# Institutions and the productivity challenge for European regions

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## Abstract

Europe has witnessed a considerable labour productivity slowdown in recent decades. Many potential explanations have been proposed to address this productivity 'puzzle'. However, how the quality of local institutions influences labour productivity has been overlooked by the literature. This article addresses this gap by evaluating how institutional quality affects labour productivity growth and, particularly, its determinants at the regional level during the period 2003–2015. The results indicate that institutional quality influences regions' labour productivity growth both directly—as improvements in institutional quality drive productivity growth—and indirectly—as the short- and long-run returns of human capital and innovation on labour productivity growth are affected by regional variations in institutional quality.

## 1. Introduction

Productivity growth in the European Union (EU) has been low and tended to decline in recent decades. It has been low relative to past performance and relative to other areas of the world. Productivity growth in the 1960s in the EU-15 was a healthy 4.6% per annum (Carone et al., 2006), but has been declining decade on decade since then.[1] Between 2008 and 2016, labour productivity change in the Eurozone was just 0.35% per annum (Draghi, 2016).

The decline in productivity over time has been accompanied by a significant worsening of the EU's position relative to other areas of the world. Since the mid-1990s, productivity growth in the Eurozone has been year-on-year lower than that observed in other advanced economies and, except for 1999, in emerging market economies (Draghi, 2016).

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1    There are no reliable data for the EU-28 for that period.

Not all countries in the EU have fared equally. Post-2004 Member States in Central and Eastern Europe still enjoy relatively healthy levels of productivity growth. In contrast, in the former EU-15, productivity has been hovering barely above zero (Marrocu et al., 2013). A growing gap between a more productive and competitive North and a stagnant South is also becoming increasingly evident (Gopinath et al., 2017).

A considerable amount of research has tried to explain the reasons for this productivity 'puzzle', that is, the general productivity slowdown and the internal differences in productivity paths within Europe, using both a macro (country-level) and a micro (firm-level) perspective. However, productivity differences go beyond what happens at the level of the firm and differ considerably within countries, especially in a period that has witnessed an increasing concentration of advanced economic activity in a small number of economically dynamic areas of Europe (Rosés and Wolf, 2018; Carrascal-Incera et al., 2020).

The aim of this article is to address this gap about changes in productivity—defined as output per person employed—and to develop policy recommendations for improvements in productivity at the regional level in Europe. In particular, the analysis will focus on how skill, innovation and institutional deficiencies in many regions of Europe represent a barrier for productivity growth, and how these deficiencies not only lead to substantial economic waste, but also threaten economic, social and political stability during a period in which developments in artificial intelligence and an increasing use of robots are widening the European regional productivity gap.

In order to do this, the article analyses the sources of regional labour productivity growth across 248 regions in 19 EU countries for which full datasets are available between 2003 and 2015. The hypotheses driving the research are that, first, differences in changes in regional productivity across the EU depend on a combination of territorial variations in physical and human capital endowments, as well as a region's innovative capacity, and, secondly, that the impact of each of these factors on productivity changes in Europe is highly dependent on the quality of institutions in each region. The analysis focuses on short-run labour productivity growth, but provides evidence concerning its long-run dynamics as well. Previous research on how institutional quality affects regional economic outcomes has focused on other dimensions, such as economic growth, innovation or entrepreneurship (Nistotskaya et al., 2015; Rodríguez-Pose and Ketterer, 2020). However, it has completely neglected how institutional quality affects regional productivity in the EU, meaning that the knowledge of how variations in institutional quality shape the productivity slowdown at a regional level in Europe is extremely limited.

The results highlight that productivity growth across European regions is both directly and indirectly associated with regional institutional quality. First, improvements in institutional quality drive productivity growth. Secondly, the link between human capital and innovation outputs, on the one hand, and productivity growth, on the other, is far weaker that what could be expected, as variations in local institutional quality strongly mediate the effects of both factors on productivity changes. Regions with low institutional quality encounter strong barriers in translating skills and training into greater productivity in the labour market. Hence, addressing enduring institutional bottlenecks represents a key element for tackling the productivity challenge in Europe.

In order to reach these conclusions, the article is structured as follows. A short description of the productivity challenge in Europe at the regional level is given in Section 2. Section 3 presents the data and the modelling, and the estimation approach. The empirical results are depicted in Section 4. Section 5 presents the conclusions and some policy implications.

## 2. The productivity challenge in Europe and its regional dimension

In a Europe that is affected by a large number of challenges, ranging from the increasing competition derived from globalisation and economic integration to ageing and rising environmental risks, labour productivity growth is often regarded as the most feasible way to confront uncertainty and secure the viability of the European social model. As argued by Mokyr (2010), sustained economic growth, especially in advanced economies, requires constant and sustained technological change. Sustained technological change (TC) is generally a result of improvements in both physical and human capital, as well as greater investment and progress in innovation capacity (Quatraro, 2009).

Yet, while Europe has experienced non-negligible improvements in the educational achievements of its population, in investment in physical capital, and its innovation capacity has continued to grow, productivity has stagnated and, in many parts of the Continent, declined (Decker et al., 2017). Especially over the last two decades, Europe has grappled with a productivity slowdown, which is not just a result of the Great Recession but actually precedes it (Cette et al., 2016). In 1995, most large European economies had productivity levels that were roughly equivalent to those found in the USA. France, Germany, Italy and the UK were as productive as the USA. Spain was somewhat behind, albeit having experienced a rapid period of convergence since the 1950s. Since then, the tide has turned and the European economies are not just losing out to the USA, but also to the rest of the world (Cette et al., 2016). Such decline has accelerated recently, putting Europe in a difficult position. As Figure 1 shows, since 2003 productivity growth in Europe has stagnated. The
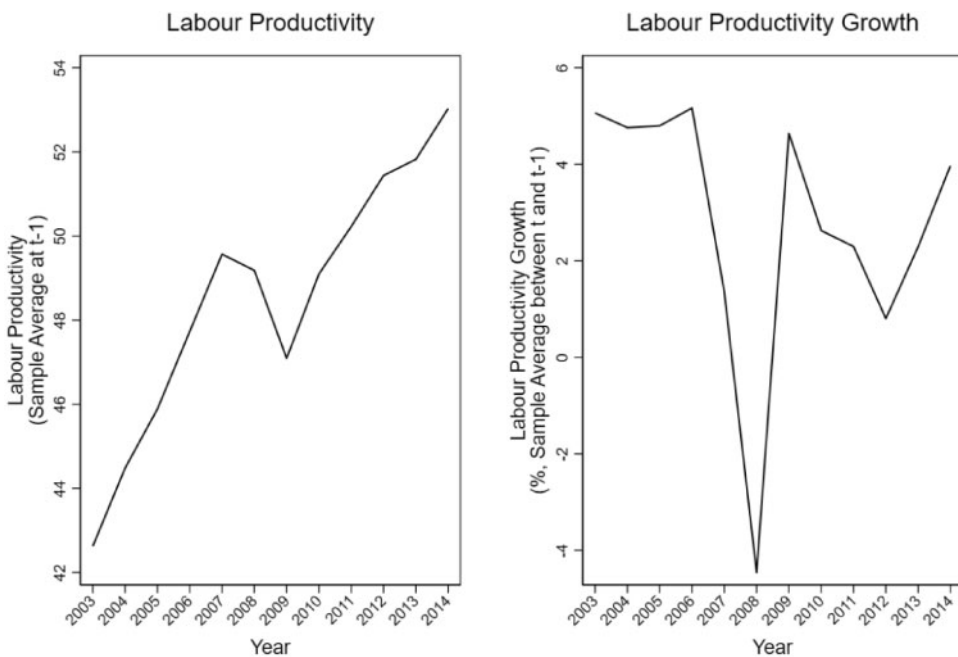


**Figure 1.** Labour productivity (growth) dynamics. *Notes*: Labour productivity is defined as gross value added per employee. The plots consider yearly averages for 248 NUTS-2 regions in the sample, with $t = 2003, \ldots, 2015$. Authors' elaboration on data drawn from the European Statistical Office (Eurostat).

Great Recession produced a trough in productivity growth—productivity growth in 2008 was negative—from which Europe still must recover. The post-2008 rates of productivity growth remained lower than in pre-crisis times, at least until 2015. On the whole, during what van Ark (2016) has called the post-2005 era of the 'new digital economy', labour productivity has recorded a marginally positive—and almost linear—growth trend, while its growth has remained well below what is needed to preserve both the competitiveness of the European economy and to maintain its social welfare model.[2]

Moreover, the distribution of labour productivity is becoming more unequal. In the 'new digital economy' increases in productivity are more and more concentrated in frontier firms, that is, those at the top 5% of the distribution (Andrews et al., 2016). And as research and development (R&D) expenditure projects become larger—the top 10% of Scoreboard firms concentrate 71% of R&D expenditure (Veugelers, 2018)—the 'new digital economy' implies that productivity changes are ever more the privilege of a number of superstar firms (Veugelers, 2018).

