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Institutions & the Productivity Challenge for European Regions

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Jobs & Incomes in the Dawning Era of Intelligence Robots

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DG ECFIN's Fellowship Initiative 2018-2019 "The Productivity Challenge: Jobs and Incomes in the Dawning Era of Intelligent Robots" has solicited contributions examining current and possible future productivity developments in Europe. In view of possible hysteresis effects after the crisis and in the general context of ageing populations and globalisation, the aim has been to re-examine the ongoing trends and drivers and to identify policies to tap fully the potential for inclusive productivity growth. The fellowships have been awarded to prominent scholars in the field to interact with staff in ECFIN and other Commission colleagues, and to prepare final reports on specific research questions within this general topic.

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Directorate-General for Economic and Financial Affairs

Institutions and the Productivity Challenge for European Regions

Andrés Rodríguez-Pose and Roberto Ganau

Abstract

Europe has witnessed a considerable labour productivity slowdown in recent decades. Many potential explanations have been put forward to try to address this so-called productivity 'puzzle'. However, how the quality of local institutions influences labour productivity in different parts of Europe has been, so far, overlooked by the literature. This paper addresses this gap in our knowledge by evaluating how the quality of local institutions affects changes in labour productivity at a regional level, across 248 European regions during the period between 2003 and 2015. The results indicate that institutional quality plays a crucial role in determining different regional labour productivity trajectories. This role is both direct – as improvements in institutional quality have a substantial impact on productivity growth – as well as indirect – as the returns of investments in human capital and local innovative capacity rise significantly as the quality of government increases.

JEL Classification: E24, J24, O47, R11.

Keywords: Labour productivity, institutions, institutional quality, physical capital, human capital, innovation, regions, Europe.

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CONTENTS

1. INTRODUCTION

Productivity growth in the European Union (EU) has been low and tended to declining in recent decades. It has been low relative to past performance and low relative to other areas of the world. Productivity growth in the 1960s in the EU15[1] was a healthy 4.6% per annum (Carone et al., 2006), but has been declining decade on decade since then. 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, with the exception of 1999, in emerging market economies (Draghi, 2016). The gap in productivity change between the Eurozone and emerging market economies has exceeded four percentage points in some years (Draghi, 2016).

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. By contrast, in the former EU15 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': i.e. 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 in which there has been increasing concentration of advanced economic activity in a small number of economically dynamic areas of Europe (Rosés and Wolf, 2019).

The aim of this paper is to address this gap in our knowledge about changes in productivity – defined as an output per person employed – and to develop policy recommendations for improvements in productivity at a 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 likely to widen the European regional productivity gap.

In order to do this the paper analyses the sources of regional labour productivity growth across 248 regions in 19 countries of the EU for which full datasets are available during the period 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, second, 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 results of the analysis will highlight that productivity growth across European regions is positively associated with investment in physical capital, but that the link between human capital and innovation outputs, on the one hand, and productivity growth, on the other, is far weaker that what

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

could be expected. The main reason for this is that local institutional quality strongly mediates the effects of, especially, human capital on changes in productivity. Regions with low institutional quality encounter strong barriers in translating skills and training into greater productivity in the labour market. Hence, the paper will posit that addressing long-lasting institutional bottlenecks, especially in the least developed regions of Europe, represents a key element for tackling the productivity challenge in Europe.

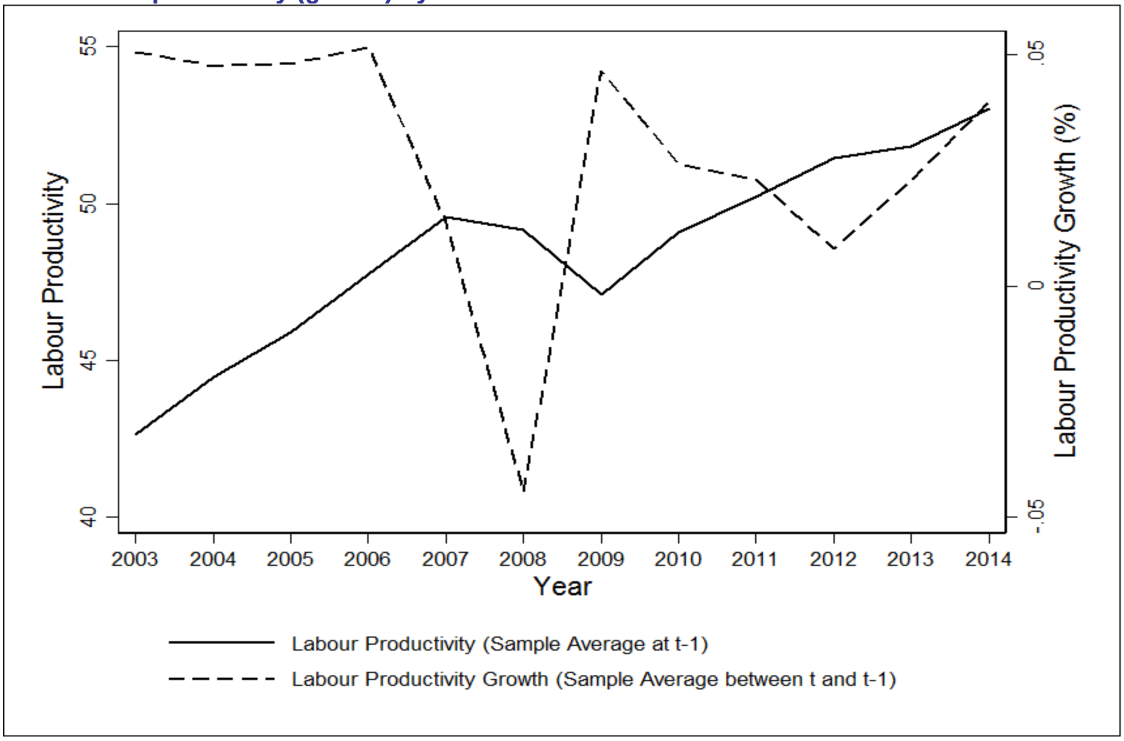
In order to reach these conclusions, the paper is structured as follows. A short description of the productivity challenge in Europe at a regional level follows this introduction. Section 3 presents the data and the modelling and the estimation approach. The empirical results are depicted in section 4. The last section presents the conclusions and some preliminary 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 increasingly 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 is generally a result of improvements in both physical and human capital, as well as greater investment and progress in innovation capacity.

Yet while Europe has witnessed non-negligible improvements in the educational achievements of its population and – with ups and downs related to the economic cycle – investment in physical capital and the innovation capacity has continued to grow, productivity has stagnated and, in many parts of the Continent, is declining (Decker et al. 2017). Especially over the last 10 to 15 years Europe has grappled with a productivity slowdown. Throughout Europe there has been a slowdown in productivity which is not a result of the Great Recession, but actually precedes it (Cette, Fernald and Mojon, 2016). In 1995 most large European economies had productivity levels that were roughly equivalent to those found in the US as a whole. France, Germany, Italy and the UK were as productive as the US. 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 US, but also to the rest of the world (Cette, Fernald and Mojon, 2016). Such decline has accelerated of recent putting Europe as a whole in a difficult position. In particular, as Figure 1 shows, since 2003 productivity growth in Europe has stagnated below 0.5% per annum. The Great Recession produced a trough in productivity growth – productivity growth in 2008 was negative – from which Europe as a whole still has to recover. The post-2008 rates of productivity growth remain lower than in pre-crisis times, at least until 2015. On the whole, during what van Ark (2016) calls 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 subdued and well below what would be needed to preserve both the competitiveness of the European economy and to maintain its social welfare model.

