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Sjoerd Beugelsdijk, Mariko J. Klasing & Petros Milionis

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Regional economic development in Europe: the role of total factor productivity

Sjoerd Beugelsdijk[a], Mariko J. Klasing[b] and Petros Milionis[c]

ABSTRACT

Regional economic development in Europe: the role of total factor productivity. *Regional Studies*. This paper documents the fact that the large and persistent differences in economic development across subnational regions in European Union countries can largely be attributed to differences in total factor productivity (TFP). Applying the technique of development accounting, the paper decomposes differences in output per worker across 257 European Union regions into a component due to the local availability of production factors and a component due to TFP. As the analysis reveals, TFP differences are large even within countries, and are strongly related to economic geography and historical development paths. This suggests limited interregional diffusion of technology and of efficient production practices.

KEYWORDS

regional economic development; total factor productivity; development accounting; European regions

摘要

欧洲的区域经济发展：全要素生产力的角色。*Regional Studies*. 本文纪录欧盟横跨次国家区域的经济发展中，广大且续存的差别可大幅归因于全要素生产力（TFP）的差别之现实。本研究运用发展会计的技术，将欧盟二百五十七座区域中工人的平均产出差异，分解为由生产要素的在地可及性所导致的因素，以及由TFP所导致的因素。本分析揭露，TFP的差异，即便在国家内部亦相当大，并与经济地理和历史发展路径强烈相关。这显示出有限的跨区域技术扩散及有效的生产实践。

关键词

区域经济发展; 全要素生产力; 发展会计; 欧洲区域

RÉSUMÉ

L'aménagement du territoire en Europe: le rôle de la productivité globale des facteurs. *Regional Studies*. Cet article démontre que les importants écarts de développement économique qui persistent à travers les régions infranationales situées dans les pays-membres de l'Union européenne s'expliquent dans une large mesure par les écarts de productivité globales des facteurs (PGF). En appliquant la méthode de la comptabilité de développement (development accounting), on décompose les écarts de rendement par travailleur selon 257 régions de l'Union européenne en une composante relative à la disponibilité locale des facteurs de production et une deuxième composante qui s'explique par la PGF. Comme laisse voir l'analyse, les écarts de PGF s'avèrent importants même au sein des pays, et se rapportent étroitement à la géographie économique et aux sentiers de développement historiques. Cela laisse supposer une diffusion interrégionale limitée de la technologie et des procédés de production efficaces.

MOTS-CLÉS

aménagement du territoire; productivité globale des facteurs; comptabilité de développement; régions européennes

CONTACT

[a] s.beugelsdijk@rug.nl
Department of Global Economics & Management, Faculty of Economics & Business, University of Groningen, Groningen, the Netherlands.
[b] m.j.klasing@rug.nl
Department of Global Economics & Management, Faculty of Economics & Business, University of Groningen, Groningen, the Netherlands.
[c] **(Corresponding author)** p.milionis@rug.nl
Department of Economics, Econometrics & Finance, Faculty of Economics & Business, University of Groningen, Groningen, the Netherlands.

ZUSAMMENFASSUNG

Regionale Wirtschaftsentwicklung in Europa: die Rolle der Gesamtfaktorproduktivität. *Regional Studies*. In diesem Beitrag dokumentieren wir die Tatsache, dass sich die umfangreichen und anhaltenden Unterschiede in der Wirtschaftsentwicklung verschiedener subnationaler Regionen der Mitgliedstaaten der Europäischen Union in großem Umfang auf Unterschiede bei der Gesamtfaktorproduktivität zurückführen lassen. Unter Anwendung der Technik der Entwicklungsbilanzierung zerlegen wir die Unterschiede bei der Leistung pro Arbeitnehmer in 257 Regionen der Europäischen Union in eine durch die lokale Verfügbarkeit von Produktionsfaktoren bedingte Komponente sowie in eine durch die Gesamtfaktorproduktivität bedingte Komponente. Aus der Analyse geht hervor, dass die Unterschiede bei der Gesamtfaktorproduktivität selbst innerhalb desselben Landes umfangreich ausfallen und in einem engen Zusammenhang mit der Wirtschaftsgeografie und den bisherigen Entwicklungspfaden stehen. Dies lässt auf eine begrenzte interregionale Diffusion von Technik und effizienten Produktionspraktiken schließen.

SCHLÜSSELWÖRTER

regionale Wirtschaftsentwicklung; Gesamtfaktorproduktivität; Entwicklungsbilanzierung; europäische Regionen

RESUMEN

Desarrollo económico regional en Europa: el papel de la productividad total de los factores. *Regional Studies*. En este artículo documentamos el hecho de que las diferencias enormes y persistentes en el desarrollo económico en las regiones subnacionales de los países de la Unión Europea pueden atribuirse en gran medida a las diferencias en la productividad total de los factores (PTF). Aplicando la técnica de la contabilidad del desarrollo, desglosamos las diferencias de rendimiento por trabajador en 257 regiones de la Unión Europea en un componente según la capacidad local de los factores de producción y un componente según la PTF. A partir del análisis podemos determinar que las diferencias en la PTF son mayores incluso dentro de un mismo país, y están estrechamente vinculadas con la geográfica económica y las rutas de desarrollo histórico. Esto indica una difusión interregional limitada de la tecnología y las prácticas de producción eficientes.

PALABRAS CLAVES

desarrollo económico regional; productividad total de los factores; contabilidad del desarrollo; regiones europeas

JEL O18, O47, O52, R10

HISTORY Received 22 September 2015; in revised form 8 May 2017

INTRODUCTION

Within-country differences in the level of economic development are large. Using data from 2005 for a large sample of subnational regions across the world, Gennaioli, La Porta, Lopez-de Silanes, and Shleifer (2013) show that the ratio of income per worker between a country's richest and poorest region is on average equal to 4.4. The same data indicate also sizeable income differences within European Union (EU) countries, which are relatively small and homogeneous, with the corresponding ratio being approximately equal to 2.2.

Starting with Barro & Sala-i-Martin (1991), Sala-i-Martin (1996), and Quah (1996), a vast literature has explored the evolution of these regional income differences over time and the extent to which they have been growing or shrinking, leading to income convergence or divergence. While this literature provides evidence of some degree of convergence taking place among groups of closely integrated regions (Bosker, 2009; Fischer & Stirboeck, 2006; Geppert & Stephan, 2008), overall, regional income disparities are very persistent. EUROSTAT data show that the ratio of incomes between a country's richest and poorest region as well as the income ranking of regions within countries have been very stable, with a correlation coefficient of around 0.93 since 2000 and of 0.84 since 1980.

A better understanding of the persistent nature of these regional economic disparities in Europe is important for two reasons. First, it is the European Commission's explicit goal to reduce economic disparities between EU regions in order to promote social cohesion (European Commission, 2010).[1] Second, contemporary EU Cohesion Policy emphasizes the role of technological progress, innovation and knowledge externalities (Barca, 2009; McCann & Ortega-Argilés, 2015), recognizing that improvements in productivity are key to enhancing regional economic performance, and that innovation and knowledge creation are critical to achieve such productivity gains.[2] Against this background, this paper explores three related research questions:

- How big are regional differences in technological sophistication and production efficiency, as captured by total factor productivity (TFP), and which regions are Europe's leaders and laggards in terms of TFP?
- What is the relative importance of differences in TFP in explaining differences in the level of economic development across EU regions?
- Which are the main factors that can account for the observed regional differences in TFP?