The rise in labour productivity inequality is, nevertheless, not limited to firm size and technological component. It also has a profound geographical dimension. Figure 2 maps the spatial distribution of labour productivity growth across regions in Europe. It shows the existence of three groups of regions according to their labour productivity trajectories between 2003 and 2015. The highest productivity growth has been concentrated in eastern European regions, as well as in Scandinavia. These are regions and countries which clearly outstripped the average productivity growth recorded in Europe as a whole. Many of these countries—including Bulgaria, Czechia, Poland, Romania and Slovakia—saw rather high (relative to the rest of the EU) productivity increases across the whole country, at least until the outbreak of the Great Recession. The panorama was slightly more mixed in Denmark, Hungary and Sweden. Relatively high productivity growth rates were also the norm in eastern and southern Ireland and most of Portugal. The second group includes most regions in France, Germany, Greece and Italy, which witnessed far lower rates of productivity growth. In particular, regions in Greece and Italy had the lowest productivity increases. The third, intermediate group includes most regions in Austria, the Benelux, Spain and the UK, which experienced, on average, moderate productivity growth. However, within this group differences in productivity growth were high between low (e.g. North Yorkshire and Asturias) and high performers (e.g. Aberdeenshire and the Basque Country).[3]

What determines these differences in productivity growth across regions of Europe? Much research has been conducted trying to solve this productivity 'puzzle' (Broersma and van Dijk, 2008; Barnett et al., 2014; Martin et al., 2018). Traditional analyses have delved into the basic factors behind productivity in order to explain why productivity has stagnated badly in some areas and economic sectors, while in others it has remained relatively healthy. Pessoa and Van Reenen (2014), for example, when studying the productivity slowdown in the UK, focused on issues related to wage flexibility and the

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2  Annual labour productivity growth was also much higher in post-2004 enlargement countries than in the EU-15 until the Great Recession. From 2011, instead, post-2004 enlargement countries have converged to the lower growth rates of EU-15 countries (see Supplementary Figure A1).

3  The evidence depicted in Figure 2 is in line with the general pattern for Member States of the OECD. There, within-country cross-regional disparities in labour productivity are often higher than cross-country disparities. In addition, the productivity gap between 'frontier' regions and those lagging behind in the productivity distribution has increased, highlighting a 'catching-up' problem (OECD, 2016).
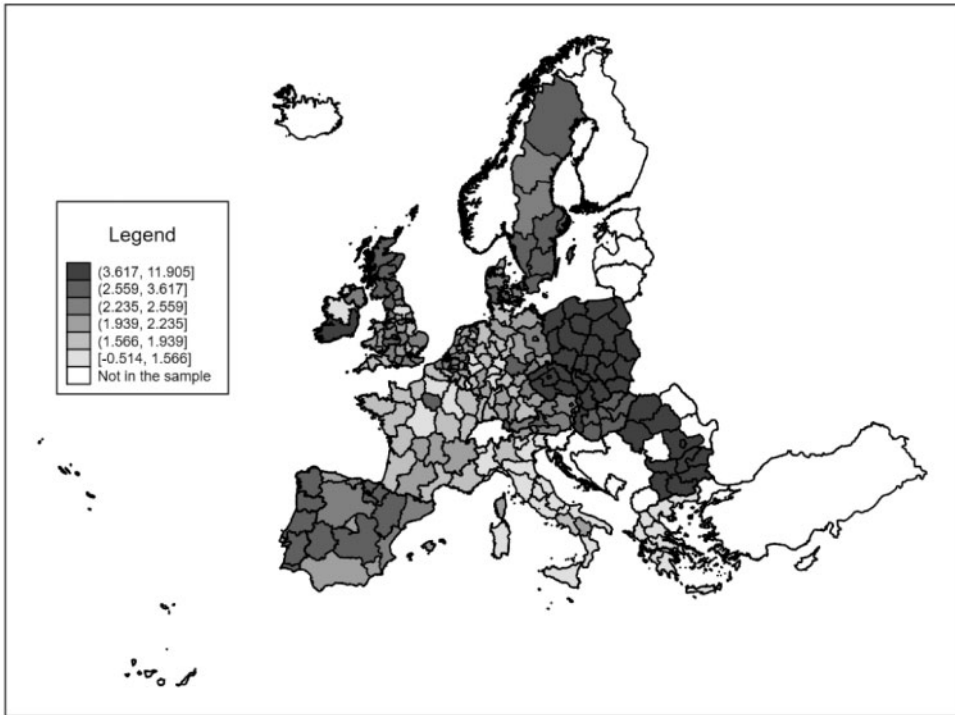
**Figure 2.** Spatial distribution of yearly labour productivity growth over the period 2003–2015. *Notes*: Labour productivity is defined as gross value added per employee. The map considers time averages over the period 2003–2015 for 248 NUTS-2 regions in the sample. Values are expressed in percentage terms. Darker areas denote higher values of the variable. Authors' elaboration on data drawn from Eurostat.

underutilisation of resources. A decline in intangible and telecoms investment and low total factor productivity growth are the main culprits for Goodridge et al. (2013). Lucidi and Kleinknecht (2010) have highlighted labour market flexibility as a key shortcoming for Italian firms' labour productivity growth, while Naastepad (2006) identified the decline in real wages growth as the main cause of the Dutch productivity crisis. Low capital investment in information and communication technology (ICT) and a lack of capacity to reallocate resources within sectors affected by fast changes in technology have also been the object of attention (Iammarino and Jona-Lasinio, 2015; van Ark, 2016; Calligaris et al., 2018), while Benos and Karagiannis (2016) have put the emphasis on skills and education.

The focus on physical and human capital and innovation to explain the slowdown in productivity is logical. After all, technology, knowledge and efficient knowledge are the key components behind productivity changes (Acemoglu, 2012). This is particularly relevant for European regions, for which the technology gap to the leader and human capital endowment appear as the key drivers of productivity growth. Differences in human capital endowment between Italy—with one of the lowest levels of formal skills among the adult population in the EU—and most of the rest of Europe can, for example, explain Italy's productivity growth slowdown. The same applies to the lower capital formation in Greece.

However, the impact of diversity in physical and human capital endowment and technological capacity for labour productivity may be enhanced by the pervasive differences in institutional quality across regions of Europe. As indicated by North (1990, 1991), economic success depends to a large extent on the quality of institutions. At country level, increasing evidence shows how heterogeneity in institutional quality expounds differences in productivity and economic performance (Hall and Jones, 1999; Olson et al., 2000), with higher institutional quality magnifying the productivity returns of physical and human capital (Hall et al., 2010) and R&D (Égert, 2017).

As in the case of country-level institutions, local institutions also contribute to create the conditions and incentives that reduce transaction costs and make the development of economic activity more viable (Rodríguez-Pose, 2013). Institutions are at the heart of innovative activity (Rodríguez-Pose and Di Cataldo, 2015). But the role of institutions for innovation goes beyond that linked to the creation of formal bodies, such as the presence of intellectual property rights protection, to encompass more informal arrangements (Mokyr, 2009), such as building of trust among different economic actors (Putnam et al., 1994). Good institutions also facilitate innovation at all levels as they contribute to generate both the right environment for scientific breakthroughs and the conditions for the assimilation of innovation (Mokyr, 2009). All these are essential factors for the adoption of innovation by firms and, consequently, for increases in labour productivity. Moreover, effective institutions can have an important indirect role in facilitating the efficient use of physical and human capital and innovation in the market place, once again leading to increases in productivity. In this respect, good institutions are at the heart of the trust-based networks that connect researchers to industrialists (Mokyr, 2009) and that make an easier diffusion of new knowledge among economic actors possible (Rodríguez-Pose and Di Cataldo, 2015).

The geographical scale at which institutions can be more effective is also changing, especially in the most developed countries. Increasingly, in the rich countries of the world, most public investment is being conducted at sub-national level. Overall, 73% of public investment in the Organisation for Economic Co-operation and Development (OECD), for example, is carried out by sub-national tiers of government (Hulbert and Vammalle, 2014). The regional scale is also one where, often, the cohesiveness and accountability of economic actors tend to be greater as existing social capital facilitates collaboration and networking (Laursen et al., 2012; Huggins et al., 2012).

In this respect, the regional approach to institutional quality complements country-level analyses by capturing the wide within-country heterogeneity existing in the EU in terms of both factor endowment and productivity trajectories. Yet, the role of how local institutions influence local productivity both directly and indirectly—through their effects on physical and human capital and local innovation—has, so far, attracted limited attention. This article covers this gap in our knowledge by assessing the extent to which the productivity challenge at the regional level in the EU depends on more than just improvements in physical and human capital and innovation, evaluating how differences in institutional quality in the places where economic actors operate may represent an asset/barrier to productivity growth.

## 3. Empirical framework

### 3.1. Modelling and data

The empirical analysis investigates the determinants of recent regional labour productivity dynamics in the EU. Two inter-related dimensions are covered. First, we examine the role that capital investments, skills, innovation and institutional factors play in directly shaping short-run regional productivity growth. Secondly, we zoom into whether and how institutional quality across the regions of Europe becomes a productivity-enhancing force—or, conversely, an obstacle—by intensifying—or reducing—the returns on productivity of physical and human capital investments and of the innovation effort.