Figure 1. **Labour productivity (growth) dynamics.**

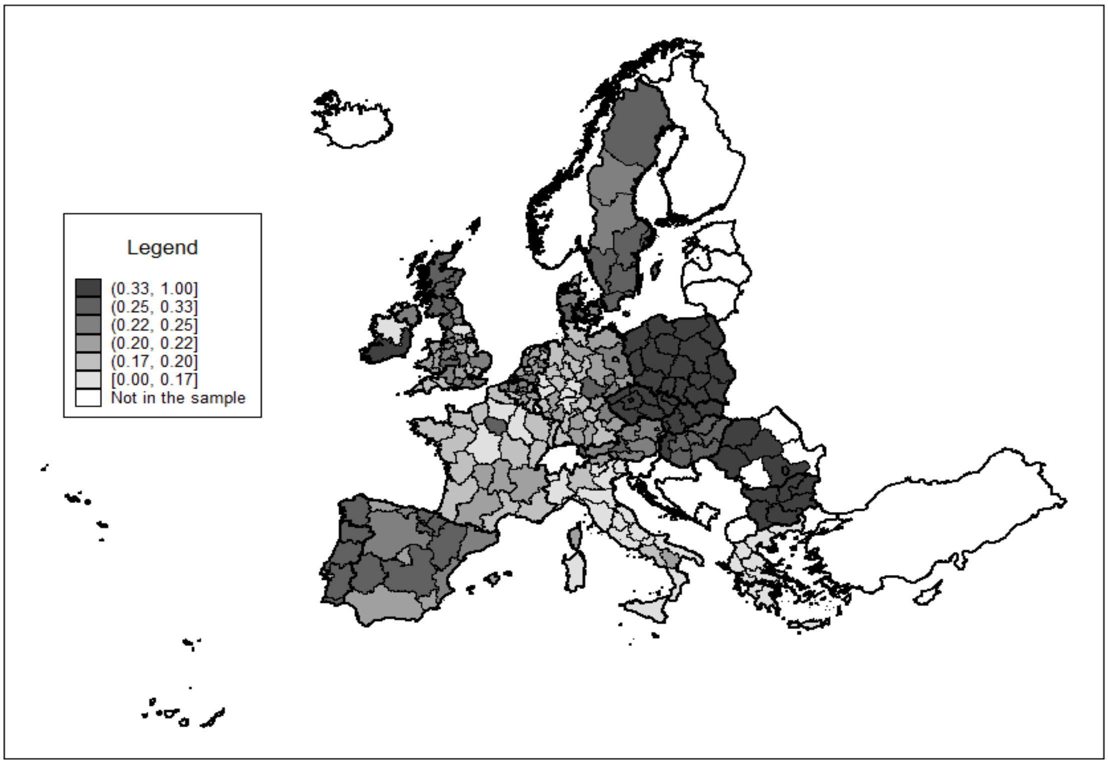


Notes: Yearly averages for 248 NUTS-2 regions in the sample, with t = 2003, ..., 2015.

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 – most located at the top 5% of the distribution (Andrews et al., 2016). And as R&D expenditure projects are larger – the top 10% of Scoreboard firms concentrate 71% of R&D expenditure (Veugelers, 2018) – the 'new digital economy' means that productivity changes are ever more the privilege of a number of superstar firms (Veugelers, 2018)

However, the rise in labour productivity inequality is not limited to firm size and technological component. It also has a profound geographical dimension. Figure 2 maps the spatial dynamics of labour productivity growth across regions in Europe. The map shows the existence of three groups of regions according to their labour productivity trajectories between 2003 and 2015. The fastest productivity growth has been concentrated in eastern European regions as well as in Denmark and Sweden. 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. The panorama was slightly more mixed in Denmark, Hungary and Sweden. Similar productivity growth rates were also the norm in eastern and southern Ireland and most of Portugal. The second group includes most regions in the 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. A third, intermediate group included most regions in Austria, the Benelux, Spain and the United Kingdom, which experienced, on average, moderate productivity growth. However, within this group differences in in productivity growth were high between low (e.g. North Yorkshire and Asturias) and high performers (e.g. Aberdeenshire and the Basque Country).

Figure 2. **Spatial distribution of yearly labour productivity growth over the 2003-2015 period**



Notes: Time averages over the 2003-2015 period. Values are standardised in the interval [0,1]. Darker areas denote higher values of the index.

What determines these differences in productivity growth across regions of Europe? Much research has been conducted on trying to solve this productivity 'puzzle' (e.g. Barnett et al., 2014). Traditional analyses have delved into the basic factors behind productivity in order to explain why productivity has stagnated badly in some areas of Europe or some economic sectors, while in others productivity change has remained relatively healthy. Pessoa and Van Reenen (2014), for example, when studying the productivity slowdown in the UK, have focused on issues related to wage flexibility and the underutilisation of resources, while a decline in intangible and telecoms investment and low total factor productivity growth are the main culprits for Goodridge et al. (2013). Low capital investment in 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.

This focus on physical and human capital and innovation to explain that slowdown in productivity is logical. After all, technology, knowledge, and efficient knowledge are the key components behind changes in productivity (Acemoglu, 2012) And it is true that differences in human capital endowment between Italy – with one of the lowest level of formal skills among the adult population in the EU – and most of the rest of Europe can help explain Italy's productivity growth slowdown. The same would apply to 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. Local institutions create the conditions and incentives that reduce transaction costs and make the development of economic activity more viable (Rodríguez-Pose, 2013). Institutions are also 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 the building of trust among different economic actors (Putnam, 1994). Good institutions also facilitate innovation at all levels, as they contribute to create 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 greater 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 subnational level. 73% of public investment in the OECD, for example, is carried out by subnational tiers of government (Hulbert and Vammalle, 2014). The regional scale is also one where, often, the cohesiveness and accountability of economic actors tends to be greater, as existing social capital facilitates collaboration and networking (Laursen et al., 2012; Huggins et al., 2012).

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 very limited attention. This paper 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. DATA AND MODELLING

The empirical analysis aims at investigating the determinant of the recent labour productivity dynamics at a regional level in the EU regions. As indicated in the previous section, two interrelated dimensions are covered. First, we examine the role that capital investments, skills, innovation, and institutional factors play in directly influencing regional productivity growth. Second, we zoom into whether and how institutional quality across the different regions of Europe becomes a productivity-enhancing force − or as 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 in the analysis is derived from the standard neoclassical Solow-Swan growth model (Solow, 1956; Swan, 1956), which specifies regional productivity according to the following production function:

$$LP_{r,t} = f(A_{r,t}, K_{r,t}, H_{r,t}, L_{r,t}) \quad (1)$$

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

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 – i.e. 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 linear function of productive efficiency and institutional quality as follows:

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

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

$$LP_{r,t} = K_{r,t}^{\alpha} H_{r,t}^{\beta} (I_{r,t} T_{r,t} L_{r,t})^{1-\alpha-\beta} \quad (3)$$

where the term $I_{r,t}$ denotes the institutional factor, and the term $T_{r,t}$ reflects companies' productive efficiency. Under the assumption that EU 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, we adopt the following structural equation for a region's long-run output per capita levels:

$$\log(LP_{r,t}) = \log(T_{r,0}) + \log(I_{r,0}) - \frac{\alpha+\beta}{1-\alpha-\beta}\log(n_{r,t}+g+\delta) + \frac{\alpha}{1-\alpha-\beta}\log(s_{r,t}^{k}) + \frac{\beta}{1-\alpha-\beta}\log(s_{r,t}^{h}) \quad (4)$$

where $LP_{r,t}$ 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 δ the depreciation rate. The model predicts higher productivity levels in territories with higher levels of investments, human capital, technological progress, and better institutional conditions.

By developing the previous theoretical model empirically, and disentangling the investments component in physical capital and investments leading to innovations, the following empirical labour productivity growth equation is specified:

$$\Delta LP_{r,t} = \beta\log(LP_{r,t-1}) + \gamma\log[K_{r,t-1}/(1-K_{r,t-1})] + \delta\log(\Delta Population_{r,t-1} + TC + DR) + \zeta\log[HC_{r,t-1}/(1-HC_{r,t-1})] + \theta\log(Innovation_{r,t-1}) + \vartheta\text{Institutional Quality}_{\text{r,t}-1} + \nu_r + \xi_t + \varepsilon_{r,t} \quad (5)$$

where $\Delta LP_{r,t} = \log(LP_{r,t}) - \log(LP_{r,t-1})$ represents the annual regional labour productivity growth, with labour productivity ($LP_{r,t}$) defined as Gross Value Added (GVA) over employment, the regional observational unit $r = 1, \dots, 248$, 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; $K_{r,t-1}$ denotes physical capital, expressed as Gross Fixed Capital Formation (GFCF) over Gross Domestic Product (GDP); $\Delta Population_{r,t-1}$ represents population growth between times $t-1$ and $t-2$; TC technological change, which is set equal to 0.02; DR the depreciation rate, which is set equal to 0.05; $HC_{r,t-1}$ human capital, defined as the percentage of population aged 25-64 years with tertiary education; $Innovation_{r,t-1}$ representing a region's innovative capacity, defined as the number of patent applications − filed under the European Patent Office (EPO), by inventors' country of residence and priority year − per million inhabitants; and $Institutional\,Quality_{r,-1t}$ as a synthetic index, capturing the quality of regional institutions. Finally, ν_r and ξ_t are region and time fixed effects (FE), respectively; while $\varepsilon_{r,t}$denotes the error term.[2]

The key right-hand side term in Equation (5) is the variable for regional institutional quality

[2] Economic and demographic data are provided by the European Statistical Office (Eurostat). Missing values in the regional series for population, human capital and patents have been filled in by linearly interpolating country-level data.