To address these questions, this paper uses the technique of development accounting to decompose regional differences in output per worker into a component capturing the local availability of measurable production factors and a component related to TFP. Using development accounting to assess the relative contributions of differences in production factors versus TFP across countries is standard in the growth and development literature (Caselli, 2005; Hall & Jones, 1999; Klenow & Rodríguez-Clare, 1997) and has produced important insights regarding the mechanics of economic development.[3] Yet, it has to our knowledge never been systematically applied at the regional level.

Most of the existing analyses of productivity differences at the regional level have focused on labour productivity (LP), measured simply as output per worker (Corrado, Martin, & Weeks, 2005; Esteban, 2000; Gardiner, Martin, & Tyler, 2004; Vieira, Neira, & Vázquez, 2011). This is because LP can be calculated easily from available data on output and employment. Measuring TFP, on the other hand, requires data on other inputs as well, such as physical and human capital, which are not widely available. Looking at TFP, however, has an important advantage over LP. It captures productivity conditional not only on available labour inputs but also on other factors of production. It reflects solely the efficiency with which different production inputs are utilized and combined, while LP bundles production efficiency and the availability of non-labour inputs together into one measure. TFP therefore captures better the overall sophistication of the production process. To the extent that TFP has been studied at the regional level (e.g., Capello & Lenzi, 2015; Dettori, Marrocu, & Paci, 2012; Marrocu, Paci, & Usai, 2013), it has been estimated indirectly by means of regression analyses that derive TFP as residuals from regressions of output levels on production inputs. This approach requires factor inputs and TFP to be orthogonal, an assumption which is unlikely to hold in practice due to complementarities between factor inputs and productivity. The development-accounting approach followed in this paper, in contrast, does not rely on such an assumption.

Using data from EUROSTAT and focusing on 257 NUTS-2 regions embedded in 21 of the current 28 EU countries,[4] the paper performs a development-accounting analysis for 2007. We focus on NUTS-2 regions as these are the administrative units at which most EU regional policies are targeted, and conduct the analysis based on 2007 data in order to abstract from the influences of the post-2007 financial crisis. The results of the analysis demonstrate that both across and within countries TFP differences explain most of the observed variation in output per worker. Specifically, we find that measurable factor inputs account for about 23% of the variation in output per worker. This implies that differences in technological sophistication and production efficiency account for most of the differences in regional economic development, corroborating previous work documenting the important role of TFP at the country level (Hsieh & Klenow, 2010). This percentage is only slightly higher across than within countries and is robust to modifications in the way factor inputs are measured.

Having documented that a large share of regional income differences is due to variation in TFP, the paper proceeds to explore which factors can account for this variation. For this purpose it considers a broad range of factors from the literature on economic development and regional economics, which are not already accounted for in the calculation of regional TFP levels. These are factors related to a region's physical and economic geography, its economic structure, its cultural characteristics and institutional quality, and its history. Regressing the computed regional TFP levels on all these factors, while controlling for country-specific effects, the paper finds that the observed variation in TFP can be largely attributed to regional differences in terms of economic geography and historical development paths. This pattern is robust to a battery of additional tests including alternative methods to calculate TFP and considerations of regional heterogeneity and spatial interaction across regions.

The above described findings regarding (1) the large size of TFP differences within EU countries and (2) their strong association with economic geography and historical development are new and in line with the theoretical predictions of New Economic Geography (NEG). NEG models attribute a critical role to agglomeration effects and localized knowledge spillovers in explaining growth and development patterns (Krugman, 1991, 1993). As such, this paper complements previous empirical studies that have related regional productivity advantages to the geographical concentration of economic activity (Ciccone & Hall, 1996; Henderson, Kuncoro, & Turner, 1995) and knowledge spillovers (Anselin, Varga, & Acs, 1997; Jaffe, Trajtenberg, & Henderson, 1993; Rauch, 1993). The separation between factor inputs and TFP that this paper provides, however, goes a step further by highlighting how the regional concentration of production activities spurs technological progress and gives rise to more efficient production practices that are slow to diffuse even within the same country.

Overall, the paper suggests that the spatial dimension of technology diffusion is an important factor behind the persistent development gaps across European regions. This implies that in order to promote regional economic development and reduce regional disparities, regional policy should focus on facilitating the diffusion of knowledge and best practices and support regions in specializing smartly by building on existing synergies and exploiting economies of scale (McCann & Ortega-Argilés, 2015).

The paper is structured as follows. The next section outlines the basic rationale behind the development accounting approach and describes the data on the basis of which TFP is computed. The third section discusses the obtained TFP figures and their importance in explaining regional differences in output per worker. The fourth section presents the results of the regression analyses regarding the correlates of within-country TFP differences. The final section summarizes the findings and discusses their broader implications.

DEVELOPMENT ACCOUNTING: METHODOLOGY AND DATA

Methodology

Development accounting constitutes a well-established methodology for disentangling observed differences in output levels into differences in factors of production and differences in TFP. It builds on the works of Klenow and Rodríguez-Clare (1997), Hall and Jones (1999), and Caselli (2005). It begins by postulating an aggregate production function, which, following the standard in the literature, is taken to be of the Cobb–Douglas form:

$$Y_{it} = A_{it}K_{it}^{\alpha}(h_{it}L_{it})^{1-\alpha} \quad (1)$$

where Y_{it} is aggregate output in region i in year t; K_{it} is the respective stock of physical capital; L_{it} is the employed labour force; and h_{it} is the average level of human capital of each worker. A_{it} reflects the efficiency with which the factors inputs K_{it}, h_{it} and L_{it} are used in the production process, or, in other words, TFP. α is the capital share of output, which in our baseline case is assumed to be the same in all regions and throughout all time periods. Specifically, we set $\alpha = 1/3$, the typical value assumed in the macroeconomic literature reflecting the cross-sectional and time-series evidence reported by Gollin, Parente, and Rogerson (2002). In our robustness analyses, we also explore the alternative approach of allowing for region-specific capital income shares by using a generalized translog version of equation (1) as in Inklaar and Timmer (2013). This more flexible approach permits differences in production structures across regions to be reflected in different values for α.

Rewriting equation (1) in per worker terms, the production function implies that output per worker, y_{it}, is a function of the per worker inputs of physical capital, k_{it}, and human capital, h_{it}:

$$y_{it} = A_{it}k_{it}^{\alpha}h_{it}^{1-\alpha} \quad (2)$$

We use this expression to back out the level of productivity from data on y_{it}, k_{it} and h_{it}. Based on expression (2), we can also assess how much of the regional variation in output per worker is explained by variation in the factor inputs and how much should be attributed to underlying differences in TFP. This can be done, as discussed in greater detail by Caselli (2005), by performing a standard variance decomposition and calculating the following statistic:

$$V_t^{kh} = \frac{\mathrm{Var}[\ln(y_{it}^{kh})]}{\mathrm{Var}[\ln(y_{it})]}, \quad \text{with} \quad y_{it}^{kh} = k_{it}^{\alpha}h_{it}^{1-\alpha} \quad (3)$$

Specifically, V_t^{kh} reflects the share of the observed variance in the natural logarithm of output per worker across regions that is explained solely by variation in physical and human capital. Note that this share would be equal to 1 if A_{it} were the same across all regions, and it would be strictly less than 1 as long as there is some regional variation in TFP. Thus, lower values for V_t^{kh} imply that a larger share of the observed differences in output per worker should be attributed to TFP.

