	0.064	0.046	0.016	-0.119*	0.002	-0.119*
	(1.02)	(0.76)	(0.25)	(-1.85)	(0.04)	(-1.85)
Employment rate	0.545***	0.534***	0.513***	0.516***	0. 505***	0.520***
	(7.37)	(6.37)	(6.99)	(6.91)	(6.10)	(6.21)
Empl. Density (log)	-0.005	0.013	-0.004	0.004	0.014*	0.016
	(-0.13)	(0.26)	(-0.10)	(0.10)	(0.28)	(0.32)
Accessibility (log)	-0.049**	-0.055**	-0.050**	-0.026	-0.056**	-0.033
	(-2.07)	(-2.30)	(-2.09)	(-1.08)	(-2.41)	(-1.40)
Constant	2.304***	2.912***	2.471**	2.899***	3.049***	3.318***
	(6.16)	(6.65)	(6.48)	(7.25)	(7.18)	(7.21)
R-squared	0.536	0.552	0.541	0.613	0.556	0.610
No. of Observations	2,184	2,184	2,184	1,996	2,184	1,996
No. of Regions	188	188	188	187	188	187
No. of instruments				10		12
Weak identification				189.009		48.688

Note: Robust t-statistics in parenthesis. ***, **, and * denotes coefficient is statistically significant at the 0.01, 0.05, and 0.10 level respectively. For the Weak identification test, Cragg-Donald Wald F statistic is reported. The null hypothesis of weak identification is rejected using Stock-Yogo critical values.

More importantly for our purposes, a positive and significant relationship between the quality of government and regional growth emerges from all the specifications of the model in which government quality is included among the explanatory variables. The effect is positive and highly statistically significant according to all the model specifications including the government quality index among the right-hand-side variables. The range of the estimated coefficients lies between 0.024 and 0.040, with 0.038, being associated to government quality in the richest of the model specifications presented here (column 6 of Table 1).

These results confirm earlier findings by Ketterer and Rodríguez-Pose (2018) and Rodríguez-Pose and Ketterer (2020). Thus, from a partial equilibrium point of view, it appears that the government quality is a fundamental determinant of economic growth at the regional level in the EU. We now turn to a general equilibrium setting in order to understand the full implications of the relationship between government quality and growth when all the channels operating in an economy are taken into account, something that, to the best of our knowledge, has not been analysed yet in the literature.

Quality of government and growth in a general equilibrium setting

Do these results stand in a general equilibrium setting? General equilibrium models have the advantages of more solid theoretical and econometric foundations and provide far greater internal consistency. At the same time, they allow for a far bigger level of disaggregation. All these factors make general equilibrium models more suitable and reliable when assessing the impact of public policies, as they facilitate measuring, in a more reliable and consistent way, the returns of different types of investment. Hence, in order to test whether the results of the partial equilibrium model stand, we perform the general equilibrium analysis using the RHOMOLO model, a spatial CGE model of the EU NUTS2 regions. The main features and technical details of the model are described in the Supplementary Appendix. In the model, the quality of institutions at regional level is attached to the public capital, constituting a combined factor of production.

Simulations set up

The aim of this analysis is to quantify the system-wide benefits of enhancing institutional quality across EU regions. Since it is plausible to assume that government quality is capable of affecting economic growth mainly via public capital and its role in the economy, we concentrate on public capital investments. In particular, we set up a baseline scenario

simulating the impact of the ESIF investments on infrastructures in energy production, transport, and communication, as well as investments in social infrastructure (human capital and health and housing infrastructures). In other words, we focus solely on the part of ESIF that can be considered as public capital expenditure. Over the programming period 2014-2020, cumulative public capital expenditures were approximately 50% of the whole Cohesion policy, representing, in total, 1.3% of the annual EU GDP (see the Appendix for the list of expenditure categories included in this analysis).[4]

The regional distribution of the funds over the whole implementation period is laid out in Figure 1, where each region is characterised by a different colour shade, depending on the amount of these public capital investments. The bulk of these capital expenditures targeted Southern and Eastern Europe. For some regions, the total amount of funds received over the whole implementation period represented substantial amounts of investments relative to their GDP. For instance, the regions of Hungary and Poland received cumulative funds of around 15% of their annual GDP in investments, while Portugal and the South of Italy were allocated cumulative funds of around 5% and 2.5% of their annual GDP, respectively.[5]

Although the EU budget is organised over a seven-year programming cycle, the actual implementation period of ESIF may be different. This discrepancy is due to the so-called N+2 rule, which indicates that at the beginning of each programming period annual funding is

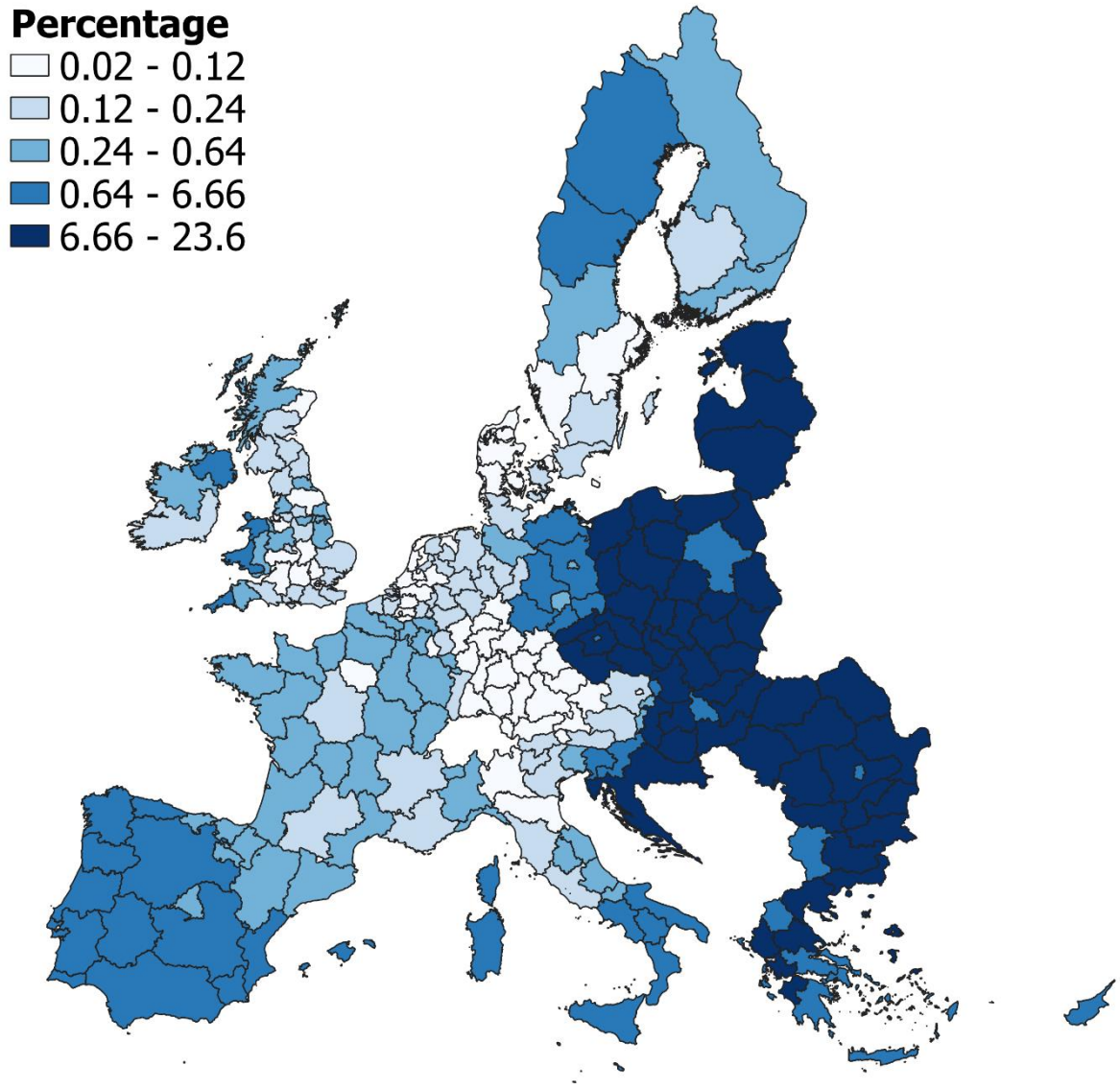
[4] The ESIF amounted to roughly €460 billion for the period 2014-2020, a third of the total EU budget. 43% of expenditures were allocated to the European Development Fund (ERDF), 21.7% to the European Agricultural Fund for Rural Development (EAFRD), 20.1% to the European Social Fund (ESF), 13.7% to the Cohesion Fund (CF), and 1.2% to European Maritime and Fisheries Fund (EMFF). The Cohesion policy 2014-2020 split the policy interventions in 123 categories (See the Nomenclature for the categories of intervention of the Funds under the Investment for growth and jobs goal and of the Youth Employment Initiative, available here: https://webgate.ec.europa.eu/esiflegislation/pages/viewpage.action?pageId=34441370). The 123 categories of expenditures are shown in Table A3 in the Appendix together with the list of those considered as public capital expenditures in our analysis.