($Institutional\ Quality_{r,-1t}$), defined using data drawn from the 2013 wave of the European Quality of Government Index (EQGI) dataset provided by the Quality of Government Institute at the University of Gothenburg. The EQGI dataset contains individual-level information derived from a citizen-based survey of the perception and experience of individuals with respect to corruption, quality and impartiality in terms of education, public health care and law enforcement (see Charron et al. (2013) and Charron et al. (2014) for details).[3]

Following the approach proposed by Charron et al. (2014: 83), and largely employed in the empirical literature analysing the regional dimension of institutions in the EU (e.g. Rodríguez-Pose and Di Cataldo, 2015; Crescenzi et al., 2016; Ketterer and Rodríguez-Pose, 2018), the survey questions have been adapted to, and interpolated with, four of the six institutional dimensions defining the country-level Worldwide Governance Indicators (WGI) dataset developed by the World Bank, which covers the period 1996-2015 (Kaufmann et al., 2010). Specifically, the four dimensions considered are government effectiveness, rule of law, voice and accountability, and control of corruption.[4] 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. Second, it captures country-specific dimensions − e.g. legal system, immigration, trade, security − which are not considered in the survey-based data. Third, it can help overcoming 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 at al., 2014):

$$IQI_{r,t-1} \equiv IQI_{r,c,t-1}$$

$$= \overline{WGI}_{c,t-1} + \left(IQS_{r,c} - \overline{IQS}_c^w\right) \qquad (6)$$

where the term $\overline{WGI}_{c,t-1}$ denotes the average of the four considered institutional dimensions from the WGI dataset in country c at time $t-1$; $IQS_{r,c}$ represents the region-specific score derived from the corresponding four survey-based institutional dimensions; and $\overline{IQS}_c^w$ denotes the country-specific, population-weighted average of the survey-based regional score. The regional index defined in Equation (6) is subsequently standardised in the interval $[0,1]$ − from the lowest to the highest level of institutional quality − to obtain the variable depicting regional institutional quality ($Institutional\ Quality_{r,-1t}$).[5]

[3] Although the dataset used in the empirical analysis is defined at the NUTS-2 geographic level, the survey-based information collected in the EQGI dataset corresponds to regions defined at either the NUTS-2 level (Austria, Bulgaria, Czech Republic, Denmark, France, Ireland, Italy, the Netherlands, Poland, Portugal, Romania, Slovakia and Spain) or the NUTS-1 level (Belgium, Germany, Greece, Hungary, Sweden and the United Kingdom). Therefore, the same value of the regional institutional quality variable is assigned to all NUTS-2 level territories within the same NUTS-1 level territory, if information is available uniquely at the NUTS-1 level.

[4] 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.

[5] The same approach has been used to construct also the region-specific, time-varying variables for the individual institutional dimensions considered in the synthetic index of institutional quality.

Table 1. **Sample structure and representativeness**

Country	NUTS-2 Regions		Sample Representativeness
	In the Country	In the Sample	
Austria	9	9	100.00
Belgium	11	11	100.00
Bulgaria	6	6	100.00
Czech Republic	8	8	100.00
Denmark	5	5	100.00
France	22	22	100.00
Germany	38	38	100.00
Greece	13	13	100.00
Hungary	7	7	100.00
Ireland	2	2	100.00
Italy	21	21	100.00
Netherlands	12	12	100.00
Poland	16	16	100.00
Portugal	7	5	71.43
Romania	8	5	62.50
Slovakia	4	4	100.00
Spain	19	16	84.21
Sweden	8	8	100.00
United Kingdom	40	40	100.00
Total	256	248	96.88

Notes: The five French Départements d'Outre-Mer are excluded from the analysis à priori. The Portuguese regions of Azores and Madeira, the Romanian regions of Nord-Est, Sud-Est and Sud-Vest Oltenia, and the Spanish regions of Ceuta, Melilla and Canary Islands are excluded from the analysis due to data availability problems.

Table 1 presents the structure of the sample, which includes 248 NUTS-2 regions located in 19 EU countries. The sample covers 96.88% of all sub-national territories of the 19 countries considered in the analysis, and represents 95.65% of gross value added (GVA), 93.74% of employment, and 93.47% of population of the EU-28 area (Table 2).

Table 2. **Sample coverage with respect to EU-28 totals**

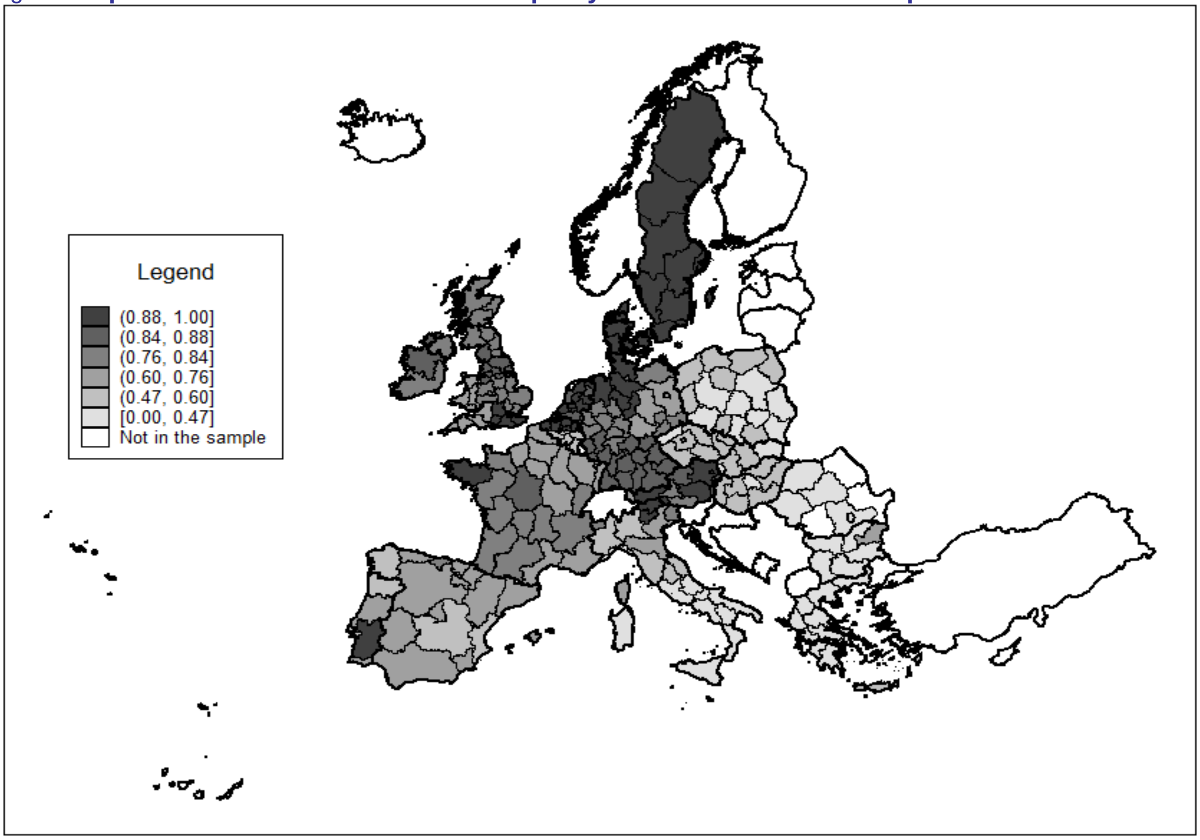
Variable	Sample Representativeness (%)
Gross Value Added	95.65
Employment	93.74
Population	93.47

Notes: Mean values over the period 2003-2015.

Table A1 in Appendix reports some descriptive statistics of the dependent and explanatory variables entering Equation (5), while Table A2 presents the correlation matrix of the explanatory variables.

Figure 3 maps the spatial distribution of the average region-level institutional quality index for the period of analysis. Considerable heterogeneity in institutional quality is in evidence both across and within countries. Across Europe regions characterised by a good institutional quality – mainly located in Scandinavia, the Netherlands, Germany and Austria – coexist with regions with very weak local institutions, fundamentally in the south eastern corner of Europe, from the south of Italy, to Greece, Bulgaria and Romania (Figure 3). In between, regions in the remaining post-2004 member states of the EU with more than one region – Czechia, Hungary, Poland, Slovakia and Slovenia – also suffer from weak institutional quality. However, the institutional conditions there are generally better than in the south eastern corner 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 and the UK) or right on the average of the sample, as in the case of Portugal and Spain.