The empirical model proposed for regional productivity growth is derived from the standard neoclassical Solow–Swan growth model (Solow, 1956; Swan, 1956), which specifies regional productivity according to the following production function:

$$\text{LP}_{r,t} = f(A_{r,t}, K_{r,t}, H_{r,t}, L_{r,t}) \tag{1}$$

where productivity in region $r$ at time $t$ ($\text{LP}_{r,t}$) is defined as a function of technology ($A_{r,t}$), physical capital ($K_{r,t}$), human capital ($H_{r,t}$) and labour ($L_{r,t}$).

We hypothesise that local institutional differences—reflecting the quality, efficiency, accountability of governments, the relevance of corruption in a territory, and the state of local bureaucracy and of the judicial systems—shape changes in regional productivity. This implies assuming that productivity growth is constrained by government capability, with the quality of government being a force able to influence both technical and non-technical regional growth parameters.

In order to assess whether this is the case, we define the technology parameter ($A_{r,t}$) as a combination of technological know-how—that is, productive efficiency ($T_{r,t}$) which, in turn, is determined by technology adoption choices made by profit-maximising firms—and by the quality of regional institutions ($I_{r,t}$). Thus, the technology parameter can be specified as a function of productive efficiency and institutional quality as follows:

$$A_{r,t} = g(T_{r,t}, I_{r,t}) \tag{2}$$

Based on this, we develop the traditional Solow–Swan growth framework considering both physical and human capital aspects *à la* Mankiw et al. (1992), complementing the model with institutional regional parameters. Assuming a Cobb–Douglas production function setting with constant returns to scale, the substitution of Equations (2) into (1) yields the following specification:

$$\text{LP}_{r,t} = K_{r,t}^{\alpha} H_{r,t}^{\beta} (I_{r,t} T_{r,t} L_{r,t})^{1-\alpha-\beta} \tag{3}$$

where the term $I_{r,t}$ denotes the institutional factor, and the term $T_{r,t}$ reflects companies' productive efficiency. Assuming that regions differ in their initial level of technology (Mankiw et al., 1992), we compute steady-state values of human and physical capital per effective unit of labour and, taking natural logarithms, adopt the following structural equation for a region's long-run output per capita levels:

$$\log(\text{LP}_{r,t}) = \log(T_{r,0}) + \log(I_{r,0}) - \frac{\alpha+\beta}{1-\alpha-\beta} \log(n_{r,t} + g + \delta) + \frac{\alpha}{1-\alpha-\beta} \log\left(s_{r,t}^{k}\right)$$

$$+ \frac{\beta}{1 - \alpha - \beta} \log\left(s_{r,t}^h\right) \tag{4}$$

where $\mathrm{LP}_{r,t}$ denotes labour productivity of region $r$ at time $t$, $s_{r,t}^k$ represents investments, $s_{r,t}^h$ denotes human capital, $n_{r,t}$ indicates population growth, $g$ is the exogenous growth rate of technology and $\delta$ is the depreciation rate (DR). These are the factors that, as indicated in the previous section, recent research has brought to the fore as the main productivity-inducing factors. Based on existing theory, the model predicts higher productivity in territories with higher levels of investment, human capital, technological progress and better institutional conditions.

By developing the previous theoretical model empirically and disentangling the investments component into physical capital and investments leading to innovation, the following augmented empirical equation for short-run labour productivity growth is specified:

$$\begin{aligned} \Delta \mathrm{LP}_{r,t} = {} & \beta \log(\mathrm{LP}_{r,t-1}) + \gamma \log\left[K_{r,t-1}/(1 - K_{r,t-1})\right] + \delta \log\left(\Delta \mathrm{Population}_{r,t-1} + \mathrm{TC} + \mathrm{DR}\right) \\ & + \zeta \log\left(\mathrm{Population\ Density}_{r,t-1}\right) + \theta \log\left[\mathrm{HC}_{r,t-1}/(1 - \mathrm{HC}_{r,t-1})\right] \\ & + \vartheta \log(\mathrm{Innovation}_{r,t-1}) + \lambda \mathrm{Institutional\ Quality}_{r,t-1} + \nu_r + \xi_t + \varepsilon_{r,t} \end{aligned} \tag{3}$$

where $\Delta \mathrm{LP}_{r,t} = \log(\mathrm{LP}_{r,t}) - \log(\mathrm{LP}_{r,t-1})$ denotes the annual regional labour productivity growth; with labour productivity ($\mathrm{LP}_{r,t}$) defined as total gross value added (GVA) over total employment; the regional observational unit $r = 1, \ldots, 248$ defined at the geographic level 2 of the 'Nomenclature des Unités Territoriales Statistiques' (NUTS) adopted by the EU; and the temporal dimension $t$ defined over the period 2003–2015.

The right-hand side of Equation (5) includes variables for: the growth-initial labour productivity level ($\mathrm{LP}_{r,t-1}$); physical capital ($K_{r,t-1}$), defined as gross fixed capital formation (GFCF) as percentage of gross domestic product (GDP); population growth rate between times $t-1$ and $t-2$ ($\Delta \mathrm{Population}_{r,t-1}$), with TC and DR assumed as constant and equal to 0.02 and 0.05, respectively (Arbia et al., 2010); population density (Population Density$_{r,t-1}$), defined as population per square kilometre, and aimed at controlling for agglomeration-related forces and capturing regional features related to population distribution and concentration of economic activities; human capital ($\mathrm{HC}_{r,t-1}$), measured as the share of the population aged 25–64 years with tertiary education; innovative capacity (Innovation$_{r,t-1}$), defined as the number of patent applications—filed under the European Patent Office, by inventors' country of residence and priority year—and quality of regional institutions (Institutional Quality$_{r,-1t}$). $\nu_r$ and $\xi_t$ are the region and time fixed effects (FEs), respectively, while $\varepsilon_{r,t}$ denotes the error term.[4]

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4   Data on GVA, employment, GFCF, GDP, population, surface, population with tertiary education and patents are drawn from the *Regio* database provided by Eurostat. Missing values in the regional series for population, human capital and patents have been filled in by linearly interpolating country-level data provided by Eurostat. According to Eurostat, GFCF is defined as resident producers' acquisitions (less disposals) of fixed assets (e.g. machinery and equipment, vehicles, buildings, structures, computer software) during a given period, plus additions of non-produced assets realised by the productive activity of producer or institutional units. The physical and human capital variables are defined through a logistic transformation of the form $Z = \log[X/(1 - X)]$, rather than using a simple log-transformation, given their bounded nature in $[0, 1]$—as they are defined as percentage values. The use of a logistic transformation allows us to maintain their original bounded nature, while exploiting a variation in $[-\infty, +\infty]$.

The variable for regional institutional quality (Institutional Quality$_{r,t-1}$) is defined using data drawn from the 2013 wave of the European Quality of Government Index (EQGI) dataset provided by the Quality of Government Institute of the University of Gothenburg. The EQGI contains individual-level information derived from a citizen-based survey on the perception and experience of individuals in their own locality with respect to corruption, quality and impartiality in terms of education, public healthcare and law enforcement.[5] The concept of institutional quality encompasses factors such as corruption, rule of law and the impartiality of the public sector, capturing the capacity of regional governments to provide and administer public services impartially, effectively and in a non-corrupt manner (Rothstein and Teorell, 2008; Charron et al., 2014, 2015). Hence, the EGQI aims at capturing the 'quality', rather than the 'quantity', of public services delivered by regional governments. In this respect, regional institutional quality is defined based on four main 'pillars', including the degree of corruption of the local public sector, the strength of the rule of law, the level of voice and accountability in terms of corruption-free local elections and local media freedom, and the effectiveness of local governments in providing high-quality services in an impartial manner (Charron et al., 2014).

Following the approach proposed by Charron et al. (2014, 83) and widely employed in the empirical literature analysing regional institutions in the EU (Rodríguez-Pose and Di Cataldo, 2015; Crescenzi et al., 2016; Ketterer and Rodríguez-Pose, 2018; Ganau and Rodríguez-Pose, 2019), the 16 survey questions of the EQGI dataset have been adapted to, and interpolated with, four of the six institutional 'pillars' defining the country-level Worldwide Governance Indicators (WGI) dataset developed by the World Bank (Kaufmann et al., 2010). Specifically, the four 'pillars' considered are government effectiveness, rule of law, voice and accountability and control of corruption.[6] This interpolation of the region- and country-specific indicators has a series of advantages. First, it allows us to cover the entire period of analysis. Secondly, it captures country-specific dimensions— for example, legal system, immigration, trade, security—which are not considered in the survey-based data. Thirdly, it can overcome potential biases affecting the regional index, induced by the limited number of respondents per region (Charron et al., 2014).