[5] There is considerable regional heterogeneity behind public capital expenditures being about 50% of total 2014-2020 Cohesion policy investments. Capital expenditures represent, on average, 60% of the total Cohesion policy investments in eastern and southern European regions, while they constitute between 20% and 35% of the funds in the more developed EU regions.

allocated to each programme and these funds must be spent by the end of the second year after their allocation. In our simulations, we assume that regions are shocked for 10 periods and the funds are equally distributed over that period. Thus, the funds allocated to regions of Hungary and Poland represent, on average, 1.5% of the annual GDP of the region over the entire ten year spending period. Those allocated to Portuguese and southern Italian regions on average represent 0.5% and 0.25% of their annual GDP, respectively. Although most investments tend to take place towards the end of each programming period, we believe this assumption does not bear any meaningful consequences for the specific purposes of this exercise.

The Cohesion policy is mainly financed by the national contributions to the EU budget. Those contributions are proportional to the GDP weight of each member state, so that the larger the GDP share over the EU GDP of a country, the higher its contribution. Thus, we assume that the policy is financed by regions in accordance with their regional GDP level, irrespectively of the amount of funds received. This assumption is reasonably close to the actual disbursement method. We also assume that the investment is financed via non-distortionary taxation on household income.

***Figure 1**: Distribution of cumulative ESIF public capital expenditure by region (% of 2013 GDP)*



Source: own elaborations on DG REGIO data.

The temporary increase in public investment financed through a lump sum tax on household income, as defined above, represents the baseline scenario of our analysis. The aim of the article is not to explore the economic mechanisms at work with regards to the public capital investments of Cohesion policy, but rather to build a scenario against which to compare the potential effects of changes in the quality of government affecting the effectiveness of the public capital stock and, in turn, the production processes of the European economies.

Thus, we simulate an increase in institutional quality affecting public capital to be compared with the first baseline scenario. This ensures that the quality improvement is analysed in a context in which public capital stock changes over time as a result of the implementation of ESIF.

We assume that in each region the quality of government follows an autoregressive process, AR(1), as shown in the equation below:

$$\log(q_t) = c + \rho \log(q_{t-1}) + \varepsilon_t \quad (2)$$

Where q_t is the time-series of the European Quality of Government Index, ρ is the persistence parameter and ε is the shock implemented in the model.[6] Using OLS regression analysis, we find that the average estimated value of ρ is around 0.76 with standard deviation across regional values around 0.2.[7] In all regions, we impose $\varepsilon = 0.05$ only for the first period (an increase in government quality of five percentage points) while from the second period onwards, ε bounces back to zero. Thus, the shock is temporary, but the persistence parameter governs the period-by-period intensity of shock. For instance, the higher the level of ρ, the longer the timeframe for the shock to disappear. Intuitively this also means that regions characterised by a higher persistence are more likely to benefit from improvements in institutional quality in the long run.

The persistence parameter is a crucial element in our analysis, as it determines the duration of the government quality shock over time. A number of institutional factors may affect the degree of persistence of government quality. Constant political instability, institutional rigidities, the coherence and effectiveness of institutional structures, the impartiality and transparency of

[6] As the European Quality of Government Index is calculated using survey data, the indicator is accompanied by a margin of error. The time series of this indicator is constructed using the point estimates of the indicator.

[7] We report the distribution of the estimated values for all regions in Figure A1 of the Appendix.

tendering, public service provision and procedures, the role of the media, and the degree of social trust may all potentially explain different degrees of persistence across countries and regions over time.[8]

Given the model configuration, any improvement in regional government quality works similarly to a Hicks-neutral technical change. The improved quality generates an increase in effective public capital, in turn, rising the productivity of capital and labour according to the initial shares of these factors of productions. This also means that the prices attached to factors of production are expected to fall, reducing the general equilibrium price of commodities. The fall in prices should also trigger competitiveness effects stimulating exports and, therefore, also improve regional current accounts.

We expect the long-run magnitude of the impact in each region to be affected by its initial level of government quality, by the persistence of the latter, and by the regional capital stock that is combined with the quality of government in the production function.[9] It is reasonable to assume that a positive relationship will emerge between GDP (and other variables, such as employment and private consumption) and each of those parameters/variables. The precise nature of such relationship can only be uncovered by analysing the results of the simulations as we do below.

Empirical analysis and results

The results of the modelling simulations are presented as follows: first, we present the baseline state of the economy, following the injection of the ESIF categorised as public capital

[8] The investigation of the role played by each of these potential determinants would certainly require greater attention in future research. These are all interesting issues that, nevertheless, fall outside the scope of this paper.

[9] Public capital enters the production function as an unpaid factor of production and it is augmented by the quality of government in a multiplicative way. This results in a composite factor that we refer to as effective public capital. Please see equation (A1) in the Appendix for further details.

expenditure. Then, we focus on the system-wide effects of an improvement of government quality in all the EU regions.

The baseline scenario

The baseline scenario assumes the injection of the ESIF public capital investments presented in the section above (spread evenly over the ten years-long policy implementation period) financed through a lump sum tax on household income. After the shock, the economies gradually return to their original equilibrium. However, the supply-side nature of the shock suggest that the funds generate long-run effects, with their impact remaining long after the end of the programming period. Thus, in this section we quantify the impact during and after the policy implementation period. We also comment on the drivers and transmission mechanisms behind the economic effects caused by the shock.

Table 2 shows the percentage deviations from base year values of some key macroeconomic variables obtained for the aggregate EU economy.[10] We report the results obtained for selected periods to assess the effects of public investment both during the implementation period (years 1, 5, and 10) and after the end of it (years 20 and 30). We report the cumulative impacts in addition to the year-specific ones. This strategy allows us to evaluate the extent of the legacy effects associated with an increase in capital expenditure. In period 1, private capital stock is fixed at its initial level, while the public stock of capital adjusts immediately as capital expenditure increases. In this period, public investments negatively affect both household consumption and investments, while employment increases. In addition, there is a reduction in commodity prices and an increase in exports of goods and services. The related changes in exports are greater than the changes in GDP and compensate crowding out effects on consumption and investments. After period 1, constraints on private capital stock are relaxed

[10] Note that since we are using data for the 2014-2020 programming period, the UK is included in the EU.

allowing the economy to expand further. Consumption and investments are crowded in and the changes in employment gradually become lower than the changes in GDP, meaning that capital accumulation stimulates positive substitution effects in favour of private capital. At the end of the implementation period, the supply-side implications of the policy are reflected in huge improvements in the current account. In this period (year 10 of the simulation), exports increase by 0.44% while imports register a tiny increase of 0.004%, and the cumulative changes amount to +1.88% and +0.23%, respectively.