Data

The data used to calculate TFP levels for regions in the EU are taken from the EUROSTAT Regional Database. The database covers regions at different levels of aggregation following the NUTS classification of the EU.[5] The present analysis focuses on 257 NUTS-2 regions in 21 EU countries, excluding small EU countries and few overseas territories.[6] To calculate TFP levels we need data on output and employment, which are readily available, and data on physical and human capital, which we construct ourselves based on the available information for investment spending and educational attainment.

Output per worker

The employed output data reflect gross value added (GVA) in each region, which excludes taxes paid or subsidies received from the government, and are based on the European System of Accounts (ESA) 2010 accounting standards. The data are adjusted for price differences across countries and over time with country-specific purchasing power standard (PPS) indices and price deflators provided by EUROSTAT.[7] This way the nominal GVA series is converted into constant 2005 PPS terms. The resulting figures are then divided by the total number of workers, including self-employed individuals, in each region. Thus, the output data used in the calculations of regional TFP levels correspond to regional purchasing-power-adjusted levels of real GVA per worker.

Physical capital per worker

To obtain estimates of regional physical capital stocks the perpetual inventory method is employed. This method allows for the construction of a capital stock series based on investment data using the formula:

$$K_{it} = I_{it} + (1 - \delta_i)K_{it-1}. \quad (4)$$

Thus, the physical capital stock, K_{it}, in region i in period t is equal to the capital investment, I_{it}, in that period plus the amount of un-depreciated capital left over from the previous period, with δ_i indicating the rate of physical capital depreciation.

Data on regional investment in terms of gross fixed capital formation are available in the EUROSTAT Regional Database for the years since 2000. These are then converted from current prices to constant prices by using the country-level price deflator of gross fixed-capital formation reported by EUROSTAT. The depreciation rate δ_i is allowed to vary across regions. Specifically, the region-specific depreciation rates employed are weighted averages of the sector-specific depreciation rates reported in the World Input–Output Database (WIOD) database (Timmer, Dietzenbacher, Los, Stehrer, & de Vries, 2015) with the weights corresponding to the average share of each region's sector in the total GVA of each region between 2000 and 2007.[8]

Beyond data on investment spending and depreciation rates, the application of the perpetual inventory formula requires also a value for the capital stock in the initial year, which in our case is 2000. Typically, in the literature this value is a guesstimate (Bernanke & Gürkaynak, 2002; Klenow & Rodríguez-Clare, 1997), which in the case of a long time-series for investment has little effect on end-of-period capital stock estimates. In our case, though, as the investment series is relatively short, the end-of-period estimate is likely to be sensitive to the initial value chosen. In light of this, we use three different approaches to pin down the value of the capital stock in 2000.

For the baseline series, K_{it}^{A}, the paper follows the approach proposed by Garofalo and Yamarik (2002) and attributes the country-level sector-specific capital stocks reported in WIOD (Timmer et al., 2015) to each region based on the share of each region's GVA in that sector in the country-wide GVA in that sector.

For the alternative series, K_{it}^{B}, we apportion the country-level capital stocks reported in Penn World Tables 8 (PWT8) (Feenstra, Inklaar, & Timmer, 2015) to each country's subnational regions based on the share of each region's average share in the GVA of the country.

For the alternative series, K_{it}^{C}, we follow Feenstra et al. (2015) and postulate for all regions a capital-output ratio of 2.6. This produces a conservative estimate for the initial differences in capital stocks across regions that ignores existing variation in capital intensities due to variation in the sectoral composition of each region. More details regarding the construction of the initial values for these three initial capital stock series are explained in Section A in the supplemental material online.

By using these three alternative values for the initial regional capital stock, we can produce three different regional capital stock series for the subsequent years. The per worker capital stocks, k_{it}^{A}, k_{it}^{B}, k_{it}^{C}, are then constructed by dividing the estimated figures for each region with the corresponding number of workers and multiplying by the country-specific price indexes for capital goods, which matches the units in which the employed output data are measured.

Human capital

To measure the average level of human capital in each region, we use information on the share of the working-age population that has attained different levels of education. The EUROSTAT Regional Database provides data on the share of the population aged 25–64 years who have attained each of the following levels in the International Standard Classification of Education (ISCED) system:

- ISCED 0–2: Pre-primary, primary, lower secondary.
- ISCED 3–4: Upper secondary, post-secondary non-tertiary.
- ISCED 5–6: First- and second-stage tertiary.

Following Barro and Lee (2013), we assume that ISCED 0–2 corresponds to six years of schooling, ISCED 3–4 to 12 years, and ISCED 5–6 to 16 years. Based on this assumption, our baseline estimate of average years of schooling for the working-age population in each region, ays_{it}^{base}, can be calculated by multiplying the population shares with the respective years of schooling attained at each level. In addition to this baseline estimate, we also make two alternative assumptions regarding the years of schooling attained. In our lower-bound estimate, ays_{it}^{low}, we assume that ISCED levels 0–2, 3–4 and 4–5 correspond to six, nine and 12 years of schooling respectively. In our upper-bound estimate, ays_{it}^{high}, we assume nine, 12 and 16 years of schooling for each of the respective ISCED education levels. Section B in the supplemental material online provides details on these assumptions and discusses robustness checks.

To convert average schooling years into human capital, we assume a standard Mincerian human capital function of the form:

$$h_{it} = e^{\varphi(ays_{it})}$$

where $\varphi(ays_{it})$ is a piecewise linear and parameterized as follows:

$$\varphi(ays_{it}) = \left\{ \begin{array}{ll} 0.134 \cdot ays_{it} & \text{if}\, ays_{it} \leq 4 \\ 0.134 \cdot 4 & \text{if} \;\; 4 < ays_{it} \leq 8 \\ \quad + 0.101(ays_{it} - 4) & \\ 0.134 \cdot 4 + 0.101 \cdot 4 & \text{if}\, ays_{it} > 4 \\ \quad + 0.068(ays_{it} - 8) & \end{array} \right\}.$$

The assumed values for the returns to schooling follow the earlier development-accounting exercises of Hall and Jones (1999) and Caselli (2005) and are in line with the microeconomic evidence summarized by Psacharopoulos (1994). They are also identical to the values used in the PWT8 to convert years of schooling into human capital. Thus, our human capital estimates are comparable with the country-level estimates reported in the PWT8. In accordance with the three sets of figures for ays_{it}, we derive three sets of figures for the average level of human capital per region: the baseline estimate, h_{it}^{base}, and the two alternatives, h_{it}^{low} and h_{it}^{high}.

