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Regional productivity growth in the EU: An assessment of recent developments

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Regional productivity growth in the EU: An assessment of recent developments

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Joint Research Centre, European Commission, Seville, Spain

JRC TECHNICAL REPORT

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Executive summary

Total Factor Productivity (TFP) has been for long considered one of the prominent indicators for the analysis of the economic performance of countries and regions. TFP can play a key role in ensuring long-term positive and sustainable rates of economic growth, along with helping to ameliorate the cross-country/cross-region differences in economic performance. As such, the analysis of its evolution is of interest to policymakers, especially in conjunction with the objectives of Cohesion policy.

The aim of this working paper is twofold: firstly, it fills a gap in the statistical information available at the NUTS2 level for European regions by calculating regional-level capital stocks employing the widely-used Perpetual Inventory Method approach. Then, in a second step, the paper utilizes these capital stock estimates together with information readily available from Eurostat in order to compute TFP levels and growth rates for the 242 EU NUTS2 regions over the 2000-2020 period. In this respect, the paper extends the recently developed experimental statistic of Eurostat known as the 'crude' Multifactor Productivity (MFP) indicator which is currently available only at the country level.

A number of interesting results emerge from the analysis of the computed indicators: firstly, both in the EU and the Euro Area, TFP growth followed a negative trend, with the trajectory being characterized by significant volatility, especially in the aftermath of the 2008 crisis and during the covid-19 shock. Secondly, our estimates indicate a significant degree of heterogeneity in the evolution of TFP across regions, with regions in the Northern periphery leading in terms of TFP levels while regions in the South exhibited the largest TFP growth rates in 2019. Moreover, based on a development accounting exercise, we present evidence that TFP can account for 50 to 80% of the observed cross-region income differences.

Lastly, preliminary evidence indicate that whereas convergence in TFP growth rates kept going on during the period 2001-2007, the eruption of the Global Financial Crisis of 2008 seems to have exerted a strong adverse impact on TFP growth rates. These negative effects caused a slowdown in TFP growth and led to a weakening of the convergence process across the EU regions.

Regional productivity growth in the EU: An assessment of recent developments *

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JEL Classification: E01; E10; O47

Abstract

The level and growth rates of Total Factor Productivity estimates have been extensively used as a means of assessing the level of efficiency in production across regions as well as a source of the observed differences in economic performance. This paper, focusing on a sample of 242 EU NUTS2 regions spanning the 2000-2020 period provides a time series of TFP estimates, based on a new dataset of regional level capital stocks, and documents significant heterogeneity in terms of TFP developments across regions and groups of regions. In 2019, before the eruption of the Covid-19 shock, the evidence suggests that TFP can account for up to 80% of the observed income differences, while it highlights that, during the period covered by the sample, convergence in terms of TFP was weakened.

Data used in the Working Paper: The data used in this working paper, along with the estimates of TFP, are available for download from the Territorial Economic Data viewer (TEDv):
https://web.jrc.ec.europa.eu/dashboard/TEDV/index.html

*The opinions expressed are those of the author(s) only and should not be considered as representative of the European Commission's official position.

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1 Introduction

Boosting productivity, improving resource efficiency and reducing regional disparities are key objectives of the European Union's (EU) Cohesion Policy. As such, understanding how EU regions have behaved over the last decades in terms of productivity growth and convergence is extremely relevant for policymakers, especially in the context of the 'leave no one behind' principle.

Usually, the measure of productivity analysed in the literature is that of labour productivity; that is, the ratio of a measure of output (e.g. Gross Domestic Product or Gross Value Added) over a measure of labour (e.g. employment or hours worked). This indicator, among others, has the advantage that it is easily computed based on data readily available e.g. from Eurostat. Nonetheless, one concern regarding this measure is that it only takes into account the effects of the production inputs. However, it stands to reason to assume that regions and countries differ significantly both in terms of the factor endowments (i.e. capital and labour) they possess and, equally importantly, in terms of technology and the efficiency with which they utilize these factors. To this end, in this paper we utilize Total Factor Productivity (TFP) as our measure of productivity, as it can account for both aspects (see, also, Beugelsdijk et al. (2018) and Marrocu et al. (2013)).

TFP has long been considered a key concept in the analysis of the economic performance of countries and regions and a potential source of the observed income differences amongst them. Under the standard interpretation, TFP is essentially a measure of the efficiency with which economies are able to convert the factors of production into output. As such, a straightforward implication is that improvements in TFP can be the source of increased economic performance. The achieved TFP growth rates essentially determine whether regions converge in terms of productivity and, hence, in terms of economic performance.