Table 2. *Impact on key macroeconomic variables - percentage deviations from steady-state equilibrium (cumulative impact in parenthesis)*

	Implementation period			**Post-implementation**	
	1	**5**	**10**	**20**	**30**
GDP	-0.006	0.151	0.374	0.394	0.271
	(-0.006)	(0.342)	(1.771)	(6.026)	(9.286)
Export	0.045	0.137	0.435	0.546	0.379
	(0.045)	(0.306)	(1.881)	(7.484)	(12.031)
Import	-0.027	0.039	0.004	-0.075	-0.056
	(-0.027)	(0.132)	(0.227)	(-0.344)	(-0.999)
Employment	0.029	0.161	0.353	0.366	0.262
	(0.029)	(0.467)	(1.849)	(5.659)	(8.760)
Household cons.	-0.147	-0.036	0.131	0.305	0.212
	(-0.147)	(-0.466)	(-0.145)	(3.073)	(5.614)
Commodity prices	-0.028	-0.061	-0.149	-0.153	-0.104
	(-0.028)	(-0.175)	(-0.745)	(-2.369)	(-3.626)
Investment	-0.154	0.195	0.413	0.317	0.199
	(-0.154)	(0.240)	(1.901)	(6.033)	(8.510)

Note: % deviation from initial steady-state

Looking at the last two columns to the right of Table 2 (the long run), we find substantial legacy effects that persist well beyond the last year in which the investments are carried out. The GDP is 0.39% and 0.27% above base year values, ten and twenty periods after the end of the implementation period, respectively (amounting to substantial cumulative changes of +6.03%

and +9.29% in periods 20 and 30). The long-term persistence of the shock is also reflected on employment, consumption, and investments.[11]

The long lasting impact of ESIF public capital investments also generates improvements in the EU current account in periods 20 and period 30 (with above-baseline exports and below-baseline imports), indicating that public investments have prolonged positive competitiveness effects. Thus, expansionary policies that aim to increase the stock of public capital may crowd out consumption and investments in the first years of the programming period. However, long-term positive effects materialise as soon as the economy adjusts and the persistence of the shock continues to ensure positive terms of trade effects even many periods after the end of the shock. In monetary terms, our simulations suggest that the Cohesion policy public capital investments considered in our analysis may generate, cumulatively, up to €455 of GDP for each European citizen in the short run (period 10) and about €2,380 in the long run (period 30) — using the average EU GDP per capita in 2013 (amounting to €25,600) as the reference.

The economic impact of improving quality of institutions

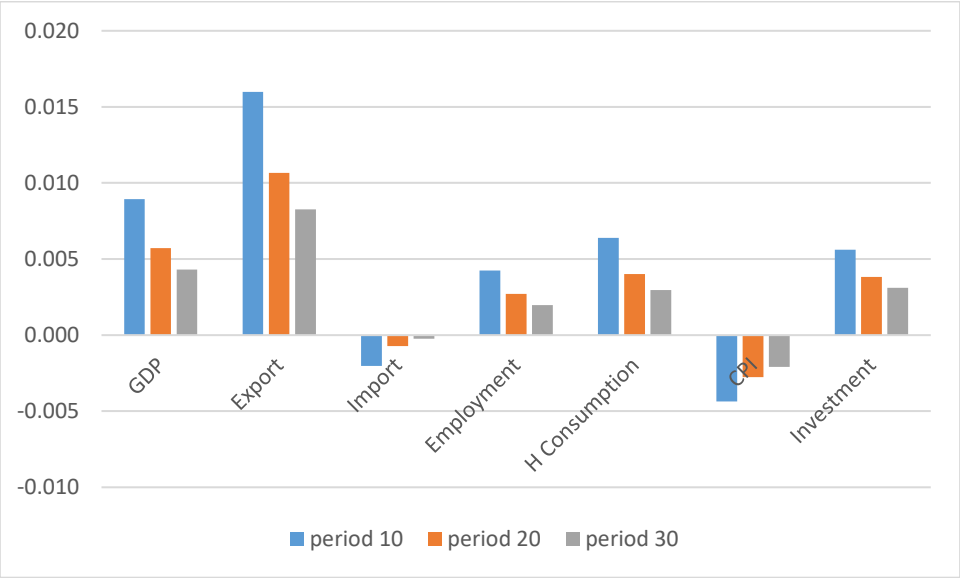
In this Section, we initially focus on the system-wide effects of improving institutional quality. All the results reported in this section are to be interpreted as deviations from the baseline scenario presented in the previous section.

Figure 2 shows the percentage deviations from the baseline of some key macroeconomic variables for period 10 and period 20. In all periods, GDP and employment are above their baseline values. Changes in employment are lower than those in GDP, suggesting that the

[11] For GDP, employment and investments we observe a declining pattern of legacy effects, while for household consumption our simulation suggests a peak in period 20. This is perhaps to be expected, as the additional government investment has been completed at the end of the implementation period and this frees up resources for households that were bearing the full cost of the investments.

improvement in government quality causes a substitution in favour of capital. As in Di Cataldo and Rodríguez-Pose (2017), better government quality creates an economic expansion with an increase in investment and a reduction in the unemployment rate, putting workers in the condition to bargain for higher wages. Hence, the real wages rise generating additional income and consumption that boost the economy even further. The change in government quality also positively affects the productivity of production factors and thus puts downward pressure on commodity prices, while enhancing competitiveness vis-à-vis the rest of the world. In all periods, exports of goods and services grow faster than GDP and imports fall, generating extensive improvements in the current account.

Figure 2: *Percentage deviations from baseline at periods 10, 20, and 30*



Since the values of the shock persistence parameter ρ lie between zero and one, the government quality shock in most regions gradually diminishes in intensity. Thus, on aggregate, the expansionary effects are reduced over time. The main adjustments remain in operation in this period, meaning that most of the regions experience persistent benefits from the shock.

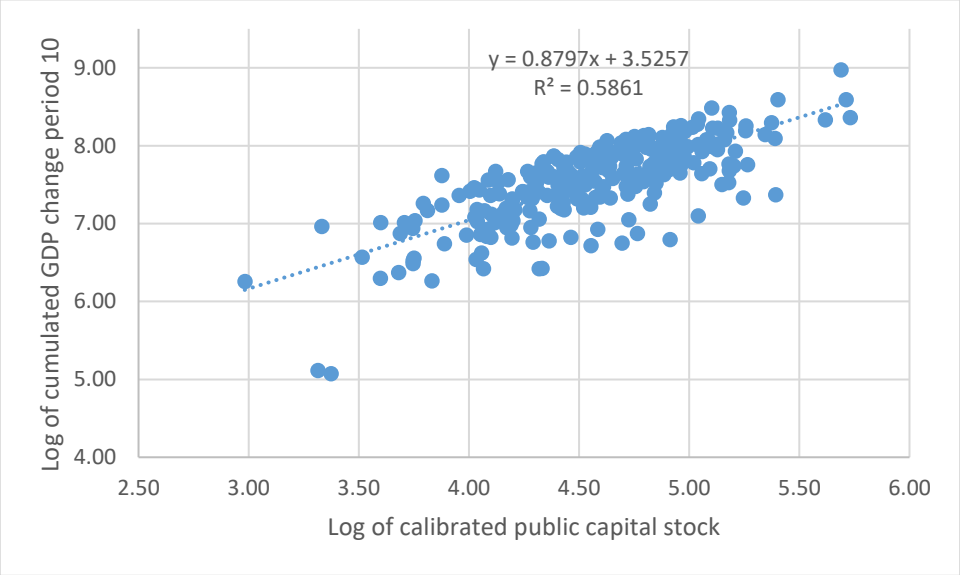
Although the economic adjustments and transmission mechanisms are similar across regions, the economic impact is unevenly distributed. The improved quality of government affects the

effectiveness of the public capital stock, based on the assumption that better institutions are able to use more efficiently their whole endowment of capital and infrastructures. Thus, it seems reasonable to assume that regions with larger capital stocks will benefit the most from the policy shock. Figure 3 indeed confirms this intuition by showing the high and positive correlation between the log of the regional calibrated stock of public capital (horizontal axis) and the log of cumulative absolute changes in GDP observed in period 10 (vertical axis).[12]

The public capital stock is crucial to explaining the positive effects stemming from an improvement in quality of regional governments. However, there are other parameters affecting the different regional impact. One of these is the calibrated initial level of government quality in the model. Interestingly, there is a positive correlation between the level of the capital stock and the government quality index. This suggests that regions with better initial endowments of public infrastructure also tend to have better quality institutions. Another parameter affecting the impact across regions is the persistence parameter ρ, which plays a pivotal role in governing the time persistence of the shock.

[12] It is important to note that in the model capital stock is calibrated in steady-state with an assumed depreciation rate identical for all regions. As such, this might not reflect the real stock of public infrastructure present in each region. Nonetheless, an important implication from this analysis is that an effort to improve the quality of institutions may not be equally beneficial across all regions. Regions with better government quality are likely to benefit more.