TFP DIFFERENCES ACROSS EUROPEAN REGIONS

Based on the above-described figures for regional output per worker, physical capital per worker and human capital per worker, we compute TFP scores for our sample of 257 NUTS-2 regions. For the purpose of comparison, we also calculate TFP scores for the 21 countries in which these 257 regions are nested. Given the three different physical capital and alternative human capital stocks series and the possibility to allow for region-specific capital elasticities α, we construct six different TFP estimates. Our baseline TFP estimate, A_1, is computed from equation (2) based on a fixed $\alpha = 1/3$ and using the physical capital stock estimate k_{it}^{A}, and the human capital estimate h_{it}^{base}. The second estimate, A_2, uses the same physical and human capital stock estimates but employs a translog production function with region-specific values for α instead. The region-specific capital elasticities, α, are based on the industry-specific ratios of non-labour income to output taken from the WIOD. Series A_3 and A_4 use the two alternative physical capital

Table 1. Summary statistics, total factor productivity (TFP) estimates.

Sample: 257 European Union regions (NUTS-2)						
	Observations	**Mean**	**SD**	**Minimum**	**Maximum**	**Correlation with A1**
A1, Baseline TFP estimate	257	0.998	0.200	0.461	2.517	
A2, Alternative TFP estimate with varying α	257	0.999	0.187	0.506	2.416	0.999
A3, Alternative TFP estimate with k^{B}	257	0.993	0.206	0.452	2.572	0.977
A4, Alternative TFP estimate with k^{C}	257	0.983	0.199	0.454	2.512	0.980
A5, Alternative TFP estimate with h^{low}	257	1.000	0.204	0.466	2.573	0.996
A6, Alternative TFP estimate with h^{high}	257	1.000	0.202	0.468	2.548	0.996

stocks series respectively in combination with the baseline human capital estimate, h_{it}^{base}, and $\alpha = 1/3$. Series A_5 and A_6 are also based on a fixed value for α, but employ the two alternative human capital stocks series in combination with our baseline estimate for physical capital, k_{it}^{A}.

Basic summary statistics for all six TFP estimates are reported in Table 1. To facilitate interpretation of the TFP scores, we report values relative to the EU average. As Table 1, indicates the estimates in all six cases are similar in terms of magnitudes and highly correlated with each other. The reported standard deviations (SD) of around 0.2 also reveal a high degree of dispersion in TFP.

To visualize the differences in TFP across EU regions, Figure 1 maps the distribution of the baseline TFP scores. It shows high TFP values for core Western European regions, particularly those along the London–Amsterdam–Munich–Milan corridor, with Inner London recording the highest value.[9] Low TFP values are observed in most peripheral Eastern European regions, with regions in Bulgaria and Romania dominating the bottom of the distribution.

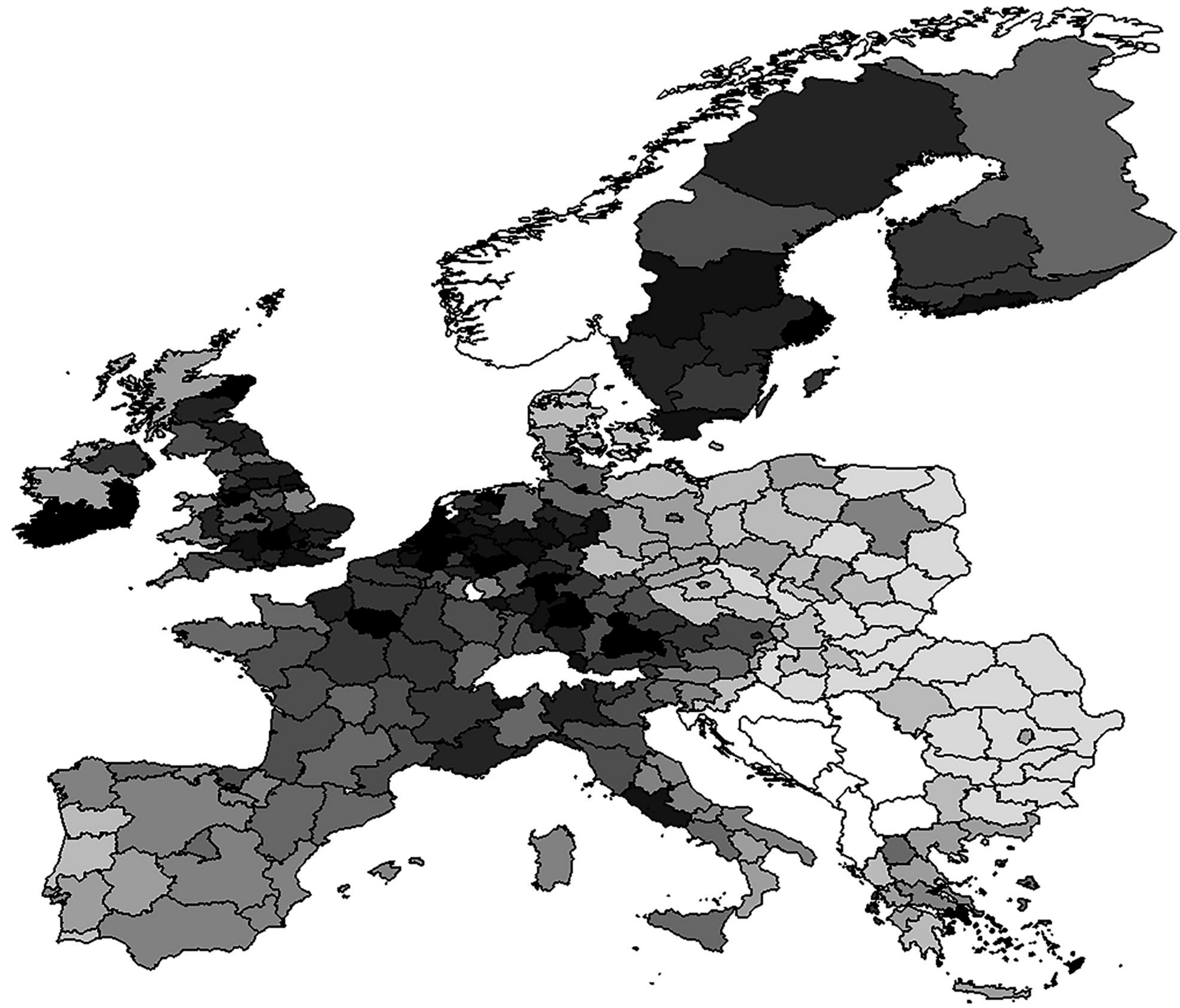

Figure 1. Baseline total factor productivity (TFP) levels (darker colours indicate higher TFP).

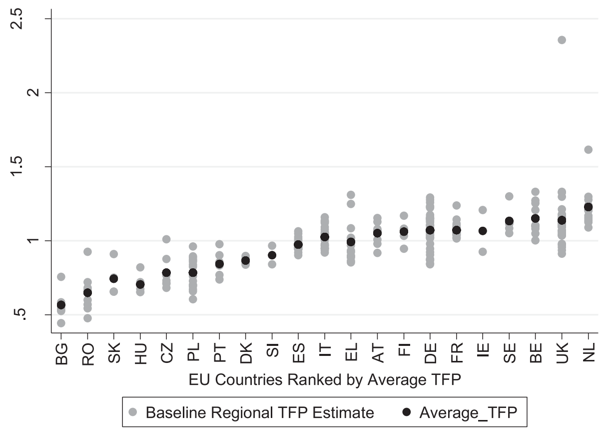

Figure 2. Total factor productivity (TFP) dispersion between and within countries.