Of course, given that TFP is not directly observable, a choice needs to be made on the approach that will provide the relevant estimates. A significant branch of the regional economics literature has opted for regression-based approaches as a means of obtaining TFP estimates (indicatively, see Dettori et al. (2012), Marrocu et al. (2013), Schatzer et al. (2019) and Siller et al. (2021)). One important caveat of this approach is that it crucially hinges on the assumption that there are no feedback effects running from the measure of output to the factors of production, i.e. that exogeneity conditions are satisfied. In case these do not hold, then the obtained estimates are affected by endogeneity biases raising concerns for their validity. This is an issue that has been largely neglected (a notable exception is, for example, Dettori et al. (2012)). To this end, we opt for computing the TFP estimates using the standard deterministic sources-of-growth analysis introduced in Solow (1957) and Jorgenson and Griliches (1967). That is, TFP is indirectly calculated as the residual component of output growth, the part that cannot be attributed to the growth of the factors of production. As such, TFP plays the role of a 'catch-all' in the context of productivity analyses, it incorporates the impact of all factors that could exert an impact on the production process but are not explicitly included in the production function (e.g. because data that could proxy for these factors are not available). For that reason, TFP is colloquially known as the 'the measure of our ignorance'.[1] In that respect, we follow the analysis of Beugelsdijk et al. (2018), Männasoo et al. (2018), Marrocu and Paci (2012) and Vogel (2015). We note here that this approach was also recently utilized by Eurostat for the calculation of an experimental indicator, the so-called 'crude' Multifactor Productivity (MFP) indicator; nonetheless, this experimental statistic is currently available at the country level only.

[1] See. for exaple, Griliches (1961) who mentions '[...]It is a measure of our ignorance, of the unknown...'. Also, see Abramovitz (1962), pg. 764

The estimates of TFP, obtained based on the above-mentioned approaches, have been extensively utilized in the literature focusing on the economic development of regions. Interestingly, TFP estimates have been used both in analyses aiming to identify the sources of differences in productivity across regions as well as determinants of regional economic performance. In particular, a number of alternative determinants of TFP have been proposed in the literature, ranging from intangible capital (see Dettori et al. (2012)) to R'n' D spending, human capital and knowledge spillovers (indicatively, see among others, Männasoo et al. (2018), Marrocu et al. (2013), Capello and Lenzi (2015) and Siller et al. (2021)). Regarding the second strand of the literature, to which this paper is rather closely related, Beugelsdijk et al. (2018) employ a development accounting approach, based on which they show that in 2007 almost 75% of the observed output variation across regions can be attributed to differences in TFP. As such, the bulk of the differences in regional economic performance is due to differences in production efficiency. Moreover, Ladu (2012) finds that, for a sample of EU regions, TFP has a persistent negative impact on employment.

A number of studies have highlighted the heterogeneous developments in terms of TFP across countries and regions (e.g. see Beugelsdijk et al. (2018), Schatzer et al. (2019) and Siller et al. (2021) for regional-level analysis). This result highlights another important issue: are these differences in TFP constant over time or is there a convergence process taking place?

This paper aims to assess recent developments in the evolution of TFP in European regions. Using a sample of 242 EU NUTS2 regions spanning the 2000-2020 period, the paper provides time series of regional level capital stocks, along with TFP levels and growth rates. Based on these data, it explores the evolution of TFP over time and the patterns that emerge across the EU regions. In order to further highlight the importance of TFP in the regional economic development process, the paper utilizes the development accounting technique in order to quantify the extent to which TFP accounts for the observed cross-region differences in output.

The evidence suggest that, for the EU as a whole, TFP growth rates followed a negative trend over the period under examination. This negative trajectory was exacerbated as a result of the global financial crisis of 2008 and the Covid-19 pandemic. Turning to the regional level, the evidence suggest that there exist significant heterogeneities across regions in terms of TFP levels and growth rates. In particular, regions in the Northern periphery of the EU appear to be the leaders in terms of TFP levels, while in 2019 the largest TFP growth rates are observed in southern regions. Nonetheless, preliminary evidence suggest that the covid shock resulted in the majority of EU regions exhibiting negative TFP growth in 2020. Moreover, our results indicate that across all regions, up to 70% of the observed differences in income can be attributed to differences in TFP; in the case of the Euro Area regions this share increases to 80%. Lastly, preliminary evidence highlight that during the period as a whole, convergence in TFP was significantly weakened after the crisis of 2008.