Figure 3: *Correlation between the calibrated public capital stock and GDP deviations from baseline at period 10*

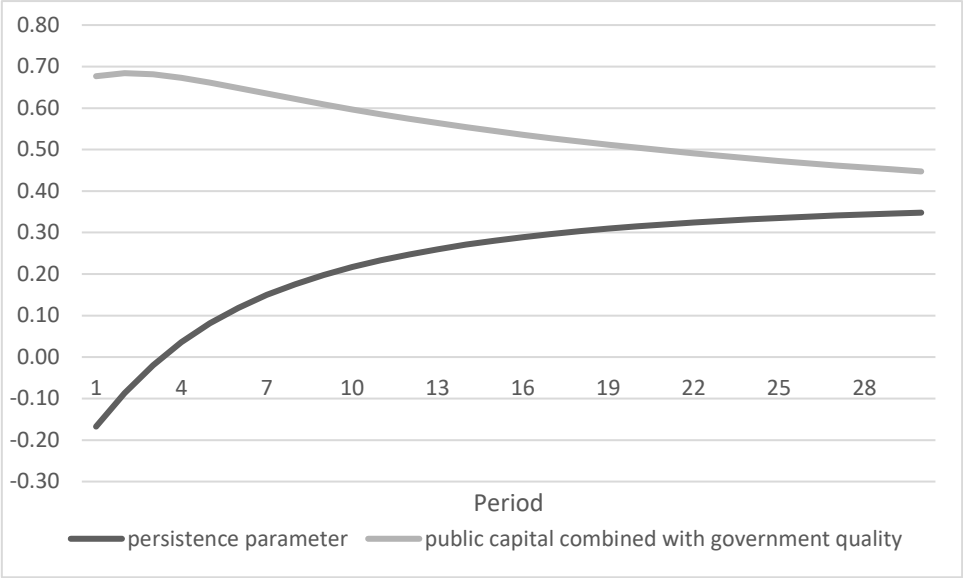


We next examine to what extent these parameters affect the economic impact across regions. Figure 4 shows the evolution of two different correlations over time. The black line reports the correlation over time between the GDP cumulative deviations from baseline and the persistence parameter. The grey line shows the period-by-period correlation between the GDP cumulative deviations from the baseline and the initial levels of the combined factor of production, that is public capital and government quality. As indicated before, these two factors are highly correlated. However, combining the two has the advantage that it gives a comprehensive well-weighted measure of effective public capital that includes the efficiency associated with the quality of institutions.

The solid line suggests that the persistence of the shock has adverse effects in the short run, but it is positively correlated with GDP deviations in the long run. This is to be expected, as a higher persistence mitigates the short-run positive impact. However, in the long run, it is likely that these regions will enjoy larger benefits. The opposite may also be true, with the stock of public capital augmented by government quality, whose correlation with changes in GDP is

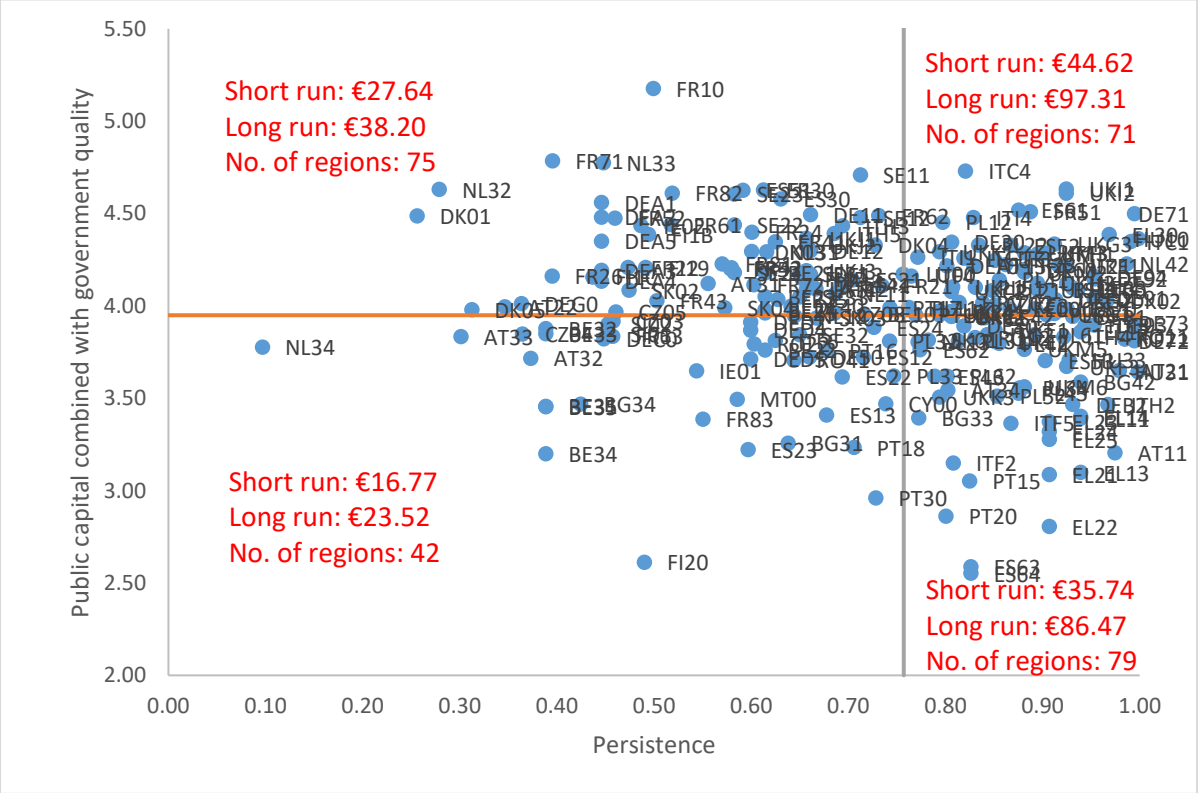
high in the short run but decreases over time. This result suggests a way to define four different groups of regions by combining the different short-run and long-run system-wide benefits associated with the hypothesised 5% temporary increase in government quality.

Figure 4: *Period-by-period correlation between absolute cumulative changes in GDP and, alternatively, the persistence parameter and public capital combined with government quality*



Building on that idea, Figure 5 plots the relationship between persistence ρ and the combined factor of production made up of public capital and government quality. The vertical and horizontal blue lines identify the average regional level of ρ and the average value of the combined factor of production respectively, dividing the plot into four quadrants. In each of these, we report the short run and long run average GDP per capita income associated with the increase in government quality for the regions populating each quadrant.

Figure 5: *Classification of regions according to the short and long run system-wide benefits of government quality improvements*



The numbers reported in Figure 5 should be read bearing in mind that, according to the baseline scenario illustrated above, the gains in terms of GDP per capita associated with European Cohesion public capital investments for the whole EU amount to €455 and about €2,380 in the short run and the long run, respectively. The numbers of Figure 5 are additional to those ones and achieved via the simulated 5% increase in government quality across all EU and UK regions. The latter numbers show a notable regional disparity depending on the initial stock of quality adjusted public capital and on the regional persistence of government quality.

In line with Rodríguez-Pose and Ketterer (2020), the EU regions starting with a relatively low adjusted stock of public capital gain little in the short run from the improvement in government quality. This is around €17 per capita, if low values of the combined factor of production are associated with low levels of ρ, and €36 per capita, if ρ is above average. However, even for smaller than average adjusted public capital endowments, higher persistence can make a

difference in the long run. The 79 regions populating the bottom-right quadrant report an increase of €86 per capita versus only €24 for the regions positioned in the bottom-left characterised by low persistence. The regions with an initial above-average adjusted public capital stock gain more in the short run (between €28 and €45 per capita, depending on the persistence parameter) as well as in the long run, with the range going from €38 on average for the 75 low persistence regions to €97 for the 71 regions characterised by both adjusted public capital and persistence above their average values.

Another result is that regions characterised by a high degree of persistence (those in quadrants 2 and 4) benefit more than the others, both in the short and in the long run. This is illustrated in Figure 6, which shows the dispersion of the short and long run regional GDP per capita impact. Furthermore, regions with larger endowments of effective public capital (quadrants 1 and 2) benefit more than those with smaller endowments with similar degrees of persistence. Essentially, this suggests that initial conditions matter and are an important factor governing the size of the shocks in this analysis as well as their economic impact.