The map also reveals substantial variation in TFP within countries. We explore the sources of this regional variation in TFP in more detail in the next section.

Figure 2 visualizes the variation in TFP within each country in a dispersion diagram. As shown there, the degree of dispersion in TFP differs substantially across countries. While in some EU countries, such as Britain and Germany, there is substantial interregional variation in TFP, in other large countries, such as France and Spain, the distribution of TFP across regions is relatively condensed.[10] Looking at Eastern European countries where TFP is on average low, we find in many of them sizeable dispersion in TFP, with the capital-city regions outperforming the rest.

To assess more carefully the relative importance of TFP in accounting for regional differences in output per worker, in Table 2 we calculate, using equation (3), V_t^{kh}, the share of the variance in output per worker that can be explained solely by the variation in factor inputs. In this context, a lower value for V_t^{kh} implies a larger role for TFP. Global country-level development-accounting studies typically find values for V_t^{kh} around 40% (Hsieh & Klenow, 2010), but these values have been shown to be lower for European countries and closer to 25% (Caselli, 2005).

Table 2 reports the V_t^{kh} for different groups of regions and based on all six TFP estimates. The first row reports that across all 257 regions the variation in output per worker explained by factor inputs is in most cases about 23%. Only when employing the translog production function and allowing for region-specific values of α do we obtain a higher ratio of about 29%.[11] This implies that the observed variation in factor inputs explain less than one-quarter of the observed variation in output per worker at the regional level. This leaves the remaining share of the variation to be attributed to TFP differences and the covariance between TFP and factor inputs.

The second row reports the variation in output per worker explained by factor inputs across countries. This ratio is found to be on average about 2 percentage points higher than the overall ratio. Production factors explain a bit more of the observed output differences across countries and the resulting shares of around 0.25 resonate well with the estimate of Caselli (2005). This similarity of our development accounting results across regions and countries give us confidence in our TFP estimates for European regions.

The next six rows report the values for V_t^{kh} for the five largest EU economies, Britain, France, Germany, Italy and Spain, as well as the average of the within-country ratios across all 21 EU countries in our sample. On average, within countries factor inputs explain about 20% of the variation in output per worker. Yet, for France and Spain we find this ratio to be substantially higher, while for Britain and Germany it is lower. This pattern mirrors the dispersion in TFP within countries presented in Figure 2.

All the above results are similar when we perform the analysis for years other than 2007 or when we exclude specific regions from the sample or merge functional regions following Annoni and Dijkstra (2013).

In summary, the variance decomposition analysis indicates that both within and between countries differences in output per worker are less the result of the local availability of production factors and more a consequence of the effectiveness with which these factors are combined in the production process. Given this importance of TFP for understanding regional differences in the level of economic development, in the following we explore which factors can explain the regional variation in TFP.

CORRELATES OF REGIONAL TFP DIFFERENCES

To understand better the sources of the large TFP differences across EU regions, we relate regional TFP levels to

Table 2. Development accounting results.

	V^{kh} for different subsamples and total factor productivity (TFP) estimates (%)					
TFP estimate	**A1**	**A2**	**A3**	**A4**	**A5**	**A6**
257 EU regions (NUTS-2)	23.11	29.02	22.11	23.18	23.26	23.65
21 EU countries	25.01	32.43	24.28	25.86	25.42	25.83
37 British regions (NUTS-2)	15.48	19.43	11.52	11.52	13.73	14.38
27 French regions (NUTS-2)	37.09	44.42	26.69	26.63	27.85	30.14
38 German regions (NUTS-2)	13.30	15.35	11.10	11.96	11.94	12.63
21 Italian regions (NUTS-2)	19.27	24.38	16.48	17.00	16.01	15.08
19 Spanish regions (NUTS-2)	47.69	53.12	37.73	38.25	30.83	32.90
Within-country average	19.63	22.80	15.77	16.38	15.71	16.65

a set of variables that have been emphasized in the literature as being important factors influencing regional economic development. This set of variables is not meant to be exhaustive, as the list of relevant regional development determinants can be potentially quite long. Instead, we focus on variables reflecting different potential sources of TFP differences in order to provide a comparative assessment of their importance for EU regions.

To assess the strength of the relationship between TFP and these variables, we estimate the following cross-sectional regression:

$$A_{ic} = \alpha + X_{ic}\beta + \theta_c + \varepsilon_{ic},$$

where the dependent variable is our measure of TFP, as calculated in the previous section, for region i in country c relative to the EU average. To control for country-specific characteristics influencing TFP, we include a set of country dummies, denoted by θ_c. All regressions are based on TFP figures and explanatory variables measured in 2007 (provided they are time varying). This is motivated by the aim of understanding the relationship between TFP and other regional characteristics in a long-run equilibrium, which arguably was disrupted by the post-2007 financial crisis. TFP data for 2007 are available for 257 regions in 21 countries, but due to missing observations on some of the explanatory variables, X_{ic}, most regressions include 251 observations.

Explanatory variables

We consider variables related to physical and economic geography, culture, institutions, history, and other structural characteristics of each region. When selecting these variables, we focus on measures that vary at the regional level and for which data are widely available, which imposes limits on the variables selection.[12] Below we briefly describe the main variables employed in the analysis. Measurement details of all variables are provided in the Data Appendix below.

- *Physical geography*: to capture the physical geography of each region we consider three key characteristics: its latitude, its access to the sea and its access to navigable rivers. These characteristics have been shown to be important for long-run economic development (Bosker & Buringh, 2017; Bosker, Buringh, & van Zanden, 2013; Gallup, Sachs, & Mellinger, 1999).
- *Economic geography*: to capture the economic geography of each region, we consider its population density, its rate of urbanization and its market potential measured by the level of gross domestic product (GDP) in the nearby regions, all three of which are sources of positive agglomeration effects (Brakman, Garretsen, & van Marrewijk, 2009; Ciccone, 2002; Redding & Venables, 2004). We also consider the average distance of each region to the country's economic centre to measure the importance of spillover effects operating from centre to periphery (Rice, Venables, & Patacchini, 2006). Furthermore, to capture knowledge-related externalities, we consider the share of workers employed in science and technology, emphasized by Anselin et al. (1997), and the social filters measure proposed by Rodríguez-Pose (1999), which reflects the innovative and learning capacity of each region.
- *Economic structure*: since TFP levels naturally vary across sectors, our analysis accounts for the economic structure of each region. Specifically, we consider the share of labour employed in agriculture as productivity in the agricultural sector tends to be lower than in the rest of the economy (Restuccia, Yang, & Zhu, 2008). We also consider the amount of oil production and reserves in each region as the presence of a large oil and gas sector may lead to overestimation of TFP as the extraction of natural resources typically involves relatively little production inputs but generates high value added (Gunton, 2003). To capture general productivity-enhancing activities, we include the number of patents filed per worker and the share of regional research and development (R&D) spending in regional GDP, both of which should be sources of positive spillover effects (Audretsch & Feldman, 1996; Jaffe et al., 1993).[13]
- *Culture*: one important mechanism through which culture may affect regional TFP is social capital. Social capital is typically measured by the level of generalized trust. As generalized trust has been shown to have a positive association with regional economic development (Beugelsdijk & van Schaik, 2005; Tabellini, 2010), our analysis employs the level of trust in each region, measured by data from the European Values Study (EVS).[14] In addition to social capital, the analysis also considers the degree of ethnic heterogeneity by including an ethnic fractionalization index, as in Gennaioli et al. (2013). This is motivated by the fact that higher diversity is generally associated with lower levels of economic development (Alesina & Zhuravskaya, 2011; Beugelsdijk & Klasing, 2017; Beugelsdijk, Klasing & Milionis, 2017).
- *Institutions*: in light of the documented regional differences in the quality of institutions (Charron, Dijkstra, & Lapuente, 2015; Rodríguez-Pose & Garcilazo, 2015), we construct a measure of the quality of governance at the regional level. We follow Becker, Egger, and von Ehrlich (2013) and use Eurobarometer survey data capturing respondents' satisfaction with local democracy and their trust in the local judicial system. This measure is by construction highly correlated with the regional quality of governance index assembled by the European Commission (Charron et al., 2015), but covers a larger number of regions. Furthermore, we consider whether a region was part of the Communist Bloc to capture the heritage of Communism in regions of Eastern Europe and parts of present-day Germany.[15]
- *History*: development outcomes have been shown to be persistent. Today's centres of economic activity may be in specific locations not because of the current optimality of these locations but because of historical path dependence (Akcomak, Webbink, & ter Weel, 2016; Bleakley & Lin, 2012; Davis & Weinstein, 2002). To account for