The rest of the paper is structured as follows: section 2 describes the calculation of regional capital stocks and TFP. Sections 3 and 4 examine the evolution of TFP both at the aggregate and the regional level over the last twenty years, focusing on the patterns that have emerged, while also paying close attention on the performance of 2009, as a means of benchmarking the pre-pandemic performance of EU regions. Section 5 presents the results of the development accounting exercise while section 6 presents some evidence regarding the presence of a convergence process across the EU regions. Lastly, section 7 concludes.

2 Computing TFP levels and growth rates

We calculate capital stocks and TFP estimates for the 242 EU NUTS2 regions over the 2000-2020 period. As already mentioned in the introduction, we employ the standard sources-pf-growth approach proposed by Solow (1957) in order to calculate TFP levels and growth rates.

We assume that production is characterized by a Cobb-Douglas production function of the form:

$$Y_{it} = AK_{it}^{\alpha_{it}} L_{it}^{1-\alpha_{it}} \tag{1}$$

where Y denotes Gross Value Added (GVA) in 2015 chain-linked volumes, L is hours worked and K is the capital stock (in 2015 chain-linked volumes) in region i and period t. Moreover, α_{it} denotes the region-specific, time-varying capital share, that is, the proportion of income that accrues to capital – see below how we compute this, and the corresponding labour share, using National Accounts data. It should be noted here that this specification incorporates a number of strong assumptions including, among others, perfect competition, a single homogeneous capital good etc. Although the various criticisms that have been raised against this approach certainly have merit, we note that the limited availability of data at the regional level precludes us from utilizing a more elaborate, more detailed production function that could, for example, distinguish between tangible and the various types of intangible capital assets.

Then, using equation 1, the level of TFP can be directly obtained as:

$$A_{it} = \frac{Y_{it}}{K_{it}^{\alpha_{it}} L_{it}^{1-\alpha_{it}}} \tag{2}$$

The growth rate of TFP is calculated based on the first-differences of the of the log-linearized Cobb Douglas production function of equation 1; that is, the growth accounting equation takes the form:

$$\Delta \ln A_{it} = \Delta \ln Y_{it} - \tilde{s}_{K,it} \Delta \ln K_{it} - \tilde{s}_{L,it} \Delta \ln L_{it} \tag{3}$$

where $\tilde{s}_{K,it}$ and $\tilde{s}_{L,it}$ denote the shares of capital and labour income in GVA, respectively. In particular, they are calculated as the Divisia indices:

$$\tilde{s}_{i,t} = \frac{s_{i,t} + s_{i,t-1}}{2} \tag{4}$$

where $\tilde{s}_{K,t} + \tilde{s}_{L,t} = 1$ (that is, $s_{K,t}$ and $s_{L,t}$ correspond to the α and $1-\alpha$ in equation 1, respectively). As is evident from equation 3, the growth rate of TFP, denoted by $\Delta \ln A_t$, is obtained as a residual.

While GVA and hours worked data can be directly obtained from ESTAT (in particular, series nama_10r_3gva and nama_10r_2emhrw, respectively), data for the regional level of the capital stock are not readily available. To this end, we calculate the levels of the capital stock via employing the Perpetual Inventory Method (PIM), given by the following formula:

$$K_{i,t+1} = (1-\delta) K_{it} + I_{it} \tag{5}$$

where I_t denotes real Gross Fixed Capital Formation (GFCF). Given that regional chain-linked volumes data for GFCF are not available, we compute them using country-level GFCF deflators.[2] A common issue with the application of the PIM is the selection of the initial level of the capital stock, i.e. $K_{0,i}$. We apply the approach of Klenow and Rodríguez-Clare (1997), based on which:

$$\frac{K_{0,i}}{Y_{0,i}} = \frac{\bar{I}/\bar{Y}}{\bar{g}_i + \delta} \tag{6}$$

[2] The same approach is followed for the calculation of chain-linked GFCF values in the ARDECO database.

where $\frac{\bar{I}}{\bar{Y}}$ is the average investment ratio for the period covered in our sample, $\bar{g}$ is the average GVA growth rate for region i and δ is the time-invariant depreciation rate. For the depreciation rate we employed commonly used values in the literature, ranging from 4 to 7%. As the results were qualitatively similar, we only present results for the 6% case. As a robustness check, we followed the approach of Beugelsdijk et al. (2018), who assume that the capital stock of the initial period is equal to 2.6 times the initial level of GVA. We report that the results are qualitatively similar. Also, note that unlike Klenow and Rodríguez-Clare (1997), we do not account for population growth as our output measure is GVA.