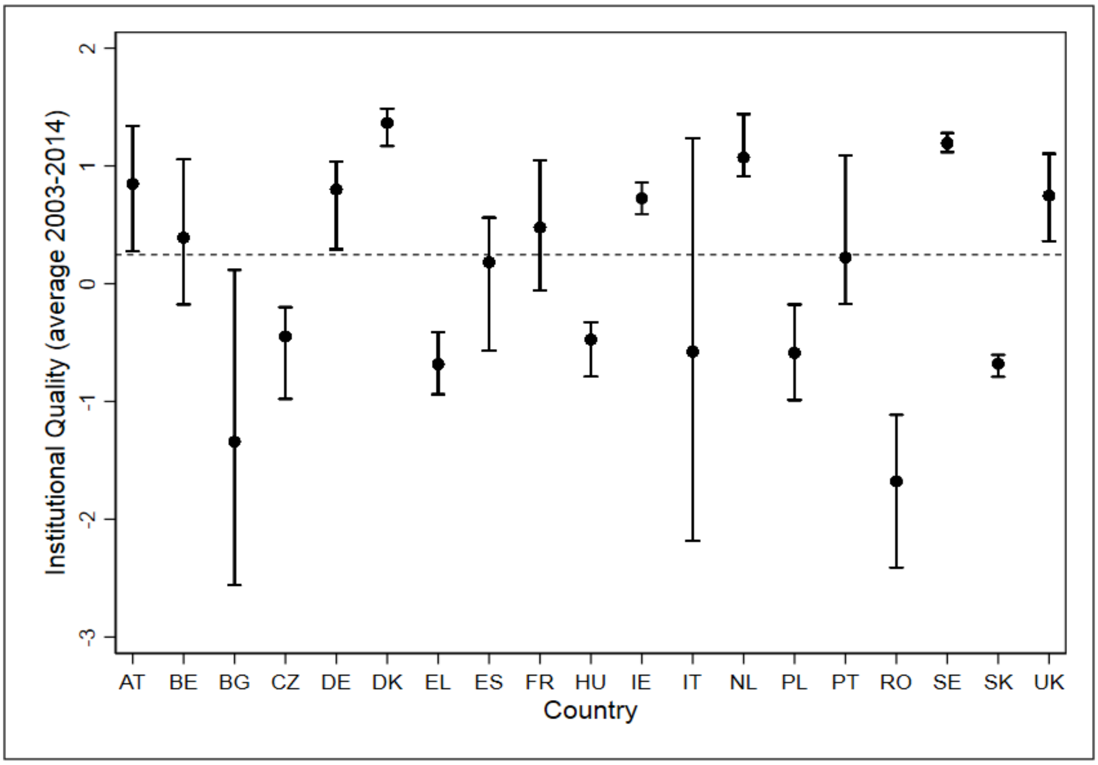
Figure 3. **Spatial distribution of the institutional quality index over the 2003-2014 period**



Notes: Time averages over the 2003-2014 period. Values are standardised in the interval [0,1]. Darker areas denote higher values of the index.

Figure 4 complements Figure 3 by plotting the within-country variability in institutional quality. Overall, 60.89% of the regions in the sample had a level of institutional quality throughout the period of analysis which was above the sample mean. In particular, the best institutional setting, according to the surveys, was found in the Danish region of Midtjylland, while the Bulgarian region of Yugozapaden had the lowest value of the institutional quality index. All regions were above the sample mean in Austria, Denmark, Germany, Ireland, the Netherlands, Sweden and the United Kingdom, while all regions were below the sample mean in Bulgaria, Czechia, Hungary, Greece, Poland, Romania and Slovakia. Looking at the remaining countries, the percentage of regions lying above the sample average value was 45.5% in Belgium, 54.6% in France, 52.4% in Italy, 40% in Spain, and 62.5% in Portugal.

Figure 4. **Within-country variability in regional institutional quality**



Notes: The non-standardised annual institutional quality index ($IQI_{r,t-1}$) is averaged over the period 2003-2014. The dashed line refers to the sample average, while the dots refer to country-level mean values.

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 estimates of Equation (5). Specifically, endogeneity can emerge in this context for several reasons, among which reverse causality − if the best performing regions are also those characterised by 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.

In order to correct for potential endogeneity, the empirical literature has suggested the instrumenting of institutional variables with historical and geographic instrumental variables (IV) (e.g. Acemoglu at al., 2001; Glaeser et al., 2004; Rodrik et al., 2004). At the European regional level, for example, Rodríguez-Pose and Di Cataldo (2015) exploit regional variations in 1880s literacy rate to instrument current institutional quality, while, in a similar context, Ketterer and Rodríguez-Pose (2018) use variables capturing periods of domination by the Roman Empire, Charles the Great, number of kingdom changes in the early Middle-Ages, and indicators of early Christianisation.

However, given the geographic width of our sample, the abovementioned identification strategies are hard to implement due to limitations in data availability. Therefore, the proposed identification strategy follows Buggle and Durante (2017), who analyse the historical and long-lasting 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 − in a period where 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 regional institutional settings which emerged in the past. In addition, the validity of the identification strategy is guaranteed by the fact that climate variability in the agriculture-based pre-industrialisation period is likely to be an exogenous force with respect to labour productivity growth in a period where economic development and growth are driven by technology advancement and industrial automation.

Following Buggle and Durante (2017), the region-specific variable capturing precipitation variability in the pre-industrialisation period is defined using reconstructed paleoclimatic data available for the period 1500-1750. Paleoclimatic data are drawn from the European Seasonal Temperature and Precipitation Reconstruction (ESTPR) database, which provides grid cells of 0.5° width, each containing yearly seasonal observations for the period 1500-2000 − see Luterbacher et al. (2004) and Pauling et al. (2006) for details.[6]

Let p denote precipitations, let s denote seasons (winter, spring, summer and 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 $t = 1500, \dots, 1750$. This leads to constructing the variable capturing precipitation variability during the growing season as follows. A season-specific inter-annual standard deviation measure is then calculated at the cell level for $p_{i,s,t}$ over all years t, 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. Finally, the region- and season-specific inter-annual standard deviation measures defined over the period 1500-1750 are averaged with respect to the growing seasons identified with spring and summer for Europe. Thus, the IV captures the mean variability during the growing season averaged over the years from 1500 to 1750, i.e. from the first available year of information to what can be considered as a starting year for the Industrial Revolution, two and a half centuries later − see Buggle and Durante (2017) for details.

The implementation of such an identification strategy leads to an estimation issue related to the fact that the structure of the dataset is a (balanced) panel, while the chosen IV is time-invariant, making a two-way FE estimation not feasible. A possible solution to this problem is represented by the Hausman-Taylor (HT) estimator (Hausman and Taylor, 1981), which allows the inclusion of time-invariant explanatory variables in the model under the assumption that only some of the explanatory variables are correlated with the region-specific effects. In fact, the HT estimator uses within transformations and individual means of both time-varying and time-invariant exogenous variables to identify the endogenous variables, while strictly exogenous variables are used to identify themselves (Baltagi, 2001; Baltagi et al., 2003). Therefore, the HT estimator is an IV estimator by itself. However, the use of an external IV based on a clear identification strategy facilitates the proper detection of the causal effect of institutional quality on labour productivity growth. Thus, a two-step IV version of the HT estimator is employed to correct for the endogeneity of the time-varying regional institutional quality variable using the time-invariant instrument capturing regional precipitation variability in the pre-industrialisation period. Specifically, a first-step equation is

[6] Although the paleoclimatic data used are available for the period 1500-2000, the IV is defined with respect to the period 1500-1750 in order to capture the pre-industrialisation nature of the effect of climate-related economic risk on the emergence of institutions.

specified having regional institutional quality as the dependent variable, and the external IV as additional exogenous explanatory variable. The second-step equation is thus specified using the estimated predicted values of institutional quality from the first-step equation in place of the "true" institutional quality variable as explanatory variable for labour productivity growth. Both steps are estimated using the HT estimator, and a bootstrapping procedure is employed to correct the standard errors.[7]

4. EMPIRICAL RESULTS

4.1. MAIN RESULTS

By conducting a two-way FE estimation of Equation (5), we examine the relationship between the endowments in physical and human capital, the level of innovation, and institutional quality in each region, on the one hand, and changes in productivity, on the other (Table 3). We also assess how institutional quality contributes to shape the returns on labour productivity of the other three factors. Columns (1) to (7) report the results related to a series of modified versions of Equation (5) aimed at testing the consistency of the explanatory variables, while column (8) refers to the complete specification, including all explanatory variables.

When focusing on column (8), 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 − although marginally significant 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, problems of overeducation 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 and innovative capacity are negligible, while overall institutional quality at a regional level is positively associated with labour productivity growth. In particular, it is estimated that a unit change in institutional quality can lead to a 19.2% increase in labour productivity growth.

Column (9) in Table 3 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. This is achieved by including interaction terms between the institutional quality variable and the variables for physical and human capital, and innovative capacity. 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.

[7] A similar approach has been employed by Rodríguez-Pose and Di Cataldo (2015).