the legacy of history on current TFP differences, we consider each region's historical urban density in 1800 based on data from Bairoch, Batou, and Chevre (1988). We also consider for each region how many cities were historically located on the crossing of two or more Roman roads, which Bosker et al. (2013) have shown to be correlated with historical development over the past two millennia.

Table 3 shows the descriptive statistics for all these explanatory variables, as well as their correlations with our baseline TFP estimate. Several variables exhibit a strong positive correlation with TFP. The regression analysis below assesses more carefully the relative importance of these variables in explaining TFP differences across regions.

REGRESSION RESULTS

Table 4 shows the main regression results relating regional TFP levels, expressed relative to the EU average, to the aforementioned explanatory variables. Column 1 reports the estimation results of a cross-sectional regression specification including all explanatory variables. Column 2 adds country dummies to the specification. In columns 3–6 we follow a standard general-to-specific approach and iteratively eliminate from the specification variables based on their significance levels. In column 3 we drop variables with a significance level lower than 0.5; and in column 4 variables that subsequently fall in this category. Then in column 5 we proceed to eliminate variables with a significance level lower than the conventional threshold of 0.1; and in column 6 again variables that subsequently fall below that threshold.[16]

The resulting specification of column 6 highlights the main variables that are closely associated with regional variation in TFP. Specifically, we find that TFP levels are higher in regions that are closer to large markets, have a young and well-educated workforce, are more trusting, and have also historically been more urbanized On the other hand, TFP is lower in regions with a Communist history and a relatively large share of the agricultural sector.[17] These seven variables together with the country dummies explain 75% of the overall variation in regional TFP levels and 72% of the variation in TFP levels within EU countries.

To assess the relative importance of our main explanatory variables, Table 5 reports the implied effect sizes in terms of a 1 SD change in the explanatory variables, with the variables ordered by their quantitative importance. Quantitatively most important is the post-Communist dummy, with TFP being on average 22 percentage points lower in a region that was part of the former Communist Bloc. This is followed by historical urban density with an effect size on TFP relative to the EU average of 7 percentage points for a 1 SD change. This is much larger than the effect of the contemporary urbanization rate whose standardized effect is only 1.3 percentage points. Next in line are the social filters and the agricultural labour share whose implied magnitudes are slightly above and slightly below 5 percentage points respectively. A 1 SD increase in market potential is associated with an increase in relative

Table 3. Summary statistics, regressors.

Sample: 257 European Union regions (NUTS-2)	Observations	Mean	SD	Minimum	Maximum	Correlation with A1
A1, Baseline total factor productivity (TFP) estimate	251	1.000	0.201	0.444	2.357	
Latitude	251	48.517	5.687	28.353	66.439	0.254
River Access	251	1.422	1.832	0.000	14.000	0.126
Sea Border	251	0.470	0.500	0.000	1.000	0.177
Population Density	251	0.353	0.869	0.003	9.244	0.479
Urbanization Rate	251	0.356	0.283	0.000	1.585	0.291
Workers in Science & Technology	251	26.680	6.750	12.000	51.600	0.529
Market Potential	251	0.217	0.252	0.003	1.784	0.598
Distance to Economic Center	251	0.224	0.196	0.000	1.739	–0.141
Agr Labor Share	251	0.064	0.080	0.000	0.507	–0.624
Oil Production	251	0.017	0.055	0.000	0.548	–0.389
R&D Spending	249	0.014	0.012	0.001	0.067	0.438
Patents per Worker	250	0.109	0.131	0.000	0.672	0.456
Social Filters	251	0.141	1.521	–3.444	4.321	0.554
Ethnic Diversity	251	0.625	0.541	0.000	1.946	–0.343
Trust	251	0.343	0.157	0.037	0.781	0.415
Institutional Quality	251	0.298	0.576	–1.200	1.713	0.496
Post Communist	251	0.235	0.425	0.000	1.000	–0.688
Urban Density 1800	251	0.025	0.192	0.000	2.946	0.462
Roman Roads Hubs	251	0.610	1.308	0.000	9.000	0.066

Table 4. Stepwise regression results.