Formally, the region-specific time-varying institutional quality index (IQI$_{r,t-1}$) is constructed as follows (Charron et al., 2014):

$$IQI_{r,t-1} \equiv IQI_{r,c,t-1} = WGI_{c,t-1} + \left( IQS_{r,c} - \overline{IQS}_c^w \right) \tag{6}$$

where $\overline{WGI}_{c,t-1}$ denotes the average of the four mean-standardised institutional 'pillars' from the WGI dataset in country $c$ at time $t-1$; IQS$_{r,c}$ represents the region-specific score

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5   The EQGI dataset has two main advantages. First, it represents the only existing source of information capturing within-country variations in institutional quality. Second and unlike other datasets on institutions, it relies on survey data collected from about 83,000 individuals. Hence, it captures the perception and experience of a large number of individuals with respect to the provision and administration of public services, rather than being based on the opinion of a limited number of experts (Charron et al., 2015). However, it also comes with two main limitations. First, it does not observe region-specific dynamics of institutional quality over time. Secondly, the survey-based information corresponds to regions at either NUTS-2 level (Austria, Bulgaria, Czechia, Denmark, France, Ireland, Italy, the Netherlands, Poland, Portugal, Romania, Slovakia, Spain) or NUTS-1 level (Belgium, Germany, Greece, Hungary, Sweden, the UK). We assign the same value of regional institutional quality to all NUTS-2 regions within the same NUTS-1 region, if information is only available at the NUTS-1 level.

6   The WGI dataset includes two further dimensions, namely, regulatory quality and political stability and absence of violence. However, these two dimensions cannot be accounted for in constructing the regional institutional quality index due to the lack of corresponding information in the EQGI dataset.

derived from the corresponding four survey-based institutional 'pillars'; and $\overline{\mathrm{IQS}}_c^w$ denotes the country-specific, population-weighted average of the survey-based regional score.[7] The regional index defined in Equation (6) is subsequently normalised in the interval $[0, 1]$— from the lowest to the highest level of institutional quality—to obtain the variable depicting regional institutional quality (Institutional Quality$_{r,t-1}$).[8]

The final sample includes 248 NUTS-2 regions in 19 EU countries. In particular, it covers 96.88% of all sub-national territories of the countries considered in the analysis (see Supplementary Appendix Table A1) and represents 95.65% of GVA, 93.74% of employment and 93.47% of population of the EU-28 area (see Supplementary Appendix Table A2). Supplementary Appendix Table A3 reports some descriptive statistics of the dependent and explanatory variables entering Equation (5), while Supplementary Appendix Table A4 presents the correlation matrix of the explanatory variables.

Considerable heterogeneity in institutional quality is in evidence both across and within countries (Supplementary Appendix Figure A2). Across Europe, regions with good institutions—mainly located in Scandinavia, the Netherlands, Germany and Austria—coexist with regions with relatively low institutional quality, fundamentally in the south eastern corner of Europe, from the south of Italy, to Greece, Bulgaria and Romania. In between, regions in the remaining post-2004 Member States of the EU (Czechia, Hungary, Poland, Slovakia and Slovenia) also suffer from weak institutional quality. However, the institutional conditions are better than in the South East of the EU. The final group consists of regions in Belgium, the British Isles, France, the Iberian Peninsula and northern Italy. Here, the local government quality is either slightly above average (Belgium, France, Ireland, the UK) or right on the average of the sample, as in the case of Portugal and Spain. Although institutional quality has remained, on average, fairly stable over the time period considered (see Supplementary Appendix Table A5), there has been a tendency for cross-country variation in institutional quality to increase between 2003 and 2015 (see Supplementary Appendix Figure A3).

In total, 60.89% of the regions in the sample had levels of institutional quality throughout the period of analysis which were above the sample mean (see Supplementary Appendix Figure A4). In particular, the best institutional setting, according to the survey, was found in the Danish region of Midtjylland, while the Bulgarian region of Yugozapaden had the lowest score. All regions in Austria, Denmark, Germany, Ireland, the Netherlands, Sweden and the UK were above the sample mean, while all regions in Bulgaria, Czechia, Hungary, Greece, Poland, Romania and Slovakia were below the mean. The percentage of regions lying above the sample average value in the remainder of countries was 45.5% in Belgium, 54.6% in France, 52.4% in Italy, 40% in Spain and 62.5% in Portugal.

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7  Charron et al. (2014, 83) classify the 16 survey questions of the EQGI into four 'pillars': government effectiveness, rule of law, voice and accountability, and control of corruption. This allows constructing region-specific indexes reflecting these four 'pillars'. The mean-standardised four indexes are then averaged to obtain the region-specific score for institutional quality (IQS$_{r,c}$).

8  Time-varying, interpolated variables capturing the four institutional 'pillars' have been constructed following the same approach. Let $\overline{\mathrm{WGI}}_{p,c,t-1}$ denote the mean-standardised value for institutional 'pillar' $p$ from the WGI dataset in country $c$ at time $t-1$; let IQS$_{p,r,c}$ denote the mean-standardised region-specific score derived from the 'pillar'-specific survey questions; let $\overline{\mathrm{IQS}}_{p,c}^w$ denote the country-specific, population-weighted average of the survey-based, 'pillar'-specific regional score; then, the region-specific, time-varying index for 'pillar' $p$ is defined as follows:

$$\mathrm{IQI}_{p,r,t-1} \equiv \mathrm{IQI}_{p,r,c,t-1} = \overline{\mathrm{WGI}}_{p,c,t-1} + \left(\mathrm{IQS}_{p,r,c} - -\mathrm{IQS}_{p,c}^w\right)$$

and is further normalised in the interval $[0, 1]$.

### 3.2. Estimation approach

Equation (5) is estimated through a two-way FE estimator, which allows relaxing issues related to unobserved heterogeneity and omitted variables. However, potential endogeneity of the institutional quality variable is likely to bias the FE estimation of Equation (5). Endogeneity can emerge for several reasons, among which reverse causality—if the best performing regions are also those with a better institutional setting, because strong institutions are a consequence of a good economic environment—and measurement errors—because the institutional index defined in Equation (6) represents only a partial proxy of what is, by nature, a complex phenomenon which is hard to capture, measure and operationalise.

The empirical literature has suggested correcting for the potential endogeneity of institutional variables with historical and geographic instrumental variables (IVs) (Acemoglu et al., 2001; Glaeser et al., 2004; Rodrik et al., 2004; Rodríguez-Pose and Di Cataldo, 2015; Ketterer and Rodríguez-Pose, 2018). Along these lines, the proposed identification strategy follows Buggle and Durante (2017), who analyse the historical and enduring relationship between economic risk and social cooperation and find a positive association between climate variability in the pre-industrialisation period and current social trust in European regions. Drawing on this evidence, the proposed identification strategy exploits regional variations in precipitation variability during the growing season in the pre-industrialisation period (1500–1750) to instrument current levels of regional institutional quality. The rationale of the identification strategy relies on the idea that high levels of weather risk—captured by precipitation variability during the growing season—at a time when individuals' subsistence was based on agricultural production, called for the development of efficient and effective local institutions able to cope with weather-related economic risks. Under the new institutionalist idea of path dependency (North, 1990), current institutional frameworks are the result and keep traces of past (formal and informal) institutions. As institutions are historically and geographically rooted, current regional institutional quality is expected to reflect the quality of past regional institutional settings. In addition, the validity of the identification strategy is guaranteed by the fact that climate variability in the agriculture-based pre-industrialised Europe is likely to be exogenous to labour productivity growth in recent times.

The region-specific variable capturing precipitation variability in the pre-industrialisation period is defined using reconstructed paleoclimatic data available for 1500–1750. Paleoclimatic data are drawn from the European Seasonal Temperature and Precipitation Reconstruction database, which provides grid cells of 0.5° width, each containing yearly seasonal observations for 1500–2000 (Luterbacher et al., 2004; Pauling et al., 2006 for details).[9]

Two alternative IVs are constructed to capture historical precipitation variability. The first IV is defined as a time-varying variable. It is constructed by considering precipitation variability over 20-year intervals in the pre-industrialisation period (1500–1740), making it straightforward to instrument the time-varying institutional quality variable within a two-way FE estimation approach. The second IV is defined as a time-invariant variable. It is built using precipitation variability over the entire pre-industrialisation period. The rationale for also considering a time-invariant version of the IV is that climate-related

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9   Although the paleoclimatic data used are available for the period 1500–2000, the IV is limited to the years between 1500 and 1750 to capture the pre-industrialisation nature of the effect of climate-related economic risk on the emergence of institutions.

phenomena may have gradually changed at a time free from industrial production and human-related pollution.[10] Formally, let $p$ denote precipitations; let $s$ denote seasons (winter, spring, summer, autumn); let $i$ denote the grid cell, with $i \in r$ and $r$ representing the NUTS-2 region; and let $t$ indicate the year, with $t = 1500, \ldots, 1750$. This leads to constructing the variable capturing precipitation variability during the growing season as follows. A season-specific inter-annual standard deviation measure is calculated at the cell level for $p_{i,s,t}$ over either 20-year intervals between 1500 and 1740, or all years $t$ between 1500 and 1750, before averaging the cell-level standard deviation measures over all cells within a region $r$ in order to obtain region- and season-specific measures of precipitation variability. Then, the region- and season-specific inter-annual standard deviation measures defined over either 20-year intervals between 1500 and 1740, or the entire period 1500–1750 are averaged with respect to the growing seasons, identified with spring and summer. Thus, the IVs capture the mean variability during the growing season averaged over either 20-year intervals between 1500 and 1740, or the years from 1500 to 1750, that is, from the first available year of information to what can be considered as the starting decade of the Industrial Revolution.