The fact that above-average values of the persistence parameter increase the gains associated with improvements in government quality is demonstrated by Figure 7, which shows the correlation between long run GDP per capita impact and, respectively, persistence and the adjusted public capital stock for regions in the four quadrants. We note that the correlation between GDP and persistence is higher for regions characterised by above average persistence (regions in quadrants 2 and 4). This implies that regions characterised by high persistence benefit from disproportionally higher GDP impact following an improvement in government quality. This is irrespective of whether they are endowed with high or low initial levels of adjusted public capital. In contrast, the positive correlation between the stock of adjusted public capital and per capita GDP are approximately of the same magnitude across regions in the four quadrants. This suggests that the initial endowment of adjusted public capital is identically

associated with higher economic benefits for all regions following a rise in the quality of government.

Figure 6: *Dispersion of the short and long run regional GDP impact of government quality improvements*

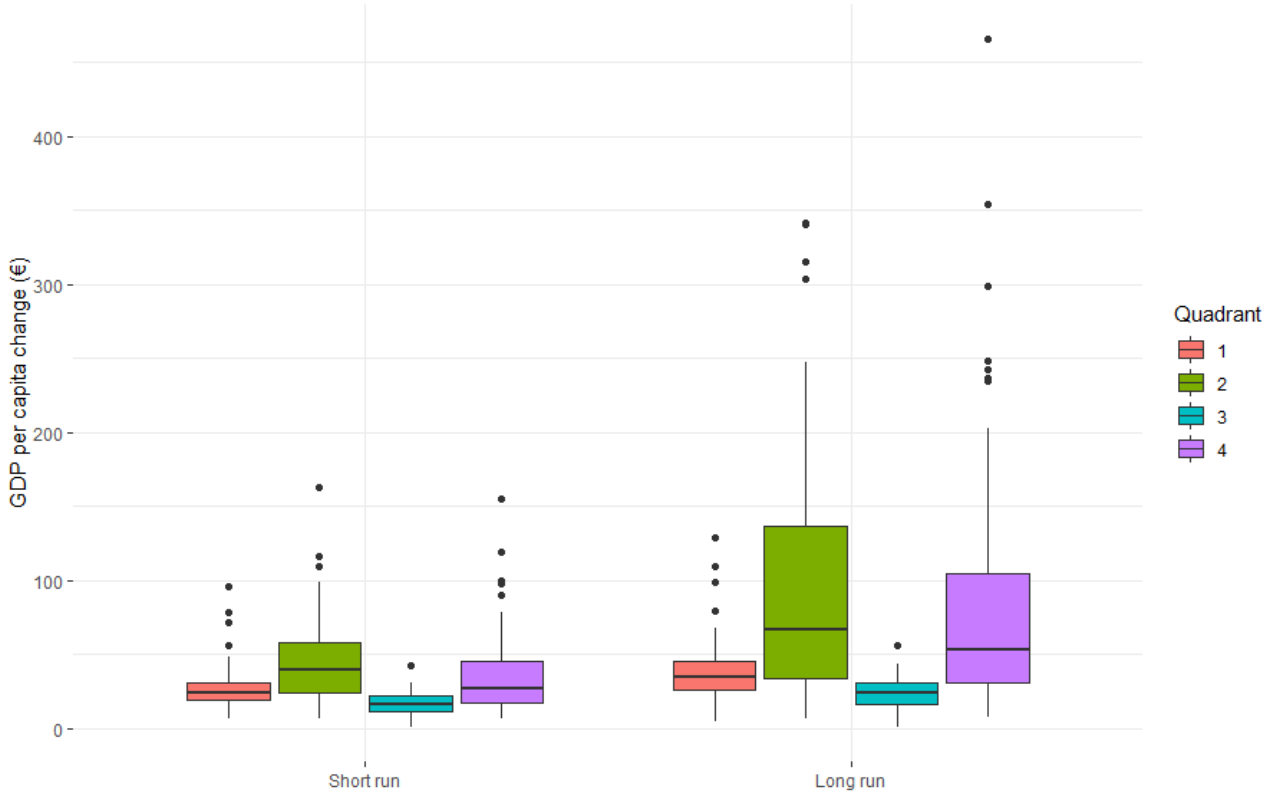
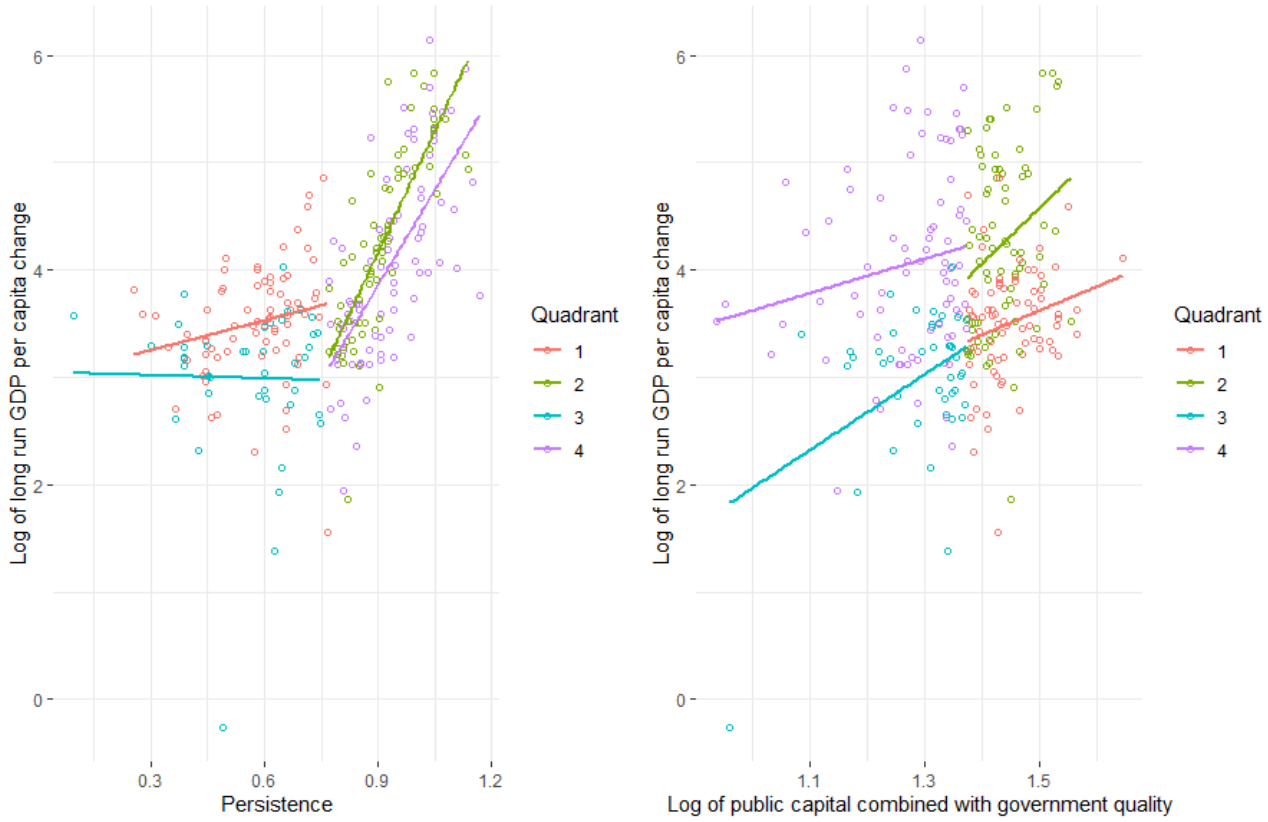


Figure 7: *Correlation between absolute cumulative changes in long run regional GDP and, alternatively, the persistence parameter (left) and public capital combined with government quality (right)*



Overall, these results indicate that even a small improvement in government quality may yield ample monetary gains depending on the regional public capital endowments and on the characteristics of government quality over time. For instance, the 71 regions of the upper right quadrant of Figure 5 see the Cohesion policy gains related to public capital investments increased on average by 7% in the short run and by just above 3% in the long run. Slightly smaller gains are found for the regions with smaller values of either of the two key parameters, or both. In any case, this finding is telling of the economic potential of government quality in the EU in relationship to policies affecting public capital.