Dependent variable: A1, Baseline total factor productivity (TFP) estimate						
	(1)	(2)	(3)	(4)	(5)	(6)
Latitude	0.003**	0.001				
	[0.001]	[0.002]				
River Access	0.007**	0.002				
	[0.003]	[0.004]				
Sea Border	0.000	0.006				
	[0.015]	[0.013]				
Population Density	–0.012	–0.010	–0.011	–0.012		
	[0.015]	[0.012]	[0.012]	[0.012]		
Urbanization Rate	0.022	0.040*	0.045**	0.052*	0.048*	0.047*
	[0.024]	[0.021]	[0.020]	[0.026]	[0.025]	[0.026]
Workers in Science & Technology	0.005***	0.002	0.002			
	[0.002]	[0.002]	[0.002]			
Market Potential	0.141***	0.070**	0.070*	0.074**	0.079**	0.079**
	[0.038]	[0.032]	[0.035]	[0.034]	[0.028]	[0.029]
Distance to Economic Center	0.012	–0.023	–0.027	–0.028		
	[0.030]	[0.025]	[0.021]	[0.021]		
Agr Labor Share	–0.335**	–0.544**	–0.550**	–0.574**	–0.606***	–0.620***
	[0.143]	[0.251]	[0.246]	[0.219]	[0.193]	[0.189]
Oil Production	–0.171	–0.175	–0.182	–0.190		
	[0.162]	[0.133]	[0.129]	[0.135]		
R&D Spending	0.722	0.751	0.943	1.057		
	[0.681]	[0.822]	[0.714]	[0.684]		
Patents per Worker	0.011	0.045				
	[0.070]	[0.053]				
Social Filters	–0.009	0.021*	0.023*	0.028***	0.038***	0.035***
	[0.006]	[0.012]	[0.013]	[0.008]	[0.006]	[0.005]
Ethnic Diversity	–0.008	–0.005				
	[0.010]	[0.011]				
Trust	0.024	0.048*	0.051**	0.051**	0.046**	0.042*
	[0.049]	[0.024]	[0.022]	[0.022]	[0.021]	[0.020]
Institutional Quality	–0.014	–0.033	–0.034*	–0.036*	–0.037	
	[0.016]	[0.021]	[0.020]	[0.020]	[0.023]	
Post Communist	–0.265***	–0.234***	–0.241***	–0.246***	–0.252***	–0.222***
	[0.024]	[0.021]	[0.019]	[0.018]	[0.022]	[0.006]
Urban Density 1800	0.374***	0.396***	0.402***	0.405***	0.359***	0.356***
	[0.045]	[0.032]	[0.032]	[0.033]	[0.025]	[0.025]
Roman Roads Hubs	–0.010**	0.000				
	[0.004]	[0.004]				
Constant	0.733***	0.933***	0.998***	1.038***	1.044***	1.030***
	[0.089]	[0.125]	[0.078]	[0.024]	[0.024]	[0.023]
Countries	21	21	21	21	21	21
Observations	248	248	249	249	251	251
Country dummies	No	Yes	Yes	Yes	Yes	Yes
Overall adjusted R^2	0.821	0.778	0.774	0.756	0.738	0.747
Within adjusted R^2	–	0.720	0.725	0.726	0.718	0.715

Notes: Estimation with ordinary least squares (OLS). Robust standard errors clustered at the country level are shown in brackets.
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

Table 5. Magnitudes.

Based on regression specification of Table 4, column (6)			
Variables	**Coefficient**	**SD**	**Change in total factor productivity (TFP)**
Post Communist	−0.222	0.425	−9.42%
Urban Density 1800	0.356	0.192	6.84%
Social Filters	0.035	1.521	5.26%
Agr Labor Share	−0.620	0.080	−4.96%
Market Potential	0.079	0.252	2.00%
Urbanization Rate	0.047	0.283	1.33%
Trust	0.042	0.157	0.66%

TFP of 2 percentage points. Finally, trust has with 0.66 percentage points the smallest effect.

In Section C in the supplemental material online we assess the robustness of our regression results along the following lines. First, we show that the results hold also for the five alternative TFP figures. Second, we document that they are robust to changes in the sample composition and other corrections for heterogeneity across regions not captured in the main analysis, such as accounting for city-region effects and including spatial lags. Third, we show that the results also hold when employing alternatives measures of institutional quality and the innovative capacity of a region, but that the positive results for trust do not extend to alternative proxies of social capital (Beugelsdijk & Smulders, 2003; Knack & Keefer, 1997).

CONCLUSIONS

Differences in the level of economic development within EU countries are large and persistent. The aim of this paper is to shed more light on why this is the case by calculating, documenting and analysing TFP levels for 257 EU regions. To that end, we conduct, to our knowledge, the first development-accounting exercise at the subnational level to decompose regional differences in output per worker into a component reflecting the local availability of factor inputs and a component capturing differences in TFP. This exercise reveals that about 75% of the differences in regional economic development can be attributed to differences in TFP. This is similar between and within countries, suggesting that the spatial diffusion of technology and efficient production practices is limited and that the limits extend beyond national borders. TFP levels tend to be highest along the London–Amsterdam–Munich–Milan axis and lowest in peripheral regions in Eastern Europe. We furthermore document that regional differences in terms of economic geography, historical development paths and trust play a key role in explaining why some regions have higher TFP levels than others.

The finding that TFP differences are important in explaining the development gaps across European regions and that these differences are related to economic geography are broadly supportive of the extensive literature on New Economic Geography. The persistent nature of these gaps, even within the same country, and the association with historical development and culture suggest that there is a strong local dimension to technology and knowledge that needs to be better understood. This has important implications for regional development policy, which should be designed primarily with the aim to support regions (1) in building their comparative advantages in terms of technology and knowledge, (2) in specializing smartly to exploit economies of scale and (3) in building on existing synergies. These conclusions are very much in line with the current discussion on smart specialization and place-based development strategies within the EU (Barca, 2009; McCann & Ortega-Argilés, 2015). They underscore the need for EU policies to take into account available knowledge in each region and linkages across regions in order to help regions achieve their long-run development potential.

The orientation of regional development policy along these lines, of course, may not be easy. Yet, our approach of calculating, documenting and analysing TFP at the regional level could provide a useful tool for policy and provide interesting avenues for future research. The analysis could be further extended to the sectoral level and could also be used to make comparisons over time. Future research could also compare TFP levels with more disaggregate regional characteristics such as regional diversity (Frenken, van Oort, & Verburg, 2007), spatial diversification patterns (Neffke, Henning, & Boschma, 2011), and workforce mobility patterns and information on their spatial networks (Huber, 2012). Moreover, one could further explore how the spatial dimension of technology diffusion may differ depending on the innovation being embodied (i.e., new products and or services) or disembodied (i.e., superior measurement practices), and how the rents extracted from these types of innovation may have different spatial implications (Rodríguez-Pose & Crescenzi, 2008; Keller, 2004). Although disembodied innovation has long been recognized in the management literature (e.g., Beugelsdijk, 2008), its significance for TFP has only recently been acknowledged in the economic development literature (Bloom & van Reenen, 2007). Such studies could extend our analysis of regional TFP differences by exploring the microfoundations and underlying mechanisms behind the broad patterns uncovered in this paper.

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DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

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SUPPLEMENTAL DATA

Supplemental material for this article can be accessed https://dx.doi.org/10.1080/00343404.2017.1334118