Table 3. **Two-way FE estimates**

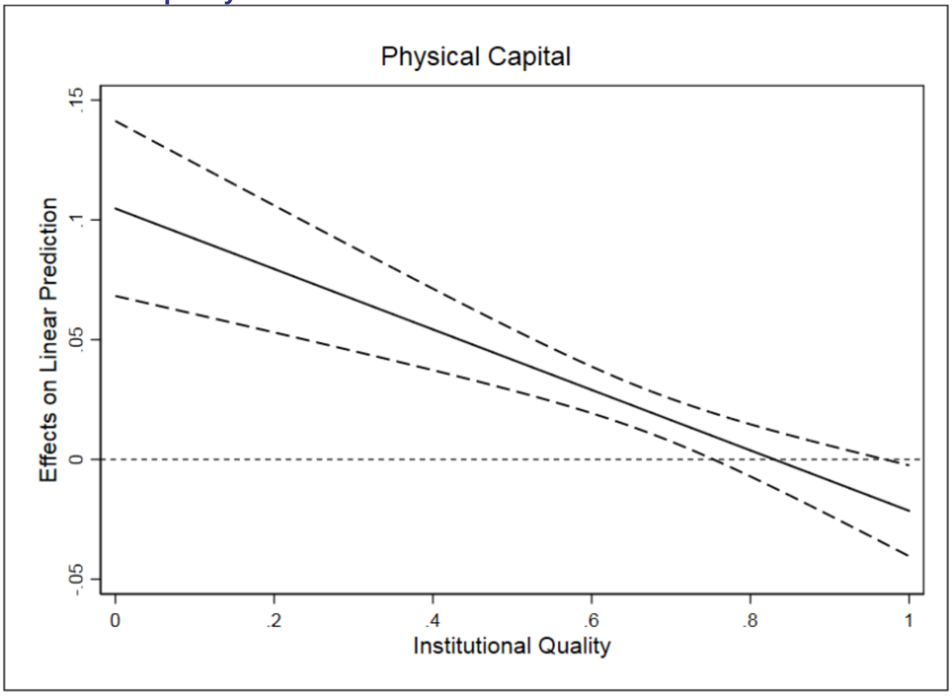
Dependent Variable	$\Delta LP_{r,t}$								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$\log(LP_{r,t-1})$	-0.215****	-0.226****	-0.225****	-0.228****	-0.247****	-0.248****	-0.248****	-0.249****	-0.236****
	(0.010)	(0.009)	(0.009)	(0.010)	(0.011)	(0.012)	(0.012)	(0.012)	(0.015)
$\log[K_{r,t-1}/(1-K_{r,t-1})]$	…	0.040****	0.040****	0.040****	…	0.031****	0.031****	0.031****	0.105****
		(0.006)	(0.006)	(0.006)		(0.005)	(0.005)	(0.005)	(0.022)
$\log(\Delta Population_{r,t-1} + TC + DR)$	…	-0.002	-0.002	-0.002	…	-0.006	-0.006	-0.005	-0.005
		(0.006)	(0.006)	(0.006)		(0.006)	(0.006)	(0.006)	(0.006)
$\log[HC_{r,t-1}/(1-HC_{r,t-1})]$	…	…	-0.016**	-0.017**	…	…	-0.014*	-0.015*	-0.061***
			(0.008)	(0.008)			(0.008)	(0.008)	(0.021)
$\log(Innovation_{r,t-1})$	…	…	…	0.002	…	…	…	0.002	-0.006
				(0.002)				(0.002)	(0.007)
$Institutional\ Quality_{r,t-1}$	…	…	…	…	0.256****	0.196****	0.194****	0.192****	0.062
					(0.039)	(0.039)	(0.038)	(0.039)	(0.074)
$\log[K_{r,t-1}/(1-K_{r,t-1})] \times Institutional\ Quality_{r,t-1}$	…	…	…	…	…	…	…	…	-0.126****
									(0.032)
$\log[HC_{r,t-1}/(1-HC_{r,t-1})] \times Institutional\ Quality_{r,t-1}$	…	…	…	…	…	…	…	…	0.072***
									(0.025)
$\log(Innovation_{r,t-1}) \times Institutional\ Quality_{r,t-1}$	…	…	…	…	…	…	…	…	0.016
									(0.010)
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	2,976	2,976	2,976	2,976	2,976	2,976	2,976	2,976	2,976
No. of Regions	248	248	248	248	248	248	248	248	248
Model F Statistic [p-value]	502.21	248.06	188.44	156.94	237.99	163.29	134.32	117.34	65.82
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Average Marginal Effect of $Institutional\ Quality_{r,t-1}$	…	…	…	…	…	…	…	…	0.202****
									(0.039)

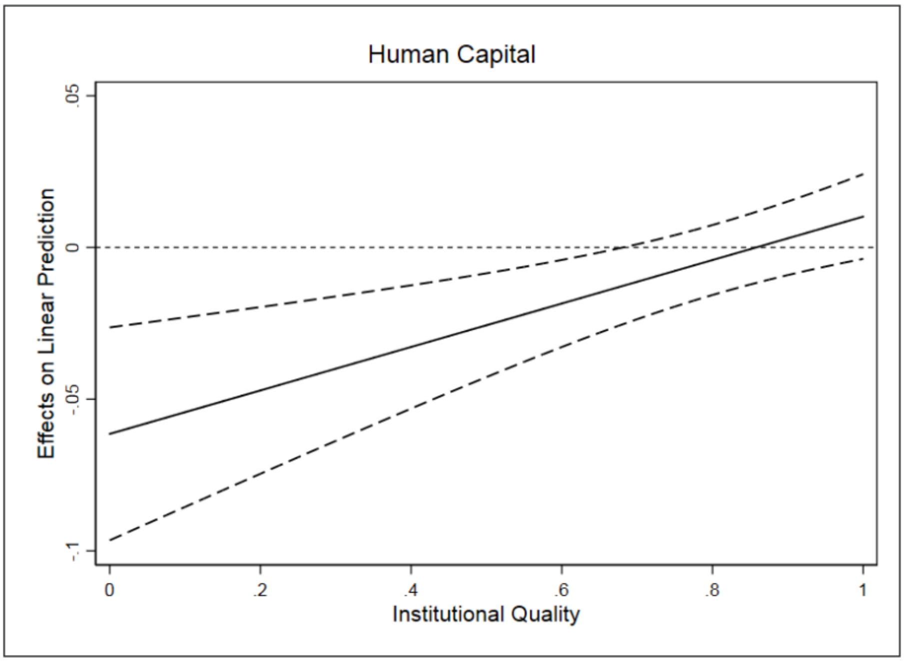
Notes: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$; **** $p < 0.001$. Robust standard errors in parentheses.

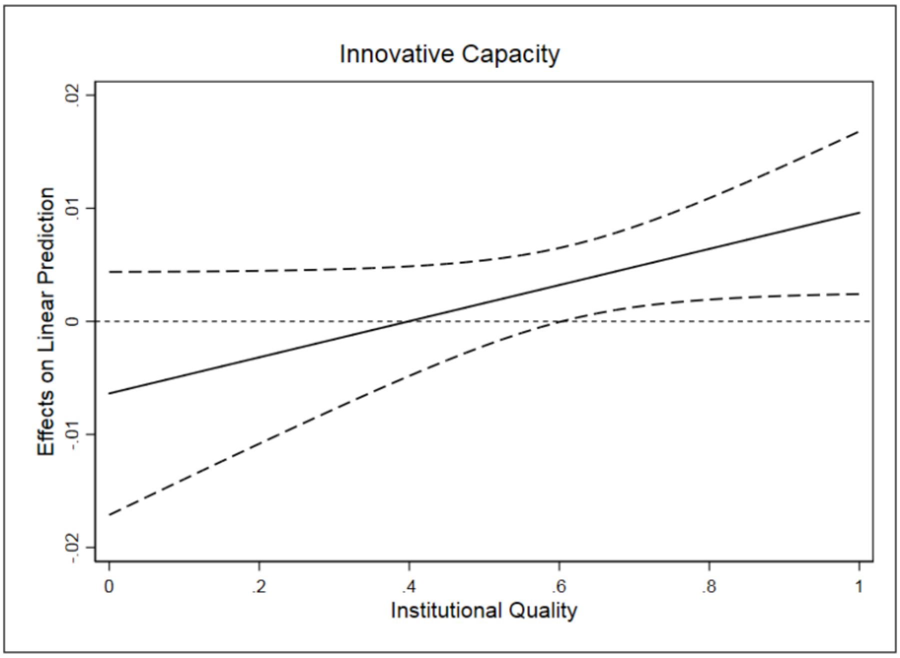
The use of interaction terms yields important results about how institutional quality shapes the impact of other factors on labour productivity. In first place, the estimated average marginal effect of the institutional quality variable − reported at the bottom right-hand corner of Table 3 − confirms the positive and statistically significant association between regional institutions and labour productivity growth. Second, the estimated effects of interacting local institutional quality with physical capital, human capital and innovative capacity, respectively, suggest that the regional quality of institutions shapes to a considerable extent the returns of these factors on labour productivity growth. These are graphically reported in Figure 5. 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 negligible for labour productivity growth (roughly for the regions in the top 20% of the institutional quality distribution). 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 it becomes negligible, but also the estimated negligible effect of innovative capacity becomes positive and statistically significant for very high levels of institutional quality (Figure 5).

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 clearly increasing the returns of human capital endowment and regional innovation capacity. Regional institutions thus emerge as a key factor behind the growth dynamics of regions in the EU and as an essential element to solve the European productivity challenge.

Figure 5. **The mediation effect of institutional quality on physical and human capital endowments, and innovation capacity**







Notes: The estimated marginal effects refer to column (9) in Table 3.

4.2. DEALING WITH ENDOGENEITY

However, as previously discussed, the estimated institutional quality-labour productivity growth relationship could to be biased by the potential endogeneity of the institutional quality variable. Therefore, the HT and the two-step IV HT estimators are employed to test the robustness of the results. Specifically, columns (1) and (2) in Table 4 report the results obtained by estimating Equation (5) and its modified version including interaction terms using the HT estimation, while columns (3) and (4) report the results obtained using the two-step procedure based on the external IV capturing the variability of precipitations during the growing season in the pre-industrialisation period 1500-1750.