On the one hand, the time-varying IV defined over 20-year intervals between 1500 and 1740 allows relying on a two-way FE-IV estimation approach, instrumenting the time-varying institutional quality variable with the time-varying IV. On the other, the time-invariant IV makes a two-way FE estimation not feasible. In order to overcome this issue, the time-invariant IV is employed within a two-stage model where the first-stage equation is estimated using a correlated random effects (CREs) approach (Mundlak, 1978), while the second-stage equation is estimated by relying on a two-way FE estimator. The CRE estimator allows controlling for region-specific effects by including the region-specific mean values of all the time-varying variables entering the model, while simultaneously including time-invariant variables.[11] Thus, the first-stage equation is specified having regional institutional quality as the dependent variable and the time-invariant IV as additional exogenous explanatory variable together with the region-specific mean values of the time-varying variables entering Equation (5), plus time FEs. Then, the second-stage equation is specified using the estimated (time-varying) predicted values of institutional quality from the first-stage equation in place of the observed institutional quality variable as explanatory variable for labour productivity growth. It is estimated by relying on a two-way FE estimation approach.

For the sake of comparability, both the two-way FE-IV estimation approach relying on the time-varying excluded IV and the two-stage equation system estimated using the time-invariant excluded IV are implemented by applying a bootstrapping procedure to correct standard errors. The errors are clustered at the regional level.

## 4. Empirical results

### 4.1. Baseline results

The two-way FE estimation of Equation (5) allows examining the short-run relationship between the endowments in physical and human capital, the level of innovation and

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10  The correlation coefficient between the time-varying and time-invariant IVs is equal to 0.784, with a $p$-value equal to 0.000.

11  The CRE estimator has the advantage of providing FE estimates of the time-varying variables' parameters, as well as consistent estimates of the time-invariant variables' parameters.

**Table 1.** Two-way FE estimates

| Dependent variable | $\Delta LP_{r,t}$ | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Estimation method | FE | | | | | | | | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| $\log(LP_{r,t-1})$ | −0.215**** (0.010) | −0.223**** (0.010) | −0.221**** (0.009) | −0.224**** (0.010) | −0.247**** (0.011) | −0.245**** (0.011) | −0.243**** (0.011) | −0.245**** (0.012) | −0.236**** (0.012) |
| $\log[K_{r,t-1}/(1-K_{r,t-1})]$ | — | 0.041**** (0.006) | 0.041**** (0.006) | 0.041**** (0.006) | — | 0.032**** (0.005) | 0.032**** (0.005) | 0.032**** (0.005) | 0.105**** (0.019) |
| $\log(\Delta\text{Population}_{r,t-1} + TC + DR)$ | — | −0.003 (0.006) | −0.003 (0.006) | −0.003 (0.006) | — | −0.007 (0.006) | −0.007 (0.006) | −0.007 (0.006) | −0.006 (0.004) |
| $\log(\text{Population Density}_{r,t-1})$ | — | 0.046 (0.045) | 0.066 (0.044) | 0.068 (0.045) | — | 0.056 (0.047) | 0.074 (0.046) | 0.076 (0.046) | 0.019 (0.044) |
| $\log[HC_{r,t-1}/(1-HC_{r,t-1})]$ | — | — | −0.019** (0.008) | −0.020** (0.008) | — | — | −0.017** (0.008) | −0.018** (0.008) | −0.061*** (0.020) |
| $\log(\text{Innovation}_{r,t-1})$ | — | — | — | 0.003 (0.002) | — | — | — | 0.002 (0.002) | −0.006 (0.007) |
| Institutional Quality$_{r,t-1}$ | — | — | — | — | 0.256**** (0.039) | 0.198**** (0.039) | 0.196**** (0.038) | 0.195**** (0.038) | 0.061 (0.056) |
| $\log[K_{r,t-1}/(1-K_{r,t-1})]$ ×Institutional Quality$_{r,t-1}$ | — | — | — | — | — | — | — | — | −0.125**** (0.029) |
| $\log[HC_{r,t-1}/(1-HC_{r,t-1})]$ ×Institutional Quality$_{r,t-1}$ | — | — | — | — | — | — | — | — | 0.069*** (0.026) |
| $\log(\text{Innovation}_{r,t-1})$ ×Institutional Quality$_{r,t-1}$ | — | — | — | — | — | — | — | — | 0.016* (0.009) |
| Region FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| No. of observations | 2976 | 2976 | 2976 | 2976 | 2976 | 2976 | 2976 | 2976 | 2976 |
| No. of regions | 248 | 248 | 248 | 248 | 248 | 248 | 248 | 248 | 248 |
| Model $F$ statistic [$p$-value] | 502.04 [0.000] | 185.63 [0.000] | 150.25 [0.000] | 130.64 [0.000] | 237.91 [0.000] | 132.16 [0.000] | 112.95 [0.000] | 101.65 [0.000] | 60.11 [0.000] |

*Notes:* *$P < 0.1$; **$P < 0.05$; ***$P < 0.01$; ****$P < 0.001$. Robust standard errors in parentheses.

institutional quality in each region, on the one hand, and changes in productivity, on the other (Table 1). We also assess how institutional quality contributes to shape the returns on short-run labour productivity growth of the other three factors by augmenting Equation (5) with a series of interaction terms between the institutional quality variable and the variables for physical capital, human capital and innovative capacity. Specifications (1)–(7) report the results related to a series of modified versions of Equation (5) aimed at testing the consistency of the explanatory variables, while specification (8) refers to the complete model, including all explanatory variables.

The results suggest that regional convergence in labour productivity is taking place across Europe, as the coefficient of the beginning-of-the-period productivity variable is negative and statistically significant. As expected, labour productivity growth is positively associated with investments in physical capital. This result seems to be fundamentally driven by productivity growth in central and eastern European regions (Bijsterbosch and Kolasa, 2010), while a negative association emerges with human capital. This negative connection can be explained by the incapacity of labour markets in many European regions to transform skills into jobs, productivity and growth. Problems linked to either low educational attainment, low quality of education, a severe mismatch between educational supply and labour demand, and, last but not least, overeducation issues may determine the weak returns of human capital on labour productivity changes across regions (Rodríguez-Pose and Vilalta-Bufí, 2005; Leuven and Oosterbeek, 2011). Moreover, tight labour market regulations restricting entry of younger and more skilled workers may also drive this result. The coefficients for population growth, population density and innovative capacity are negligible, while overall institutional quality at a regional level is positively associated with labour productivity growth. It is estimated that a unit change in institutional quality can lead to a 19.5% increase in short-run labour productivity growth.

Specification (9) in Table 1 presents the results of an augmented version of Equation (5), which dwells on the more indirect effects of local institutional quality on labour productivity change at a regional level in Europe. The aim of this exercise is to test whether and how regional institutions shape the returns of other productivity-driving factors on labour productivity growth.

The use of interaction terms yields crucial insights about how institutional quality shapes the impact of other factors on labour productivity. The estimated effects of interacting local institutional quality with physical capital, human capital and innovative capacity, respectively, suggest that the quality of regional institutions shapes to a considerable extent the returns of these factors on labour productivity growth. These impacts are expanded in Table 2, which presents the estimated returns of physical and human capital and innovative capacity at selected percentiles of the distribution of the institutional quality variable. On the one hand, the positive association between physical capital and labour productivity growth decreases as the quality of institutions in the regions increases, up to a point in which any increases in physical capital become negative—although marginally statistically significant—for labour productivity growth (roughly for the regions in the top 1% of the institutional quality distribution). In accordance with the neo-classical growth model (Solow, 1956), physical capital accumulation drives the labour productivity of less developed territories that are those also typically characterised by low-quality and still-evolving institutional settings. On the other hand, better regional institutions boost the impact of both human capital and innovative capacity on labour productivity growth. Not only does the estimated negative effect of human capital decrease as the level of institutional quality increases, up to a point in which

**Table 2.** The mediation effect of institutional quality on physical and human capital endowments, and innovation capacity

| Distribution of Institutional Quality$_{r,\,t-1}$ | Marginal effects of: | | |
|---|---|---|---|
| | Physical capital | Human capital | Innovative capacity |
| 1st Percentile | 0.094[****] | −0.055[***] | −0.005 |
| | (0.016) | (0.019) | (0.007) |
| 25th Percentile | 0.036[****] | −0.023[*] | 0.002 |
| | (0.003) | (0.012) | (0.002) |
| 50th Percentile | 0.010[***] | −0.008 | 0.006[****] |
| | (0.003) | (0.012) | (0.001) |
| 75th Percentile | −0.003 | −0.001 | 0.007[****] |
| | (0.006) | (0.013) | (0.001) |
| 99th Percentile | −0.019[*] | 0.007 | 0.009[****] |
| | (0.010) | (0.015) | (0.002) |