The last component necessary for the calculation of TFP growth is the factor income shares, that is, the shares of capital and labour income, $s_{K,t}$ and $s_{L,t}$, respectively. Starting with the share of labour income, in a first step we calculate a measure of the income of all workers as:

$$\text{LAB} = D1 \frac{\text{HW\_EMP}}{\text{HW\_SAL}} \tag{7}$$

where D1 is the compensation of employees, HW_EMP is total hours worked by employed workers and HW_SAL is total hours worked by employees. This ratio is included in order to account for the compensation of self-employed workers, whose labour income is not accounted for in the figures for the compensation of employees reported in the National accounts. In this way, we effectively assume that self-employed workers are earning the same wage as wage-earners. Then the labour income share is simply:

$$s_{L,t} = \frac{LAB}{GVA} \tag{8}$$

while the capital income share is residually calculated as $s_{K,t} = 1 - s_{L,t}$.

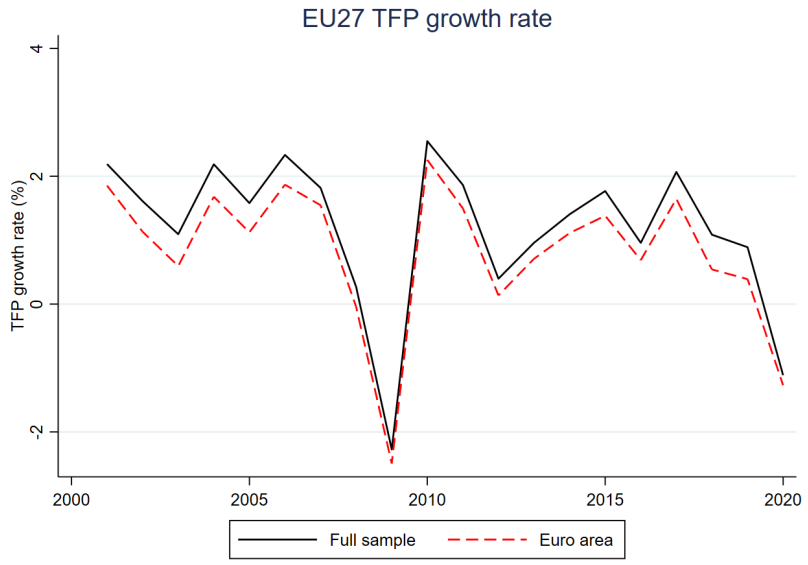
It should be noted here that the indicators computed will be made available in the Territorial Economic Data viewer (TEDv), a data visualization platform developed by the Regional Economic Monitoring (REMO) pillar of the Territorial Data Analysis and Modelling (TEDAM) team of the European Commission's Joint Research Centre (JRC). More details along with an example of the visualizations can be found in the Appendix A.

3 How has European regional productivity growth evolved since 2000?

Figure 1 depicts the evolution of the EU and the Euro Area-wide TFP growth rate based on the year fixed effects from a regression of the regional TFP growth rates on regional and time fixed effects. The regional fixed effects are included in order to account for the impact of regions entering the sample at different time periods. The fixed effects are normalized to equal the sample value of TFP growth in 2001. As can be seen, TFP growth was negatively affected by the global financial crisis shock of 2008, exhibiting a large decline. In the aftermath of the crisis, TFP growth in the EU regions remained rather stagnant and exhibited some volatility, not being able to return to its pre-2008 levels. On the contrary, as a result of the large negative Covid-19 shock, the negative TFP growth trend that had already started in 2017 was significantly amplified. Overall, it is evident that TFP growth has exhibited a negative EU-wide trend over the entire period under examination, with a rather volatile trajectory that was exacerbated by the two large negative shocks that exerted a heterogeneous impact across all regions. This development is, arguably, strongly related to the observed trend of labour productivity slowdown which has been extensively documented in the relevant literature for the EU case (see, indicatively, Corrado et al. (2016), Haskel and Westlake (2018), Goldin et al. (2021), Brynjolfsson et al. (2021) and Syverson (2017)). The reasons behind this large decline in TFP go beyond the pure mechanical explanation, i.e. that it follows from the large decline

in output in 2008. The large magnitude and pervasive nature of the Global Financial Crisis shock had a pronounced effect on TFP, which could have manifested via various channels. In particular, one potential explanation is that the crisis of 2008 was essentially a negative shock superimposed on the already declining TFP growth rates in Europe, that have their origins as early as the 1980s – see chart 1 in Fernald and Inklaar (2020). Moreover, the crisis may have reduced the incentive of firms to innovate, it could have increased the missallocation of resources (e.g. see Gopinath et al. (2017)) and, finally, it could have tightened credit constraints, leading to a decline in investment by firms (which could be even larger in the case of intangible capital assets which, due to their specific nature, cannot be used as collateral –the so-called 'tyranny of the collateral') - for more details on these mechanisms the interested reader is referred to Fernald and Inklaar (2020) and Fernald et al. (2023) and the references therein.