The HT analysis results in column (1) fully confirm the two-way FE estimates presented in column (8) in Table 3. Furthermore, the estimated marginal effects of physical capital, human capital and innovative capacity at the different levels of institutional quality − presented in the plots of Panel A in Figure 6 − confirm those already shown in Figure 5. Since the HT estimator behaves in a similar way to that of Table 3 and provides reliable results compared to the two-way FE estimator, this implies that local institutional quality is, indeed, a crucial factor behind changes in productivity at a regional level in Europe and its effect on productivity growth is both felt in a direct and indirect manner, through its influence on the effect of physical and human capital and innovative capacity on productivity.

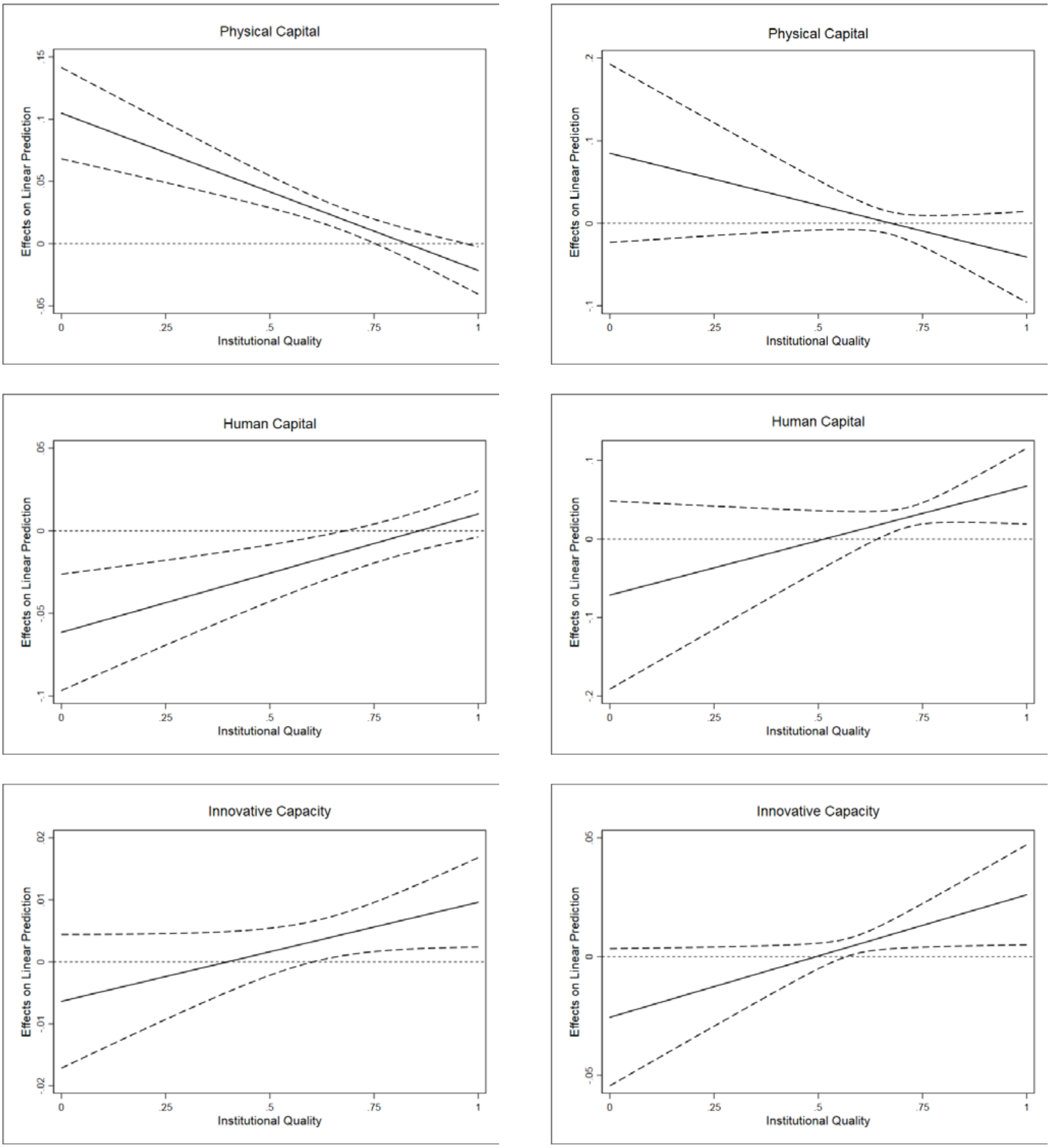
Table 4. **HT and two-step IV HT (second stage) estimates**

Dependent Variable	$\Delta LP_{r,t}$			
Estimation Method	HT		Two-step IV HT	
	(1)	(2)	(3)	(4)
$\log(LP_{r,t-1})$	-0.249****	-0.236****	-0.286****	-0.218****
	(0.012)	(0.015)	(0.022)	(0.022)
$\log[K_{r,t-1}/(1-K_{r,t-1})]$	0.031****	0.105****	0.016*	0.085
	(0.005)	(0.022)	(0.008)	(0.066)
$\log(\Delta Population_{r,t-1}+TC+DR)$	-0.005	-0.005	-0.012	-0.006
	(0.006)	(0.006)	(0.008)	(0.008)
$\log[HC_{r,t-1}/(1-HC_{r,t-1})]$	-0.015*	-0.061***	-0.012	-0.071
	(0.008)	(0.021)	(0.008)	(0.073)
$\log(Innovation_{r,t-1})$	0.002	-0.006	0.001	-0.026
	(0.002)	(0.007)	(0.002)	(0.018)
Institutional $Quality_{r,t-1}$	0.192****	0.062	0.520****	0.218
	(0.039)	(0.075)	(0.133)	(0.364)
$\log[K_{r,t-1}/(1-K_{r,t-1})]\times$ Institutional $Quality_{r,t-1}$	…	-0.126****	…	-0.125
		(0.032)		(0.098)
$\log[HC_{r,t-1}/(1-HC_{r,t-1})]\times$ Institutional $Quality_{r,t-1}$	…	0.072***	…	0.139
		(0.025)		(0.101)
$\log(Innovation_{r,t-1})\times$ Institutional $Quality_{r,t-1}$	…	0.016	…	0.052*
		(0.010)		(0.030)
Country Dummies	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes
No. of Observations	2,976	2,976	2,976	2,976
No. of Regions	248	248	248	248
Model χ^2 Statistic [p-value]	1,375.22	1,626.46	1,384.59	1,493.99
	[0.000]	[0.000]	[0.000]	[0.000]
First Stage χ^2 Statistic on IV for [p-value]:				
Institutional $Quality_{r,t-1}$	…	…	16.99 [0.000]	48.43 [0.000]
$\log[K_{r,t-1}/(1-K_{r,t-1})]\times$ Institutional $Quality_{r,t-1}$	…	…	…	58.55 [0.000]
$\log[HC_{r,t-1}/(1-HC_{r,t-1})]\times$ Institutional $Quality_{r,t-1}$	…	…	…	51.67 [0.000]
$\log(Innovation_{r,t-1})\times$ Institutional $Quality_{r,t-1}$	…	…	…	64.51 [0.000]
Average Marginal Effect of Institutional $Quality_{r,t-1}$	…	0.202****	…	0.412****
		(0.039)		(0.100)

Notes: * $p<0.1$; ** $p<0.05$; *** $p<0.01$; **** $p<0.001$. Robust standard errors in parentheses. They are bootstrapped (1,000 replications) in specifications (3) and (4), which include the predicted values of the institutional quality variable and its interaction terms obtained from the first steps of the two-step IV HT model, rather than the observed values. The excluded IV used in the first step estimations captures the variability in precipitation during the growing season over the pre-industrialisation period 1500-1750.

Figure 6. **The mediation effect of institutional quality on physical and human capital endowments, and innovation capacity**

Panel A Panel B



Notes: The estimated marginal effects presented in Panel A refer to column (2) in Table 6, while those presented in Panel B refer to column (4) in Table 4.

Moving to the two-step IV HT estimation approach, the chosen identification strategy works properly, as the test on the external IV suggests that weather-related economic risk in the pre-industrialisation period represents a good predictor of current institutional quality in EU regions. The results of column (3) display that the negative and marginally significant effect of human capital becomes negligible once the endogeneity of institutional quality is controlled for. Moreover, the estimated coefficients of the other explanatory variables broadly confirm those obtained in the previous cases. Particularly, the estimated positive effect of regional institutional quality rises, such that a unit increase in the quality of regional institutions leads to an estimated 52% increase in labour productivity growth. However, looking at the bottom of column (4), the estimated average marginal effect of institutional quality decreases to 41.2%, when its role as a mediating factor is accounted for.

In addition, the plots presenting the estimated marginal effects of physical capital, human capital and innovative capacity at different levels of institutional quality − see Panel B in Figure 6 − reveal that: a) institutional quality plays a limited role in driving the relationship between physical capital and labour productivity growth, as the estimated marginal effect of physical capital becomes negligible at all levels of institutional quality; and b) the effect of both human capital and innovative capacity on labour productivity growth is, in part, driven by institutional quality, such that their estimated effects are negative but non-significant 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 play both a positive direct effect on labour productivity growth, and a positive indirect effect by inducing positive returns of human capital and innovative capacity on productivity growth, at least in those regions which are characterised by a strong institutional environment.