*Notes*: *$P < 0.1$; **$P < 0.05$; ***$P < 0.01$; ****$P < 0.001$. Robust standard errors in parentheses. The estimated marginal effects refer to specification (9) in Table 1.

which it becomes negligible, but also the estimated negligible effect of innovative capacity becomes positive and statistically significant for very high levels of institutional quality.[12]

Therefore, the quality of regional institutions affects changes in labour productivity both directly and indirectly: the direct association is positive—better local institutions promote increases in labour productivity—while the indirect association depends on the productivity factor considered, with more efficient institutions increasing the returns of human capital endowment and regional innovation capacity. Regional institutions thus emerge as a

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12 It is worth noting that the identification of the institutional quality variable —as defined in Equation (6)— in the two-way FE estimations presented in specifications (5)–(8) in Table 1 exploits only time variations from the country-level component of the variable due to the inclusion of region FEs. It still exploits cross-regional variations from the region-specific component of the variable in the two-way FE estimation presented in specification (9), where the institutional quality variable is interacted with the three labour productivity growth determinants. The robustness of the results reported in specifications (8) and (9) in Table 1 has been tested through an Ordinary Least Squares estimator which controls for time FEs, but not for region FEs. This relaxes identification issues on the institutional quality variable related to the inclusion of region FEs. The results of this exercise are reported in Tables A6 and A7 in the Online Appendix. They confirm those reported in Table 1. A second potential issue affecting the two-way FE estimation of Equation (5) and its augmented version including interaction terms concerns Nickell's (1981) bias. As indicated by Islam (1995), the inclusion of region FEs in a model where the initial-growth level is added as explanatory variable makes the panel data specification a dynamic model. This makes the FE formulation no longer consistent with a relatively small number of observational units. Following Elhorst et al. (2010), we have dealt with the potential Nickell's (1981) bias through a two-step difference Generalised Method of Moments (GMM) estimator that allows removing region FEs through first-differencing and instrumenting the explanatory variables using internally generated GMM-type instruments (Arellano and Bond, 1991). The results of this exercise are reported in Tables A8 and A9 in the Online Appendix. They, again, confirm those reported in Table 1. Third, we have also relied on a CRE estimator using a time-invariant institutional quality variable defined without interpolating the region-specific component with the country-level, time-varying component, to test the reliability of our approach in constructing the institutional quality variable. The results of this exercise are reported in Tables A10 and A11 in the Online Appendix and confirm those presented in Table 1. Finally, we have tested the robustness of the results presented in specification (9) in Table 1 by considering the three interaction terms separately. The two-way FE estimates are reported in Tables A12 and A13 in the Online Appendix. They confirm those reported in Table 1.

key factor behind the growth dynamics of regions in the EU and as an essential element to solve the European productivity challenge.[13]

## 4.2. Dealing with endogeneity

As previously discussed, the estimated institutional quality-labour productivity growth relationship could be biased by the potential endogeneity of the institutional quality variable. Therefore, the robustness of the results reported in specifications (8) and (9) in Table 1 is tested by means of an IV approach. Specifications (1) and (2) in Table 3 report the results obtained through a two-way FE-IV estimator, employing the time-varying IV capturing precipitation variability in the growing season over 20-year intervals from 1500 to 1740. Specifications (3) and (4) show the results of estimating the two-stage equation system—based on a first-stage CRE estimator and a second-stage two-way FE estimator. We rely on a time-invariant IV capturing precipitation variability in the growing season over the entire pre-industrialisation period 1500–1750.[14]

The first-stage $F$ statistics on the excluded IVs are higher than the conservative cut-off value of 10, suggesting that weather-related economic risk in the pre-industrialisation period represents a good predictor of current institutional quality in EU regions. The second-stage IV estimates confirm the direct positive short-run effect of institutional quality on labour productivity growth, as well as the indirect role played by institutional quality in shaping the relationship between physical and human capital and innovative capacity, on the one hand, and short-run labour productivity growth, on the other.

The estimated marginal effects of physical capital, human capital and innovative capacity at the different levels of institutional quality—presented in Table 4—generally confirm those of Table 2. The results reveal that physical capital is a short-run labour productivity growth-enhancing factor only in those regions characterised by low-quality institutions, while its growth returns disappear in regions with high-quality institutions. The short-run returns of both human capital and innovative capacity on labour productivity growth are, in part, driven by institutional quality, such that their estimated effects are negative or negligible at low levels of institutional quality, but become positive and statistically significant at high levels of institutional quality. Overall, these results confirm that regional institutions have both a positive direct effect on labour productivity growth and a positive indirect effect by inducing positive returns of human capital and innovative

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13  Two further analyses have been performed to provide a more complete picture of the forces driving the short-run dynamics of labour productivity. First, Equation (5) has been modified considering the four 'pillars' for government effectiveness, rule of law, voice and accountability, and control of corruption. Table A14 in the Online Appendix reports the results of the two-way FE estimates obtained by analysing the institutional 'pillars', both individually and together. When considered all together, voice and accountability and control of corruption show positive and significant coefficients, while, by contrast, government effectiveness and rule of law display negative but insignificant coefficients. The second additional analysis examines annual changes in—rather than levels of— institutional quality and the four 'pillars'. Growth rates are defined as simultaneous with respect to the dependent variable for labour productivity growth. Despite this change, the two-way FE estimates reported in Table A15 in the Online Appendix confirms the majority of the previous findings: (i) changes in institutional quality are positively associated with changes in labour productivity and (ii) changes in all institutional dimensions but government effectiveness are positively connected to labour productivity growth. In brief, regions in Europe that managed to improve local institutions the most, experienced the greatest rises in labour productivity (Rodríguez-Pose and Ketterer, 2020).

14  The time-invariant IV used in the first-stage CRE estimation achieves exogenous variations only for the cross-sectional variation across regions.

**Table 3.** IV estimates

| Dependent variable | $\Delta LP_{r,\,t}$ | | | |
|---|---|---|---|---|
| IV in first-stage equation | Time-varying | | Time-invariant | |
| First-stage estimation method | FE | | CRE | |
| Second-stage estimation method | FE | | FE | |
| | (1) | (2) | (3) | (4) |
| $\log(LP_{r,\,t-1})$ | $-0.260^{****}$ | $-0.285^{****}$ | $-0.233^{****}$ | $-0.244^{****}$ |
| | (0.022) | (0.021) | (0.010) | (0.014) |
| $\log\left[K_{r,\,t-1}/(1-K_{r,\,t-1})\right]$ | $0.026^{***}$ | $0.200^{***}$ | $0.037^{****}$ | $0.063^{**}$ |
| | (0.009) | (0.063) | (0.006) | (0.027) |
| $\log\left(\Delta\text{Population}_{r,\,t-1}+TC+DR\right)$ | $-0.009$ | $-0.012$ | $-0.004$ | $-0.013^{*}$ |
| | (0.008) | (0.009) | (0.007) | (0.007) |
| $\log\left(\text{Population Density}_{r,\,t-1}\right)$ | $0.082^{*}$ | 0.021 | 0.072 | 0.013 |
| | (0.046) | (0.054) | (0.047) | (0.053) |
| $\log\left[HC_{r,\,t-1}/(1-HC_{r,\,t-1})\right]$ | $-0.017^{**}$ | $-0.074^{****}$ | $-0.019^{**}$ | $-0.089^{****}$ |
| | (0.008) | (0.021) | (0.008) | (0.021) |
| $\log(\text{Innovation}_{r,\,t-1})$ | 0.002 | $-0.009$ | 0.002 | $-0.031^{**}$ |
| | (0.002) | (0.007) | (0.002) | (0.016) |
| Institutional Quality$_{r,\,t-1}$ | $0.336^{**}$ | $0.241^{****}$ | $0.086^{*}$ | $0.330^{****}$ |
| | (0.157) | (0.057) | (0.045) | (0.047) |
| $\log\left[K_{r,\,t-1}/(1-K_{r,\,t-1})\right]$ $\times$institutional quality$_{r,\,t-1}$ | – | $-0.322^{***}$ | – | $-0.078^{*}$ |
| | | (0.113) | | (0.047) |
| $\log\left[HC_{r,\,t-1}/(1-HC_{r,\,t-1})\right]$ $\times$Institutional Quality$_{r,\,t-1}$ | – | $0.101^{****}$ | – | $0.119^{****}$ |
| | | (0.028) | | (0.027) |
| $\log(\text{Innovation}_{r,\,t-1})$ $\times$Institutional Quality$_{r,\,t-1}$ | … | $0.020^{*}$ | … | $0.059^{**}$ |
| | | (0.012) | | (0.027) |
| Region FE | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes |
| No. of observations | 2976 | 2976 | 2976 | 2976 |
| No. of regions | 248 | 248 | 248 | 248 |
| Model $F$-statistic ($P$-value) | 103.95 (0.000) | 91.34 (0.000) | 70.04 (0.000) | 122.27 (0.000) |
| First-stage $F$-statistic on excluded IV ($P$-value) | | | | |
| Institutional Quality$_{r,\,t-1}$ | 26.52 (0.000) | 25.84 (0.000) | 51.80 (0.000) | 42.09 (0.000) |
| $\log\left[K_{r,\,t-1}/(1-K_{r,\,t-1})\right]$ $\times$Institutional Quality$_{r,\,t-1}$ | – | 12.73 (0.000) | – | 65.94 (0.000) |
| $\log\left[HC_{r,\,t-1}/(1-HC_{r,\,t-1})\right]$ $\times$Institutional Quality$_{r,\,t-1}$ | – | 17.40 (0.000) | – | 50.70 (0.000) |
| $\log(\text{Innovation}_{r,\,t-1})$ $\times$Institutional Quality$_{r,\,t-1}$ | – | 10.62 (0.000) | – | 45.45 (0.000) |