NOTES

1. In fact, 35% of the EU's total budget – corresponding to €347 billion – was allocated during the 2007–13 budget period in the form of development-promoting Structural Funds to less developed regions.
2. Both the Lisbon Agenda as well as the Europe 2020 strategy goals of making Europe and its regions the most competitive world economy stress the importance of building knowledge infrastructures, enhancing innovation and promoting economic reform (European Commission, 2010; European Council, 2000).
3. This decomposition, for example, has been instrumental for the analysis of the information and communication technology (ICT) revolution (Jorgenson & Stiroh, 2000; Oliner & Sichel, 2000), the rapid growth of East Asian economies (Hsieh, 2002; Young, 1995), and the productivity gap between Europe and the United States (van Ark, O'Mahony, & Timmer, 2008).
4. NUTS = Nomenclature des Unités Territoriales Statistiques.
5. For each EU country, there is a hierarchical system of regional subdivision that proceeds from coarser to finer subnational NUTS units. In this system, NUTS-0 refers to the country as a whole, NUTS-1 refers to the coarsest level of subnational division, NUTS-2 to an intermediate level and NUTS-3 to the finest level. This system is designed such that the resulting regions at each level of aggregation are comparable in terms of population size.
6. Specifically, we exclude the six smallest EU countries (Cyprus, Estonia, Latvia, Lithuania, Luxembourg and Malta), which due to their size do not have a subnational division at the NUTS-2 level. It also excludes Croatia as well as eight overseas territories of France, Portugal and Finland due to limited data availability.
7. The information provided by EUROSTAT does not allow us to correct for price differences within countries. Yet, as noted by Acemoglu and Dell (2010) and Gennaioli et al. (2013), this should not have a major impact on the analysis.
8. The average regional depreciation rate is 6.3%, which is very close to the typical value of 6% employed in most development accounting studies (Caselli, 2005).
9. This corridor is also referred to as the 'Blue Banana', with the 'banana' describing its shape and blue alluding to the EU flag. The term was coined by geographer Roger Brunet.
10. As is evident from Figure 2, there is a big outlier in the TFP distribution which is the Inner London area. None of our results, however, is affected by this outlier observation, as we discuss in greater detail in the robustness analysis.
11. Allowing for region-specific α increases the ability of factor inputs to explain the variation in output – both across and within countries – and reduces the relative importance of TFP differences. Nevertheless, this does not alter our main conclusions regarding the relative explanatory power of factor inputs versus TFP between and within countries.
12. This is because for some arguably relevant factors we were either unable to find comprehensive data or the available data only displayed variation at the country level.
13. In Section C in the supplemental material online we also explore the role played by regional research and innovation networks. Yet, as the available data only cover a smaller set of regions, we do not consider this variable in our main analysis.
14. Following the standard in the literature, this is calculated as the share of the regional population indicating that 'most people can be trusted' (as opposed to 'you can't be too careful when dealing with people') averaged across all survey waves (1984–2008).
15. Section C in the supplemental material online also reports results using alternative institutional quality measures.
16. An alternative approach here would be to estimate repeatedly our regression specification eliminating in each round the variable with the highest p-value until all insignificant variables have been removed from the specification. Following this more cumbersome approach leads to exactly the same specification as that of column (6).
17. The dummy variable indicating post-Communist regions is highly significant and negatively related to productivity differences, even after the inclusion of country dummies. The inclusion of country dummies implies that the identification of this variable comes from the variation within Germany, with regions that were part of the former German Democratic Republic (GDR) being significantly less productive than West German regions. As regional institutional quality itself does not appear to be a significant predictor of within-country productivity differences, this implies that the post-Communist dummy variable is not picking up effects related to the current quality of institutions in these regions, but instead captures the more fundamental and long-lasting impacts of Communism.

APPENDIX: VARIABLE DESCRIPTIONS AND SOURCES

Variable	Description	Source
Gross Value Added	Gross value added (GVA) in all sectors converted into 2005 purchasing power standard (PPS) (European System of Accounts (ESA) 2010).	EUROSTAT (nama_10r_3gva)
Employment	Employment in all sectors	EUROSTAT (nama_10r_3empers)
Investment	Gross fixed capital formation converted into 2005 euros (ESA 2010 system of accounts)	EUROSTAT (nama_10r_2gfcf)
Primary and Lower Secondary Education	Share of the population aged 25–64 years with a lower secondary, primary and pre-primary education (International Standard Classification of Education (ISCED) levels 0–2)	EUROSTAT (edat_lfse_04)
Upper Secondary Education	Share of the population aged 25–64 years with an upper-secondary education (ISCED levels 3–4)	EUROSTAT (edat_lfse_04)
Tertiary Education	Share of the population aged 25–64 years with a tertiary education (ISCED levels 5–8)	EUROSTAT (edat_lfse_04)
Latitude	Degrees of latitude of the region's centroid	EUROSTAT Geodata
River Access	Number of cities in a region located by a river or a navigable waterway	Bosker et al. (2013)
Sea Border	Dummy variable for regions located on the sea. Hamburg and London are coded as 1 due to their almost direct sea access and the importance of maritime trade in these cities	Authors' own coding
Population Density	Population per area (km^2)	EUROSTAT (nama_r_e3popgdp; demo_r_d3area)
Urbanization Rate	Share of each region's population living in cities	EUROSTAT (ubr_cpop1; nama_r_e3popgdp)
Workers in Science & Technology	Scientists and engineers as a percentage of the active population	EUROSTAT (hrst_st_rcat)
Market Potential	Aggregate level of gross domestic product (GDP) within a 100-kilometre circle around the region	European Commission DG Regio
Distance to Economic Center	Areal distance between each region's largest city and the economic centre of the country	Authors' own coding using a distance calculator
Agr Labor Share	Number of persons employed in agriculture as a share of total regional employment	EUROSTAT (nama_10r_3empers)
Oil Production	Oil production and reserves in logs	Gennaioli et al. (2013)
R&D Spending	Share of total regional research and development (R&D) spending in regional GDP	EUROSTAT (rd_e_gerdreg; nama_10r_2gdp)
Patents per Worker	Patent applications per million of the active population	EUROSTAT (pat_ep_rtot)
Young	Share of the population aged 15–24 years in the total regional population	EUROSTAT (demo_r_d2jan)
Training	Percentage of the regional population that has participated in education and training in the past four weeks	EUROSTAT (trng_lfse_04)
Long-Term Unemployment	Long-term unemployment (12 months and more) as a percentage of unemployment	EUROSTAT (lfst_r_lfu2ltu)
Social Filters	First principal component of young, training, long-term unemployment and tertiary education	Following Rodríguez-Pose and Crescenzi (2008)

(*Continued*)

Continued.

Variable	Description	Source
Ethnic Diversity	Number of ethnic groups per region	Weidman, Rod, and Cederman (2010)
Trust	Share of the population saying 'most people can be trusted' as opposed to 'you can't be too careful when dealing with people', averaged across all European Values Study (EVS) waves	European Values Study (EVS)
Institutional Quality	Regional quality of governance predicted from regression of the regional quality of governance measure by Charron et al. (2015) on regional values of Satisfaction with democracy and Trust in the justice system from Eurobarometer	Charron et al. (2015); Eurobarometer
Post-Communism	Dummy variable equal to 1 for Eastern European countries and the regions of Germany that belonged to the former German Democratic Republic (GDR)	Authors' own coding
Urban Density 1800	Number of people living in cities with a population above 10,000 in 1800 relative to area (km^2)	Bairoch et al. (1988); EUROSTAT (demo_r_d3area)
Roman Road Hub	Number of cities in a region located at a meeting point of two or more Roman roads	Bosker et al. (2013)
Bonding Social Capital	First principal component of importance of both family and friends averaged at the region of residence	European Values Study
Bridging Social Capital	Number of organizations an individual belongs to out of the following list, averaged at the region of residence: religious organizations, cultural activities organization, youth work organizations, sports/recreation organizations and women's groups	European Values Study
Trust in National Government	Share of the regional population trusting the national government	Eurobarometer 70.1
Trust in Regional Government	Share of the regional population trusting the regional or local public authorities	Eurobarometer 70.1
SMEs Innovating in House	Share of small and medium-sized enterprises (SMEs) with in-house innovation activities	Regional Innovation Scoreboard, European Commission
SMEs Innovating Collaboratively	Share of SMEs that collaborate in innovation activities with other enterprises and institutions	Regional Innovation Scoreboard, European Commission

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