4.3. FURTHER EVIDENCE

Two further analyses have been performed in order to provide a more complete picture of the forces driving the dynamics of labour productivity in EU regions. In a first instance, Equation (5) has been modified by considering the four constituent elements of the regional institutional quality index: government effectiveness, rule of law, voice and accountability, and control of corruption, replacing the overall synthetic measure. Table 5 reports the results of the two-way FE estimates obtained by analysing the institutional pillars both individually and together.

Table 5. **Two-way FE estimates on institutional pillars**

Dependent Variable	$\Delta LP_{r,t}$				
	(1)	(2)	(3)	(4)	(5)
$\log(LP_{r,t-1})$	-0.228****	-0.237****	-0.241****	-0.243****	-0.246****
	(0.011)	(0.011)	(0.012)	(0.013)	(0.014)
$\log[K_{r,t-1}/(1-K_{r,t-1})]$	0.040****	0.035****	0.033****	0.030****	0.027****
	(0.006)	(0.005)	(0.005)	(0.006)	(0.006)
$\log(\Delta Population_{r,t-1}+TC+DR)$	-0.002	-0.004	-0.006	-0.004	-0.007
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
$\log[HC_{r,t-1}/(1-HC_{r,t-1})]$	-0.017**	-0.018**	-0.015*	-0.016*	-0.016*
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
$\log(Innovation_{r,t-1})$	0.002	0.002	0.003	0.001	0.002
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
$Government\ Effectiveness_{r,t-1}$	0.002	…	…	…	-0.052**
	(0.025)				(0.025)

Rule of $Law_{r,t-1}$	…	0.138****	…	…	-0.019
		(0.039)			(0.045)
Voice and $Accountability_{r,t-1}$	…	…	0.166****	…	0.126****
			(0.028)		(0.023)
Control of $Corruption_{r,t-1}$	…	…	…	0.171****	0.154****
				(0.032)	(0.035)
Region FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
No. of Observations	2,976	2,976	2,976	2,976	2,976
No. of Regions	248	248	248	248	248
Model F Statistic [p-value]	132.75 [0.000]	126.73 [0.000]	119.43 [0.000]	108.78 [0.000]	71.28 [0.000]

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

Two key results emerge. In first place, all institutional pillars, with the exception of government effectiveness, matter for labour productivity growth when they are included individually in the regression model. In particular, the capacity of a region to control local corruption has a strong influence on changes in regional labour productivity. Second, when considered all together, government effectiveness has a negative effect on labour productivity growth, while the variables for voice and accountability and control of corruption show positive and significant coefficients. By contrast, rule of law has a positive but negligible effect on labour productivity growth. The other explanatory variables maintain the same signs and similar significance levels than in those reported in column (8) in Table (3).

Table 6. **Two-way FE estimates on institutional change**

Dependent Variable	$\Delta LP_{r,t}$					
	(1)	(2)	(3)	(4)	(5)	(6)
$\log(LP_{r,t-1})$	-0.230****	-0.224****	-0.229****	-0.228****	-0.227****	-0.225****
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
$\log[K_{r,t-1}/(1-K_{r,t-1})]$	0.038****	0.040****	0.037****	0.040****	0.040****	0.038****
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
$\log(\Delta Population_{r,t-1} + TC + DR)$	0.003	0.001	0.001	-0.001	-0.002	0.002
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
$\log[HC_{r,t-1}/(1-HC_{r,t-1})]$	-0.019**	-0.018**	-0.017**	-0.016**	-0.019**	-0.020**
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
$\log(Innovation_{r,t-1})$	0.002	0.002	0.002	0.002	0.003	0.002

	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
ΔInstitutional Quality$_{r,t}$	0.144****	...	...	...	...	...
	(0.041)					
ΔGovernment Effectiveness$_{r,t}$	...	0.037	...	...	...	0.026
		(0.026)				(0.021)
ΔRule of Law$_{r,t}$	...	...	0.181****	...	...	0.115****
			(0.030)			(0.031)
ΔVoice and Accountability$_{r,t}$	...	...	...	0.065**	...	0.051**
				(0.027)		(0.022)
ΔControl of Corruption$_{r,t}$	...	...	...	...	0.060****	0.052****
					(0.013)	(0.010)
Region FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
No. of Observations	2,976	2,976	2,976	2,976	2,976	2,976
No. of Regions	248	248	248	248	248	248
Model F Statistic [p-value]	140.44 [0.000]	135.17 [0.000]	126.73 [0.000]	129.36 [0.000]	129.65 [0.000]	90.23 [0.000]

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

The second additional analysis considers annual changes in − rather than levels of − institutional quality and its four components. 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 6 tend to confirm the previous findings: a) changes in institutional quality are positively associated with changes in labour productivity; b) the changes in all institutional dimensions but government effectiveness are positively connected to labour productivity growth − this is the case when the four institutional pillars are considered both individually and together in the regression model; and c) the other explanatory variables maintain the same signs and similar significance levels than in the previous exercises. In brief, when considering improvements in institutional quality, those regions in Europe that managed to improve local institutions the most, experienced the greatest rises in productivity.

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. The problem of 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 has, 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 government institutions in Europe. Hence, poor local institutions can stunt productivity growth and also become a fundamental barrier for translating local human capital and innovation potential into greater productivity.

Yet, despite the evidence that poor institutions seem to be associated with 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 paper has tried to address this gap in our knowledge by examining the direct and indirect role played by institutions in regional productivity change across regions of Europe during the period between 2003 and 2015.

The results of analysis have shown that local government institutions across Europe have shaped changes in productivity to a considerable extent. In first place, good local institutions have enhanced productivity growth in those regions of Europe with the best institutional quality. A unit change in local institutional quality can lead to, depending on measurements, between an improvement of one fifth and one half in productivity. 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.

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.

REFERENCES

Acemoglu, D. (2012). Introduction to economic growth. *Journal of Economic Theory*, *147*(2), 545-550.

Acemoglu D., Johnson S. and Robinson J. A. (2001) The colonial origins of comparative development: An empirical investigation, *American Economic Review* 91(5), 1369–1401.

Andrews, D., Criscuolo, C. and Gal, P. (2016) The Best versus the Rest: The Global Productivity Slowdown, Divergence across Firms and the Role of Public Policy", *OECD Productivity Working Papers*, No. 5, OECD Publishing, Paris, https://doi.org/10.1787/63629cc9-en.

Baltagi B.H. (2001) *Econometric analysis of panel data*. Wiley and Sons Ltd: New York, NY.

Baltagi B.H., Bresson G. and Pirotte A. (2003) Fixed effects, random effects or Hausman-Taylor? A pretest estimator, *Economics Letters* 79(3), 361–369.

Barnett, A., Batten, S., Chiu, A., Franklin, J., & Sebastia-Barriel, M. (2014). The UK productivity puzzle. *Bank of England Quarterly Bulletin*, Q2.

Bijsterbosch, M., & Kolasa, M. (2010). FDI and productivity convergence in Central and Eastern Europe: an industry-level investigation. *Review of World Economics*, *145*(4), 689-712.

Buggle J. and Durante R. (2017) Climate risk, cooperation, and the co-evolution of culture and institutions, Centre for Economic Policy Research (CEPR), Discussion Paper 25243-1507990110.

Calligaris, S., Del Gatto, M., Hassan, F., Ottaviano, G. I., & Schivardi, F. (2018). The productivity puzzle and misallocation: an Italian perspective. *Economic Policy*, *33*(96), 635-684.

Carone, G., Denis, C., McMorrow, K., Mourre, G., and Röger, W. (2006). Long-term labour productivity and GDP projections for the EU25 Member States: a production function framework. The European Economy, nº 253. Brussels: European Commission Economic Papers.

Cette, G., Fernald, J., & Mojon, B. (2016). The pre-Great Recession slowdown in productivity. *European Economic Review*, *88*, 3-20.

Charron N., Dijkstra L. and Lapuente V. (2014) Regional governance matters: Quality of government within European Union member states, *Regional Studies* 48(1), 68−90.

Charron N., Lapuente V. and Rothstein B. (2013) *Quality of government and corruption from a European perspective: A comparative study of good governance in EU regions*. Edward Elgar Publishing: Cheltenham.

Crescenzi R., Di Cataldo M. and Rodríguez-Pose A. (2016) Government quality and the economic returns of transport infrastructure investment in European regions, *Journal of Regional Science* 56(4), 555–582.

Draghi, M. (2017) The productivity challenge for Europe. Lectio magistralis marking the 100th anniversary of the Deusto Business School, Madrid, 30 November 2016. https://www.ecb.europa.eu/press/key/date/2016/html/sp161130_1.en.html

Decker, R. A., Haltiwanger, J., Jarmin, R. S., & Miranda, J. (2017). Declining dynamism, allocative efficiency, and the productivity slowdown. *American Economic Review*, *107*(5), 322-26.