*Notes*: $^{*}P < 0.1$; $^{**}P < 0.05$; $^{***}P < 0.01$; $^{****}P < 0.001$. Robust standard errors (bootstrapped via 1000 replications, and clustered at the regional level) in parentheses. Predicted values of the institutional quality variable and its interaction terms obtained from the first-stage estimations are included in the second-stage equations, rather than the observed values. The first-stage estimates for specifications (1) and (2) are obtained through a two-way FE estimation approach, where a time-varying excluded IV is specified to capture regional precipitation variability in the growing season over 20-year intervals during the pre-industrialisation period 1500–1740. The first-stage estimates for specifications (3) and (4) are obtained through a CRE estimation approach which includes region-specific mean values of time-varying variables and interaction terms, as well as year dummies, and where the excluded IV is specified as time-invariant to capture regional precipitation variability in the growing season during the entire pre-industrialisation period 1500–1750. The interaction terms entering specifications (2) and (4) are instrumented using the interaction between the excluded IV and each of the three variables for physical capital, human capital and innovative capacity.

**Table 4.** The mediation effect of institutional quality on physical and human capital endowments, and innovation capacity—IV estimates

| IV in first-stage equation | Time-varying | | | Time-invariant | | |
|---|---|---|---|---|---|---|
| First-stage estimation method | FE | | | CRE | | |
| Second-stage estimation method | FE | | | FE | | |
| Corresponding to specification (#) in Table 3 | (2) | | | (4) | | |
| Distribution of Institutional Quality$_{r,\,t-1}$ | Marginal effects of: | | | Marginal effects of: | | |
| | Physical capital | Human capital | Innovative capacity | Physical capital | Human capital | Innovative capacity |
| 1st percentile | 0.155** | −0.065*** | −0.008 | 0.056** | −0.079**** | −0.026* |
| | (0.075) | (0.019) | (0.006) | (0.023) | (0.019) | (0.013) |
| 25th percentile | 0.027** | −0.019* | 0.002 | 0.021*** | −0.024** | 0.001 |
| | (0.013) | (0.011) | (0.002) | (0.007) | (0.010) | (0.002) |
| 50th percentile | −0.032 | 0.003 | 0.006** | 0.004 | 0.001 | 0.014*** |
| | (0.026) | (0.011) | (0.003) | (0.012) | (0.009) | (0.005) |
| 75th percentile | −0.059 | 0.013 | 0.008** | −0.004 | 0.013 | 0.020** |
| | (0.039) | (0.012) | (0.004) | (0.016) | (0.010) | (0.008) |
| 99th percentile | −0.095 | 0.026* | 0.010** | −0.014 | 0.028** | 0.027** |
| | (0.058) | (0.014) | (0.005) | (0.021) | (0.012) | (0.011) |

*Notes:* *$P < 0.1$; **$P < 0.05$; ***$P < 0.01$; ****$P < 0.001$. Robust standard errors (bootstrapped via 1000 replications, and clustered at the regional level) in parentheses. The estimated marginal effects refer to specifications (2) and (4) in Table 3.

capacity on productivity growth at least in those regions which are characterised by a strong institutional environment.[15]

### 4.3. Long-run analysis

We complement the short-run evidence presented in the previous two sub-sections with the analysis of the long-run relationship between institutional quality and labour productivity growth. To this aim, Equation (5) has been modified within a cross-sectional framework as follows:

$$
\begin{aligned}
\Delta \mathrm{LP}_{r,c} = {} & \beta \log(\mathrm{LP}_{r,c}) + \gamma \log\left[K_{r,c}/(1 - K_{r,c})\right] + \delta \log\left(\Delta \mathrm{Population}_{r,c} + \mathrm{TC} + \mathrm{DR}\right) \\
& + \zeta \log\left(\mathrm{Population\ Density}_{r,c}\right) + \theta \log\left[\mathrm{HC}_{r,c}/(1 - \mathrm{HC}_{r,c})\right] + \vartheta \log(\mathrm{Innovation}_{r,c}) \\
& + \lambda \mathrm{Institutional\ Quality}_{r,c} + \sum_i \mu_i X_{r,c}^i + \pi_c + \varepsilon_{r,c}
\end{aligned} \tag{7}
$$

where $\Delta \mathrm{LP}_{r,c} = \frac{1}{T}\left[\log(\mathrm{LP}_{r,c,2015}) - \log(\mathrm{LP}_{r,c,2003})\right]$ denotes labour productivity growth of region $r$ in country $c$ between 2003 and 2015; with $T$ denoting the time length of the observational period.

The right-hand side of Equation (7) includes the initial-growth level of the variables for labour productivity ($\mathrm{LP}_{r,c}$), physical capital ($K_{r,c}$), population density ($\mathrm{Population\ Density}_{r,c}$), human capital ($\mathrm{HC}_{r,c}$) and innovative capacity ($\mathrm{Innovation}_{r,c}$), as well as the growth rate of population between 2003 and 2015 ($\Delta \mathrm{Population}_{r,c}$), with TC and DR defined as before. The equation includes also the vector $X_{r,c}^i$ of region-specific geographic controls, namely, distance to Brussels, to capture the relative location of a region with respect to the geographic 'core' of the EU; land surface, to capture the absolute size of a region; and the latitude and longitude coordinates of the region's centroids, to capture the location of a region. The term $\pi_c$ represents a vector of country dummies, while $\varepsilon_{r,c}$ is the error term.

Two approaches have been considered in defining the institutional quality variable (Institutional Quality$_{r,c}$). First, Equation (7) has been estimated using the non-interpolated variable for institutional quality normalised in the interval $[0, 1]$, that is, the institutional quality variable constructed using data drawn from the 2013 wave of the EQGI dataset without further interpolation with the country-specific data derived from the WGI dataset.[16] Secondly, it has been estimated using the year 2003 value of the interpolated institutional quality variable defined in Equation (6) and normalised in the interval $[0, 1]$.

Equation (7) has been estimated using Two-Stage Least Squares (TSLS), with the institutional quality variable instrumented using the IV capturing precipitation variability in the growing season over the entire pre-industrialisation period 1500–1750.

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15  The robustness of the IV results reported in Tables 3 and 4 has been assessed, first, by clustering standard errors at country—rather than at regional—level in the bootstrapping procedure. The results of this exercise are presented in Tables A16 and A17 in Online Appendix. They confirm those of Tables 3 and 4. Second, we have replicated the IV estimation of the augmented version of Equation (5) including the interaction terms by considering the time-invariant, non-interpolated institutional quality variable. Specifically, we have relied on a two-way FE-IV estimator, and employed the time-invariant IV capturing precipitation variability during the growing season between 1500 and 1750. The results of this exercise are reported in Tables A18 and A19 in Online Appendix. They also confirm those presented in Tables 3 and 4.

16  The institutional quality variable corresponds to the region-specific score IQS$_{r,c}$ entering Equation (6) and normalised in the interval $[0, 1]$.