Conclusions

This paper has revisited the question of the link between regional quality of government and the returns of European Cohesion policy, using a more sophisticated general equilibrium framework. In this respect, the analysis has tested previous findings (e.g., Rodríguez-Pose and Garcilazo, 2015) on the role of quality of regional government for economic growth, but using novel up-to-date data and a wider variety of more sophisticated econometric methods. It has also quantified with greater precision the system-wide effects of improvements in government quality across NUTS2 EU regions, using ESIF expenditures related to public capital for the 2014-2020 programming period.

An attractive feature of the quantitative assessment strategy adopted in this paper is the link between the partial equilibrium model and the general equilibrium one. These models are often seen as competitive tools and they are rarely used in combination in quantitative policy analysis. However, a key element of the analysis above is the incorporation of the effects estimated with a partial equilibrium model into a system-wide general equilibrium framework. The econometric analysis has the advantage of capturing the effects of the quality of government in isolation, abstracting from endogenous drivers and feedback effects. It provides a measure of the direct impact of the policy. This elasticity is also a crucial parameter in the CGE analysis. Frequently, key elasticities used in CGE models for policy evaluations are taken from empirical studies that are only loosely related with the policy object of the analysis. Here, we use an appropriate estimate of the direct effect of the quality of government in order to carry on a rigorous quantification of the indirect and general equilibrium effects of the policies under consideration.

The results show that local government quality matters, and it matters a lot, in promoting economic growth across the regions of Europe. First, there is evidence of a significant direct

effect of government quality on economic growth. Second, it has shown that there are as well considerable system-wide benefits of policies aiming to improve the quality of institutions in the regions of the EU. The modelling experiment suggests that the economic impact of improving the quality of regional government can be substantial in terms of additional GDP and jobs generated. The precise magnitude of these effects depends on a few key factors which include the initial level of the quality of government, its persistence over time, and the stock of capital with which each region is endowed. A relatively small increase in government quality of 5% can yield large monetary gains both in the short run and in the long run, boosting the average regional GDP impact of ESIF public capital investments by up to 7% and 3% in the short and long run, respectively, depending on the starting conditions of each region. Exploring the heterogeneity across EU regions with respect to initial characteristics and the potential to benefit from improved government quality would be an interesting path for further research. As a larger share of Cohesion funds is being channelled to regions in less-developed and/or newer member states that also have the greatest institutional bottlenecks, the economic implications for the returns of Cohesion Investment of improvements in government quality may vary considerably across Europe.

Our conclusions have important implications for policy-making. They suggest that the returns of promoting greater public investment to trigger economic growth can be substantially enhanced if improving government quality becomes a part of public policy, in general, and of the European Cohesion effort, in particular. Inaction with respect to government quality failures — which has been the norm until very recently — bears significant costs for EU citizens. The dimension of the benefits can be important, as even a relatively small increase in government quality is likely to yield considerable benefits, which we are able to quantify in terms of euro per capita thanks to the general equilibrium model simulations. Hence, in order to fulfil the objective of improving EU competitiveness, while, at the same time, reducing some

of the gaps in territorial development, putting government quality movements firmly in the policy agenda will deliver sizeable economic results, while, simultaneously, contribute to improve the design, implementation, and returns of most public policies.

Acknowledgments

We are grateful to the editor and one anonymous reviewer for their useful comments. The views expressed are purely those of the authors and may not in any circumstances be regarded as stating an official position of the European Commission.

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Supplementary Appendix

Introducing Quality of Government in the RHOMOLO model

In this section, we describe the main features of the model by focusing on the treatment of public capital, which is the key channel through which government quality is assumed to affect the economy. Further details on the model can be found in Lecca et al. (2018).

The model is calibrated to a full set of Social Accounting Matrices (SAMs) constructed using data on bilateral intermediate and final goods trade flows for 267 NUTS2 regions of the EU and the UK, and a composite exogenous rest of the world (ROW). All shift and share parameters of the model are calibrated to reproduce the base-year dataset, represented by the inter-regional social accounting matrix for the year 2013 (Thissen et al., 2019).

Each regional economy is composed of 10 economic sectors in which firms operate under monopolistic competition. Regional goods are produced by combining the value added with domestic and imported intermediates. Final goods are consumed by households, governments and investors (in the form of capital goods), while firms consume intermediate inputs.

In equation (A1), the value added $Y_{r,j}$, in each region *r* and sector *j*, is obtained combining private capital $K_{r,j}$ and employment $L_{r,j}$ in a CES function, net of fixed costs $FC_{r,j}$.

$$Y_{r,j} = A_{r,j}\left[\left(q_r^{\mu} K_{(g)}^{d}\right)^{\xi}\left[\delta_{r,j}^{Y} \cdot K_{r,j}^{\rho_j^y} + \left(1-\delta_{r,j}^{y}\right) \cdot L_{r,j}^{\rho_j^y}\right]^{\frac{1}{\rho_j^y}}\right] - FC_{r,j} \qquad \text{(A1)}$$

$A_{r,j}$ $\delta_{r,j}^{Y}$ and ρ_j^y are the scale parameter representing Hicks neutral technical change, the capital share, and the substitution parameter, respectively. The parameter ξ is the output elasticity of public capital.

Effective public capital, $K^{d}_{(g)}$ enters the production function as an unpaid factor of production, meaning that all firms in all sectors enjoy the same level of public capital at no cost (Barro, 1990; Baxter and King, 1993; Futugami et al., 1993 and Glomm and Ravikumar, 1994; 1997).

The quality of institutions at regional level q is attached to the public capital. The size of the impact of any change to the quality of government is measured by its elasticity μ, corresponding to the $\hat{\beta}_3$ parameter reported in Table 1, column (6).

The public capital stock accumulates through public investment in infrastructure I^{G}_{r}, set exogenously for each region starting from an initial positive capital stock. The formula governing the accumulation of the stock is the following:

$$K^{s}_{(g),r,t} = (1 - \delta^{g}_{r})K^{s}_{(g),r,t-1} + I^{G}_{r,t} \tag{A2}$$

where government capital depreciates at the rate δ^{g}_{r}. In equilibrium conditions, congestion effects arise from *non-publicness* of public goods (see e.g., Bergstrom and Goodman, 1973; Stiglitz and Rosengrand 2015); therefore the public capital stock, $K^{s}_{(g),r}$ is adjusted by means of a simple model of congestion, following the traditional formulation of decreasing marginal congestion (see e.g. Edwards, 1990, Turnovsky and Fisher, 1995 and Fisher and Turnovsky, 1998).[13] The aggregate public capital service appearing in equation (1) is adjusted for congestion by aggregated production:

$$K^{d}_{(g),r} = K^{s}_{(g),r}\left(\sum_{i} Y_{r,i}\right)^{\gamma} \qquad \gamma = \frac{\eta - 1}{\eta}, \gamma \in (0, -\infty); \qquad \eta \in (0,1) \tag{A3}$$

where, γ is the congestion parameter. The increase in production reduces the effective quantity of public capital stock enjoyable by all firms and the magnitude of this effect depends on the

[13] See, among others, Glomm and Ravikumar (1994, 1997) and Judd (1999) for alternative congestion modelling approaches in the context of growth models.

level of η. When $\eta = 1$ ($\gamma = 0$), we have the case of a pure public good, available equally to all firms. Its use by one firm would not reduce its usefulness to others. Hence, firms will enjoy full benefits from its use (non-rival and non-excludable). If $\eta = 0.5$ ($\gamma = -1$), public capital still remains non-excludable but loses the property of non-rivalry.[14] The quantity of public services available to a producer declines if production increases. The higher the use of primary factors the lower the contribution of public capital in production. Such a crowding effect is stronger the lower the level of η. For $\eta < 0.5$ there is a situation of "over-crowding" (e.g. Edwards, 1990) such that the decline in public services is faster than the increase in production. The extreme case is generated when $\eta = 0$ (the smallest value according to the constraints assumed), where $\gamma \to -\infty$.