Glaeser E.L., La Porta R., López-de-Silanes F. and Shleifer A. (2004) Do institutions cause growth?, *Journal of Economic Growth* 9(3), 271–303.

Goodridge, P., Haskel, J., & Wallis, G. (2013). Can intangible investment explain the UK productivity puzzle?. *National Institute Economic Review*, *224*(1), R48-R58.

Goodridge, P., Haskel, J., & Wallis, G. (2018). Accounting for the UK productivity puzzle: a decomposition and predictions. *Economica*, *85*(339), 581-605.

Gopinath, G., Kalemli-Özcan, Ş., Karabarbounis, L., & Villegas-Sanchez, C. (2017). Capital allocation and productivity in South Europe. *The Quarterly Journal of Economics*, *132*(4), 1915-1967.

Hausman, J.A. and Taylor, W.E. (1981) Panel data and unobservable individual effects, *Econometrica* 49(6), 1377–1398.

Huggins, R., Johnston, A., & Thompson, P. (2012). Network capital, social capital and knowledge flow: how the nature of inter-organizational networks impacts on innovation. *Industry and Innovation*, *19*(3), 203-232.

Hulbert, C. and Vammalle, C. (2014) A Sub-national Perspective on Financing Investment for Growth I – Measuring Fiscal Space for Public Investment: Influences, Evolution and Perspectives", *OECD Regional Development Working Papers*, No. 2014/02, OECD Publishing, Paris, https://doi.org/10.1787/5jz5j1qk8fhg-en.

Iammarino, S., & Jona-Lasinio, C. (2015). ICT production and labour productivity in the Italian regions. *European Urban and Regional Studies*, *22*(2), 218-237.

Kaufmann D., Kraay A. and Mastruzzi M. (2010) The Worldwide Governance Indicators: Methodology and analytical issues, Policy Research Working Paper No. 5430, World Bank, Washington, DC.

Ketterer T.D. and Rodríguez-Pose A. (2018) Institutions vs. "first-nature" geography: What drives economic growth in Europe's regions?, *Papers in Regional Science* 97(S1), S25–S62.

Laursen, K., Masciarelli, F., & Prencipe, A. (2012). Regions matter: how localized social capital affects innovation and external knowledge acquisition. *Organization Science*, *23*(1), 177-193.

Leuven, E., & Oosterbeek, H. (2011). Overeducation and mismatch in the labor market. In *Handbook of the Economics of Education* (Vol. 4, pp. 283-326). Elsevier.

Luterbacher J., Dietrich D., Xoplaki E., Grosjean M. and Wanner H. (2004) European seasonal and annual temperature variability, trends, and extremes since 1500, *Science* 303(5663), 1499–1503.

Mankiw N.G., Romer D. and Weil D.N. (1992) A contribution to the empirics of economic growth, *Quarterly Journal of Economics* 107(2), 407–437.

Marrocu, E., Paci, R., & Usai, S. (2013). Productivity growth in the old and new Europe: the role of agglomeration externalities. *Journal of Regional Science*, *53*(3), 418-442.

Mokyr, J. (2009). Intellectual property rights, the industrial revolution, and the beginnings of modern economic growth. *American Economic Review*, *99*(2), 349-55.

Mokyr, J. (2010). The contribution of economic history to the study of innovation and technical change: 1750–1914. In *Handbook of the Economics of Innovation* (Vol. 1, pp. 11-50). North-Holland.

North D.C. (1990) *Institutions, institutional change and economic performance*. Cambridge University Press: New York, NY.

North, D.C. (1991). Institutions. *Journal of Economic Perspectives*, *5*(1), 97-112.

Pauling A., Luterbacher J., Casty C. and Wnner H. (2006) Five hundred years of gridded high-resolution precipitation reconstructions over Europe and the connection to large-scale circulation, *Climate Dynamics* 26(4), 387–405.

Pessoa, J.P., & Van Reenen, J. (2014). The UK productivity and jobs puzzle: does the answer lie in wage flexibility? *The Economic Journal*, *124*(576), 433-452.

Putnam, R. D., Leonardi, R., & Nanetti, R. Y. (1994). *Making democracy work: Civic traditions in modern Italy*. Princeton: Princeton University Press.

Rodríguez-Pose, A. (2013). Do institutions matter for regional development?. *Regional Studies*, *47*(7), 1034-1047.

Rodríguez-Pose A. and Di Cataldo M. (2015) Quality of government and innovative performance in the regions of Europe, *Journal of Economic Geography* 15(4), 673–706.

Rodríguez-Pose, A., & Vilalta-Bufí, M. (2005). Education, migration, and job satisfaction: the regional returns of human capital in the EU. *Journal of Economic Geography*, *5*(5), 545-566.

Rodrik D., Subramanian A. and Trebbi F. (2004) Institutions rule: The primacy of institutions over geography and integration in economic development, *Journal of Economic Growth* 9(2), 131–165.

Rosés, J.R., & Wolf, N. (Eds.). (2018). *The economic development of Europe's regions: A quantitative history since 1900*. London: Routledge.

Solow R.M. (1956) A contribution to the theory of economic growth, *The Quarterly Journal of Economics* 70(1), 65–94.

Swan T.W. (1956) Economic growth and capital accumulation, *Economic Record* 32(2), 334–361.

Van Ark, B. (2016). The productivity paradox of the new digital economy. *International Productivity Monitor*, 31, 3-18.

Veugelers, R. (2018). Are European firms falling behind in the global corporate research race?. *Policy Contribution*, *6*, 1-13.

APPENDIX

Table A1. **Descriptive statistics**

Variable		Mean	Std. Dev.	Min.	Max.
$\Delta LP_{r,t}$	overall	0.026	0.055	-0.270	0.389
	between		0.018	-0.006	0.105
	within		0.052	-0.298	0.316
$\log(LP_{r,t-1})$	overall	3.765	0.557	1.389	4.745
	between		0.546	1.797	4.585
	within		0.119	2.954	4.160
$\log[K_{r,t-1}/(1-K_{r,t-1})]$	overall	-1.303	0.305	-2.524	0.430
	between		0.247	-2.239	-0.315
	within		0.181	-2.128	-0.352
$\log(\Delta Population_{r,t-1}+TC+DR)$	overall	-2.625	0.119	-5.161	-2.069
	between		0.081	-2.969	-2.380
	within		0.087	-4.902	-2.177
$\log[HC_{r,t-1}/(1-HC_{r,t-1})]$	overall	-1.171	0.503	-2.666	0.838
	between		0.472	-2.337	0.177
	within		0.177	-2.529	-0.280
$\log(Innovation_{r,t-1})$	overall	3.734	1.684	-4.028	7.646
	between		1.634	-0.897	6.469
	within		0.420	0.549	7.038
$\text{Institutional Quality}_{r,t-1}$	overall	0.691	0.204	0.000	1.000
	between		0.202	0.004	0.995
	within		0.029	0.596	0.803
$\text{Government Effectiveness}_{r,t-1}$	overall	0.593	0.178	0.000	1.000
	between		0.175	0.003	1.000
	within		0.037	0.480	0.708
$\text{Rule of Law}_{r,t-1}$	overall	0.723	0.175	0.000	1.000
	between		0.174	0.000	0.991
	within		0.025	0.615	0.794
$\text{Voice and Accountability}_{r,t-1}$	overall	0.638	0.160	0.000	1.000
	between		0.156	0.000	1.000
	within		0.035	0.491	0.761
$\text{Control of Corruption}_{r,t-1}$	overall	0.687	0.210	0.000	1.000
	between		0.207	0.011	1.000
	within		0.037	0.574	0.782

Notes: Values refer to 248 NUTS-2 regions observed over the period 2003-2015.

Table A2. **Correlation matrix among explanatory variables**

Variable		[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]
$\log(LP_{r,t-1})$	[1]	1									
$\log[K_{r,t-1}/(1-K_{r,t-1})]$	[2]	-0.152	1								
$\log(\Delta Population_{r,t-1}+TC+DR)$	[3]	0.376	0.098	1							
$\log[HC_{r,t-1}/(1-HC_{r,t-1})]$	[4]	0.502	-0.237	0.236	1						
$\log(Innovation_{r,t-1})$	[5]	0.784	-0.132	0.217	0.489	1					
$\text{Institutional Quality}_{r,t-1}$	[6]	0.655	-0.118	0.228	0.476	0.724	1				
$\text{Government Effectiveness}_{r,t-1}$	[7]	0.586	-0.056	0.244	0.423	0.655	0.924	1			
$\text{Rule of Law}_{r,t-1}$	[8]	0.579	-0.097	0.209	0.370	0.632	0.929	0.856	1		
$\text{Voice and Accountability}_{r,t-1}$	[9]	0.415	-0.088	0.121	0.242	0.446	0.726	0.644	0.589	1	
$\text{Control of Corruption}_{r,t-1}$	[10]	0.617	-0.121	0.197	0.481	0.707	0.963	0.849	0.860	0.637	1

Notes: Values refer to 248 NUTS-2 regions observed over the period 2003-2015.

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