**Table 5.** TSLS estimates on long-run growth over the period 2003–2015

| Dependent variable | $\Delta LP_{r,c}$ | | | |
|---|---|---|---|---|
| Estimation method | TSLS | | | |
| Institutional quality variable | 2013 Wave | | Year 2003 | |
| | (1) | (2) | (3) | (4) |
| $\log(LP_{r,c})$ | $-0.008^{**}$ | $-0.029^{****}$ | $-0.009^{**}$ | $-0.017^{**}$ |
| | (0.004) | (0.005) | (0.004) | (0.008) |
| $\log\big[K_{r,c}/(1-K_{r,c})\big]$ | $0.005^{**}$ | $0.015^{***}$ | $0.004^{*}$ | $0.009^{*}$ |
| | (0.002) | (0.006) | (0.002) | (0.005) |
| $\log\big(\Delta Population_{r,c} + TC + DR\big)$ | $-0.014$ | $-0.024^{*}$ | $-0.013$ | $-0.020^{*}$ |
| | (0.010) | (0.012) | (0.009) | (0.011) |
| $\log(Population\ Density_{r,c})$ | $0.002^{**}$ | $0.004^{***}$ | $0.001^{**}$ | $0.002^{*}$ |
| | (0.001) | (0.001) | (0.001) | (0.001) |
| $\log\big[HC_{r,c}/(1-HC_{r,c})\big]$ | $0.004^{**}$ | $-0.048^{**}$ | $0.004^{**}$ | $-0.030^{**}$ |
| | (0.002) | (0.024) | (0.002) | (0.014) |
| $\log(Innovation_{r,c})$ | $0.000$ | $-0.012^{*}$ | $0.000$ | $-0.009$ |
| | (0.001) | (0.007) | (0.001) | (0.006) |
| Institutional Quality$_{r,c}$ | $0.037^{**}$ | $0.097$ | $0.023^{**}$ | $0.051$ |
| | (0.017) | (0.095) | (0.010) | (0.077) |
| $\log\big[K_{R,C}/(1-K_{r,c})\big]$ $\times$Institutional Quality$_{r,c}$ | – | $-0.015$ (0.018) | – | $-0.005$ (0.012) |
| $\log\big[HC_{R,c}/(1-HC_{r,c})\big]$ $\times$Institutional Quality$_{r,c}$ | – | $0.078^{*}$ (0.041) | – | $0.051^{**}$ (0.024) |
| $\log(Innovation_{r,c})$ $\times$Institutional Quality$_{r,c}$ | – | $0.026^{*}$ (0.015) | – | $0.021^{*}$ (0.012) |
| Region-specific geographic controls | Yes | Yes | Yes | Yes |
| Country FE | Yes | Yes | Yes | Yes |
| No. of regions | 248 | 248 | 248 | 248 |
| $R^2$ | 0.92 | 0.78 | 0.93 | 0.88 |
| Adjusted $R^2$ | 0.91 | 0.76 | 0.92 | 0.87 |
| Model $F$-statistic ($P$-value) | 117.13 (0.000) | 68.61 (0.000) | 117.21 (0.000) | 136.50 (0.000) |
| First-stage $F$-statistic on excluded IV ($P$-value) | | | | |
| Institutional Quality$_{r,c}$ | 14.38 (0.000) | 18.10 (0.000) | 15.71 (0.000) | 17.47 (0.000) |
| $\log\big[K_{r,c}/(1-K_{r,c})\big]$ $\times$Institutional Quality$_{r,c}$ | – | 10.25 (0.000) | – | 11.34 (0.000) |
| $\log\big[HC_{r,c}/(1-HC_{r,c})\big]$ $\times$Institutional Quality$_{r,c}$ | – | 27.61 (0.000) | – | 15.37 (0.000) |
| $\log(Innovation_{r,c})$ $\times$Institutional Quality$_{r,c}$ | – | 12.85 (0.000) | – | 12.01 (0.000) |

*Notes*: $^{*}P < 0.1$; $^{**}P < 0.05$; $^{***}P < 0.01$; $^{****}P < 0.001$. Robust standard errors in parentheses. The dependent variable captures regional growth rate between the years 2003 and 2015. The institutional quality variable included in specifications (1) and (2) is defined using the survey data drawn from the 2013 wave of the EQGI dataset without further interpolation with the country-level data drawn from the WGI dataset. The institutional quality variable included in specifications (3) and (4) is defined by interpolating the survey data drawn from the 2013 wave of the EQGI dataset with the time-varying country-level index drawn from the WGI, and refers to the year 2003. The explanatory variable for population growth is defined over the period 2003–2015. All the other explanatory variables refer to the year 2003. The set of region-specific geographic controls include: distance to Brussels; land surface; latitude and longitude of the region's centroid. The excluded IV captures regional precipitation variability in the growing season during the pre-industrialisation period 1500–1750.

**Table 6.** The mediation effect of institutional quality on physical and human capital endowments, and innovation capacity—long-run growth

| Institutional quality variable | 2013 Wave | | | Year 2003 | | |
| --- | --- | --- | --- | --- | --- | --- |
| Corresponding to specification (#) in Table 5 | (2) | | | (4) | | |
| Distribution of Institutional Quality$_{r,\,c}$ | Marginal Effects of: | | | Marginal Effects of: | | |
| | Physical capital | Human capital | Innovative capacity | Physical capital | Human capital | Innovative capacity |
| 1st percentile | 0.014*** | −0.042** | −0.010* | 0.009* | −0.022** | −0.006 |
| | (0.005) | (0.021) | (0.006) | (0.005) | (0.010) | (0.004) |
| 25th percentile | 0.008 | −0.012** | −0.000 | 0.006 | −0.000 | 0.003* |
| | (0.006) | (0.006) | (0.001) | (0.007) | (0.002) | (0.002) |
| 50th percentile | 0.006 | −0.002 | 0.003 | 0.005 | 0.010* | 0.007* |
| | (0.008) | (0.003) | (0.002) | (0.009) | (0.005) | (0.004) |
| 75th percentile | 0.005 | 0.005 | 0.005* | 0.005 | 0.015** | 0.009* |
| | (0.009) | (0.005) | (0.003) | (0.010) | (0.007) | (0.005) |
| 99th percentile | 0.000 | 0.027* | 0.012* | 0.004 | 0.021** | 0.012* |
| | (0.014) | (0.016) | (0.007) | (0.011) | (0.010) | (0.006) |

*Notes:* *P < 0.1; **P < 0.05; ***P < 0.01; ****P < 0.001. Robust standard errors in parentheses. The estimated marginal effects refer to specifications (2) and (4) in Table 5.

Table 5 displays the results of the TSLS estimation of Equation (7) and its augmented version—which adds the interaction terms between the institutional quality variable and the variables for physical capital, human capital and innovative capacity. The non-interpolated institutional quality variable is considered in specifications (1) and (2), while the 2003 value of the interpolated institutional quality variable is considered in specifications (3) and (4). The results of the first-stage *F*-statistics are higher than the cut-off value of 10, suggesting a good predictive power of the IV. The second-stage results are consistent with respect to the two operationalisation choices concerning the institutional quality variable. Looking at specifications (1) and (3), both physical and human capital are positive determinants of long-run labour productivity growth, while the variable for innovative capacity has a positive but statistically insignificant coefficient. Overall, the results confirm the positive association between institutional quality and labour productivity growth.

Table 6 complements Table 5 by presenting the estimated marginal effects of the variables for physical and human capital and innovative capacity on long-run labour productivity growth at selected levels of institutional quality. As a whole, the results concerning the long-run analysis confirm the short-run findings. On the one hand, physical capital seems to matter only in regions with low-quality institutions; on the other, improvements in institutional quality make human capital and innovative capacity positive determinants of long-run labour productivity growth.

## 5. Conclusions

Europe has been facing in recent decades an important productivity challenge. Its productivity growth has fallen below that of other areas of the world and this slowdown is affecting its capacity to compete in the broader world stage and its position at the economic and political vanguard. This productivity challenge, however, does not affect all countries and regions in Europe in the same way. Low productivity growth has been far more pervasive in countries like Italy or Greece, for reasons that range from structural factors, such as ageing or rigid labour markets, to a greater vulnerability of many of their economic sectors to international competition. Low levels of institutional quality have, however, also possibly contributed to low labour productivity. Low productivity growth has been in evidence in many of the regions with the lowest quality of institutions in Europe. Hence, poor local institutions can stunt productivity growth and become a fundamental barrier for translating local human capital and innovation potential into greater productivity.

Yet, despite the evidence of a link between weak institutions and the productivity 'puzzle', how and to what extent local institutions shape changes in productivity has been absent from most of the empirical productivity analysis. This article has addressed this gap by examining the direct and indirect role played by institutional quality in regional productivity change across regions of Europe during the period between 2003 and 2015.

The results of the analysis have shown that local institutions across Europe shape both short- and long-run changes in productivity to a considerable extent. In first place, good local institutions have enhanced productivity growth in those regions with the best institutional quality. But the effect is not only direct. The returns of physical and human capital and local innovative capacity for productivity are also greatly conditioned by local institutional quality. Good government and good local institutions can considerably enhance the impact of human capital and local innovative capacity on labour productivity growth.

Hence, institutional quality is at the heart of the productivity challenge in Europe. No solution to the low productivity growth conundrum can be achieved without a significant improvement in the quality of local and regional institutions, especially in those areas of Europe where lack of transparency and accountability, high levels of corruption or poor governance performance drag economic activity and innovation down. As we have shown, relatively marginal improvements in institutional quality can directly lift barriers to changes in productivity, as well as eliminate many of the factors that have thwarted reaping greater returns from investments in human capital and innovation in the market place. Hence, addressing the productivity challenge requires, among others, tackling the institutional problems of Europe.

## Supplementary material

Supplementary data for this paper are available at *Journal of Economic Geography*.

## Acknowledgements

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