The optimal path of private investments I_r^P is consistent with the neoclassical firm's profit maximisation theory, as defined in Uzawa (1969):

$$I_{i,r}^P = \delta_r K_{i,r}^P \left(\frac{rk_{i,r}}{uck_r}\right)^v \tag{A4}$$

where v is the accelerator parameter and δ is the depreciation rate. According to this formulation, the investment capital ratio ($\varphi = I_r^P/K_r^P$) is a function of the rate of return to capital (rk) and the user cost of capital (uck), allowing the capital stock to reach its desired level in a smooth fashion over time. The user cost of capital, *uck*, is derived from Hall and Jorgenson (1967) and Jorgenson (1963) as a typical no arbitrage condition, where:

$$uck_r = (r + \delta_r)p_{EU}^I + \Delta p_{EU}^I + rp_r \tag{A5}$$

[14] This corresponds to the case described in Fisher and Turnovsky (1998) called *proportional congestion*.

r, δ_r, p_{EU}^I and rp_r denote the interest rate, the depreciation rates, the investment price index at EU level, and an exogenous risk premium, respectively. Δp_{EU}^I is the change of the investment price index defined between two subsequent periods.

The RHOMOLO model incorporates imperfect labour market, where the real wage rw_r is negatively related to the unemployment rate, u_r. The general formulation is expressed in logs in Equation (A6), where θ is a calibrated parameter.

$$rw_r = \theta - \beta\, u_r \tag{A6}$$

Current government expenditures are held fixed in real terms. A no binding constraint on government budget also applies. The model ensures an unconstrained inflow of capital to sustain investment whenever required, thus not imposing any constraints on the balance of payments. The model is solved in a recursively dynamic mode.

The model calibration process assumes that regional economies are initially in steady-state equilibrium. The structural and behavioural parameters of RHOMOLO are either borrowed from the literature or estimated econometrically. The interest rate faced by producers, consumers, and investors is set to 0.04, the rate of depreciation for private capital to 0.15, while that of public capital equates to 0.05 (Kamps, 2006, and Gupta, 2014). The parameters related to the elasticities of substitution, both on the consumer and on the producer sides, are based on similar models or derived from the econometric literature. Typically, we assume a rather low elasticity of substitution in production and consumption (0.3), and a fairly high one for trade between regions (4). As for the wage curve parameterization, we typically run a long-run wage curve assuming β=0.1 (Nijkamp and Poot, 2005). We set $\xi = 0.1$ (Arslanalp et al., 2010) and $\eta = 0.5$. The model is run assuming proportional congestion effects. However, in other regional models (e.g. Alonso-Carrera et al., 2009), the congestion parameter is set equal to

0.36, while three levels of congestion parameter (high, medium, and low) are analysed in Seung and Kraybill (2001).

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Additional tables and figures

Table A1: *Description of Variables*

Variable	Definition	Data source
GDP per capita	Gross domestic product (GDP) at current market prices per capita	Eurostat
Population	Population on 1 January	Eurostat
Primary Education	Percentage of population aged 25-64 with primary education (ISCED-2011 levels 0 to 2)	Eurostat
Tertiary Education	Percentage of population aged 25-64 with tertiary education (ISCED-2011 levels 5 to 8	Eurostat
Employment	Employment 15-64 years	Eurostat
Employment rate	Employment rate 15-64 years	Eurostat
Area	Area by NUTS region (in square kilometres)	Eurostat
Employment Density	Employment divided by area	Computed
Institutions	European Quality of Government Index (EQI)	Charron et al. (2019)
EU Funds	Historic EU payments per capita	European Commission, DG REGIO
Accessibility	Population road accessibility	European Commission, DG REGIO

Table A2: *Descriptive Statistics*

	Mean	Std. Dev.	Min	Max.
GDP per capita growth (%)	3.08	6.38	-20.22	46.67
GDP per capita (€)	22,466.99	11,970.63	1,600.00	63,000.00
Quality of Government	0.00	1.00	-3.28	2.56
EU Funds per capita (€)	117.33	143.85	0.00	1,299.53
Primary Education (%)	29.32	15.91	2.70	84.80
Tertiary Education (%)	23.00	8.77	6.10	54.20
Employment Rate (%)	63.53	7.60	38.90	82.50
Employment Density	0.14	0.32	0.00	2.63
Accessibility	2,600,437	1,791,780	87,137	8,662,196
Regional Development	0.91	0.48	0.08	2.51

Note: 2,184 observations for 188 regions.

Table A3: *The 123 Cohesion policy expenditure categories*

01	Generic productive investment in small and medium – sized enterprises ('SMEs')	42	Inland waterways and ports (regional and local)	83	Air quality measures
02	Research and innovation processes in large enterprises	43	Clean urban transport infrastructure and promotion (including equipment and rolling stock)	84	Integrated pollution prevention and control (IPPC)
03	Productive investment in large enterprises linked to the low-carbon economy	44	Intelligent transport systems (including the introduction of demand management, tolling systems, IT monitoring, control and information systems)	85	Protection and enhancement of biodiversity, nature protection and green infrastructure
04	Productive investment linked to the cooperation between large enterprises and SMEs for developing information and communication technology ('ICT') products and services, e-commerce and enhancing demand for ICT	45	ICT: Backbone/backhaul network	86	Protection, restoration and sustainable use of Natura 2000 sites
05	Electricity (storage and transmission)	46	ICT: High-speed broadband network (access/local loop; >/= 30 Mbps)	87	Adaptation to climate change measures and prevention and management of climate related risks e.g. erosion, fires, flooding, storms and drought, including awareness raising, civil protection and disaster management systems and infrastructures
06	Electricity (TEN-E storage and transmission)	47	ICT: Very high-speed broadband network (access/local loop; >/= 100 Mbps)	88	Risk prevention and management of non-climate related natural risks (i.e. earthquakes) and risks linked to human activities (e.g. technological accidents), including awareness raising, civil protection and disaster management systems and infrastructures
07	Natural gas	48	ICT: Other types of ICT infrastructure/large-scale computer resources/equipment (including e-infrastructure, data centres and sensors; also where embedded in other infrastructure such as research facilities, environmental and social infrastructure)	89	Rehabilitation of industrial sites and contaminated land
08	Natural gas (TEN-E)	49	Education infrastructure for tertiary education	90	Cycle tracks and footpaths
09	Renewable energy: wind	50	Education infrastructure for vocational education and training and adult learning	91	Development and promotion of the tourism potential of natural areas

10	Renewable energy: solar	51	Education infrastructure for school education (primary and general secondary education)	92	Protection, development and promotion of public tourism assets
11	Renewable energy: biomass	52	Infrastructure for early childhood education and care	93	Development and promotion of public tourism services
12	Other renewable energy (including hydroelectric, geothermal and marine energy) and renewable energy integration (including storage, power to gas and renewable hydrogen infrastructure)	53	Health infrastructure	94	Protection, development and promotion of public cultural and heritage assets
13	Energy efficiency renovation of public infrastructure, demonstration projects and supporting measures	54	Housing infrastructure	95	Development and promotion of public cultural and heritage services
14	Energy efficiency renovation of existing housing stock, demonstration projects and supporting measures	55	Other social infrastructure contributing to regional and local development	96	Institutional capacity of public administrations and public services related to implementation of the ERDF or actions supporting ESF institutional capacity initiatives
15	Intelligent Energy Distribution Systems at medium and low voltage levels (including smart grids and ICT systems)	56	Investment in infrastructure, capacities and equipment in SMEs directly linked to research and innovation activities	97	Community-led local development initiatives in urban and rural areas
16	High efficiency co-generation and district heating	57	Investment in infrastructure, capacities and equipment in large companies directly linked to research and innovation activities	98	Outermost regions: compensation of any additional costs due to accessibility deficit and territorial fragmentation
17	Household waste management, (including minimisation, sorting, recycling measures)	58	Research and innovation infrastructure (public)	99	Outermost regions: specific action to compensate additional costs due to size market factors
18	Household waste management, (including mechanical biological treatment, thermal treatment, incineration and landfill measures)	59	Research and innovation infrastructure (private, including science parks)	100	Outermost regions: support to compensate additional costs due to climate conditions and relief difficulties
19	Commercial, industrial or hazardous waste management	60	Research and innovation activities in public research centres and centres of competence including networking	101	Cross-financing under the ERDF (support to ESF-type actions necessary for the satisfactory implementation of the ERDF part of the operation and directly linked to it)
20	Provision of water for human consumption (extraction, treatment, storage and distribution infrastructure)	61	Research and innovation activities in private research centres including networking	102	Access to employment for job-seekers and inactive people, including the long-term unemployed and people far from the labour market, also through local

					employment initiatives and support for labour mobility
21	Water management and drinking water conservation (including river basin management, water supply, specific climate change adaptation measures, district and consumer metering, charging systems and leak reduction)	62	Technology transfer and university-enterprise cooperation primarily benefiting SMEs	103	Sustainable integration into the labour market of young people, in particular those not in employment, education or training, including young people at risk of social exclusion and young people from marginalised communities, including through the implementation of the Youth Guarantee
22	Waste water treatment	63	Cluster support and business networks primarily benefiting SMEs	104	Self-employment, entrepreneurship and business creation including innovative micro, small and medium sized enterprises
23	Environmental measures aimed at reducing and/or avoiding greenhouse gas emissions (including treatment and storage of methane gas and composting)	64	Research and innovation processes in SMEs (including voucher schemes, process, design, service and social innovation)	105	Equality between men and women in all areas, including in access to employment, career progression, reconciliation of work and private life and promotion of equal pay for equal work
24	Railways (TEN-T Core)	65	Research and innovation infrastructure, processes, technology transfer and cooperation in enterprises focusing on the low carbon economy and on resilience to climate change	106	Adaptation of workers, enterprises and entrepreneurs to change
25	Railways (TEN-T comprehensive)	66	Advanced support services for SMEs and groups of SMEs (including management, marketing and design services)	107	Active and healthy ageing
26	Other Railways	67	SME business development, support to entrepreneurship and incubation (including support to spin offs and spin outs)	108	Modernisation of labour market institutions, such as public and private employment services, and improving the matching of labour market needs, including through actions that enhance transnational labour mobility as well as through mobility schemes and better cooperation between institutions and relevant stakeholders
27	Mobile rail assets	68	Energy efficiency and demonstration projects in SMEs and supporting measures	109	Active inclusion, including with a view to promoting equal opportunities and active participation, and improving employability
28	TEN-T motorways and roads — core network (new build)	69	Support to environmentally-friendly production processes and resource efficiency in SMEs	110	Socio-economic integration of marginalised communities such as the Roma

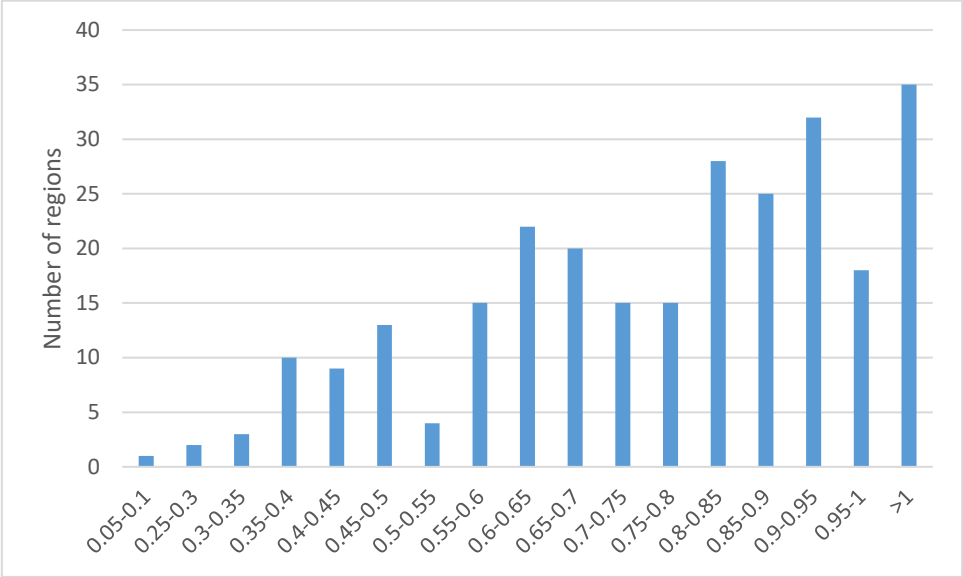
29	TEN-T motorways and roads — comprehensive network (new build)	70	Promotion of energy efficiency in large enterprises	111	Combating all forms of discrimination and promoting equal opportunities
30	Secondary road links to TEN-T road network and nodes (new build)	71	Development and promotion of enterprises specialised in providing services contributing to the low carbon economy and to resilience to climate change (including support to such services)	112	Enhancing access to affordable, sustainable and high-quality services, including health care and social services of general interest
31	Other national and regional roads (new build)	72	Business infrastructure for SMEs (including industrial parks and sites)	113	Promoting social entrepreneurship and vocational integration in social enterprises and the social and solidarity economy in order to facilitate access to employment
32	Local access roads (new build)	73	Support to social enterprises (SMEs)	114	Community-led local development strategies
33	TEN-T reconstructed or improved road	74	Development and promotion of tourism assets in SMEs	115	Reducing and preventing early school-leaving and promoting equal access to good quality early-childhood, primary and secondary education including formal, non-formal and informal learning pathways for reintegrating into education and training
34	Other reconstructed or improved road (motorway, national, regional or local)	75	Development and promotion of tourism services in or for SMEs	116	Improving the quality and efficiency of, and access to, tertiary and equivalent education with a view to increasing participation and attainment levels, especially for disadvantaged groups
35	Multimodal transport (TEN-T)	76	Development and promotion of cultural and creative assets in SMEs	117	Enhancing equal access to lifelong learning for all age groups in formal, non-formal and informal settings, upgrading the knowledge, skills and competences of the workforce, and promoting flexible learning pathways including through career guidance and validation of acquired competences
36	Multimodal transport	77	Development and promotion of cultural and creative services in or for SMEs	118	Improving the labour market relevance of education and training systems, facilitating the transition from education to work, and strengthening vocational education and training systems and their quality, including through mechanisms for skills anticipation, adaptation of curricula and the establishment and

					development of work-based learning systems, including dual learning systems and apprenticeship schemes
37	Airports (TEN-T) (1)	78	e-Government services and applications (including e-Procurement, ICT measures supporting the reform of public administration, cyber-security, trust and privacy measures, e-Justice and e-Democracy)	119	Investment in institutional capacity and in the efficiency of public administrations and public services at the national, regional and local levels with a view to reforms, better regulation and good governance
38	Other airports (1)	79	Access to public sector information (including open data e-Culture, digital libraries, e-Content and e-Tourism)	120	Capacity building for all stakeholders delivering education, lifelong learning, training and employment and social policies, including through sectoral and territorial pacts to mobilise for reform at the national, regional and local levels
39	Seaports (TEN-T)	80	e-Inclusion, e-Accessibility, e-Learning and e-Education services and applications, digital literacy	121	Preparation, implementation, monitoring and inspection
40	Other seaports	81	ICT solutions addressing the healthy active ageing challenge and e-Health services and applications (including e-Care and ambient assisted living)	122	Evaluation and studies
41	Inland waterways and ports (TEN-T)	82	ICT Services and applications for SMEs (including e-Commerce, e-Business and networked business processes), living labs, web entrepreneurs and ICT start-ups)	123	Information and communication

Source: Nomenclature for the categories of intervention of the Funds under the Investment for growth and jobs goal and of the Youth Employment Initiative, available here: https://webgate.ec.europa.eu/esiflegislation/pages/viewpage.action?pageId=34441370

Note: Table A3 reports the 123 categories of Cohesion policy expenditure for the 2014-2020 programming period. We assign those related to public capital investments used in the analysis contained in this paper to the various RHOMOLO sectors as follows: the energy-related investments from 5 to 16 (including electricity, natural gas, renewables, housing stock, and co-generation), 70 (energy efficiency in large enterprises), and waste-related investments 19 (commercial, industrial or hazardous waste management) are assigned to the B-D-E sector. Transportation investments from 24 to 44 (including railways, motorways and roads, multimodal transport, airports, seaports, waterways, and urban transport infrastructure) are assigned to the G-I sector. IT investments from 45 to 48, and 82 (ICT services and applications for SMEs) are assigned to the J sector. Construction investments from 49 to 55 and 57 (including education, health, and housing infrastructures) are assigned to the F sector. Investments related to professional, scientific and technical activities 56 and from 58 to 65 (all related to research and innovation infrastructures) are assigned to the M_N sector. Finally, climate change-related investments from 83 to 89 are assigned to the C sector.

Figure A1: *Distribution of the estimated persistence parameter*



Note: For those regions with an estimated persistence parameter larger than 1, we set a value of 1 when calibrating the RHOMOLO model.