Figure 1: Average TFP growth rate for the EU27 and the Euro Area

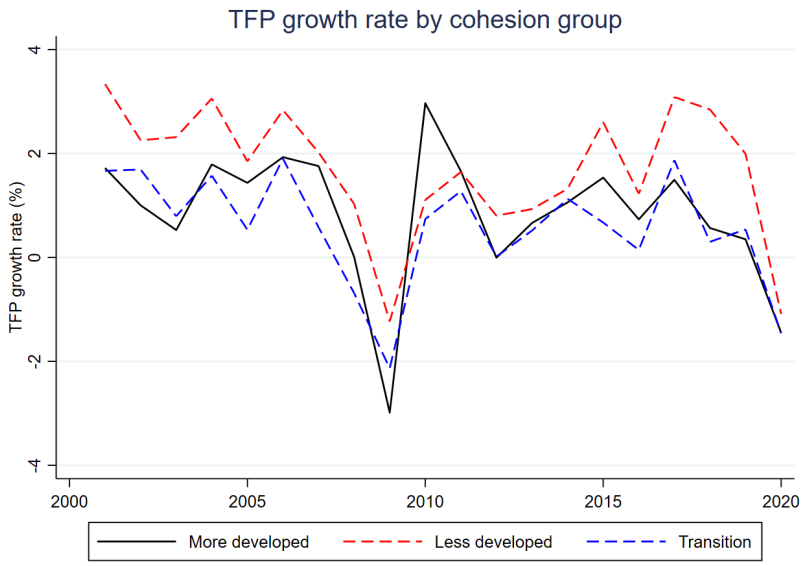


Note: The figure plots the year fixed effects from a regression of regional TFP growth rates on regional and year fixed effects. Regressions are weighted by the level of regional GVA.

Figure 2 depicts the year fixed effects of regressions for the EU regions grouped according to the Cohesion criteria; that is, regions are grouped according to whether they belong to the more developed, less developed or transition regions.[3] We observe that even though the downward trend in TFP growth is present across groups and the trajectories are characterized by a large degree of volatility, the group-specific evolution is characterized by significant heterogeneity over time. In particular, the more developed group of regions exhibited a strong rebound in the post-2008 period which was, nonetheless, short-lived. The transition regions exhibited, overall, the lowest growth rates of the three groups over time, while the less developed regions exhibited the largest decline (in absolute terms) prior to the crisis along with a strong rebound post-2008, which however was reversed after 2015.

[3] Based on the criteria of the 2021-2027 period; in particular, regions are classified as *more developed* if their GDP per capita exceeds 100% of the EU-27 average, as *transition* if their GDP per capita is between 75% and 100% of EU-27 average and as *less developed* if their GDP per capita is less than 75% of the EU27 average.

Figure 2: Average TFP growth rate for regions grouped by Cohesion group



Note: See Figure 1.

4 Patterns of productivity across EU regions and countries

This section examines the patterns of TFP levels and growth rates across the EU regions, focusing both on their evolution over time as well as benchmarking the productivity performance in 2019, the year before the eruption of the Covid-19 pandemic (while also providing some preliminary evidence for 2020) allowing for the comparison with the post-pandemic performance of the regions once the newest data vintages become available.

4.1 European regions performance over the last 20 years

We begin our analysis of the TFP performance of the EU regions by focusing on the developments in TFP levels and growth rates over the period 2001-2019. In particular, we focus on analyzing the emerging patterns in *relative* TFP levels (that is, regional TFP levels that are scaled by the TFP level of the EU27 average, so that a value exceeding (below) unity indicates that the region has attained a TFP level higher (lower) than that of the EU27) and growth rates. We note here that despite the well-known concerns related to the mismeasurement of TFP levels, the growth literature has emphasized their importance as a source of growth differentials across countries and regions (see, for example, Caselli (2005)). The importance of analyzing TFP levels is made evident in the seminal contribution of Hall and Jones (1999) who argue, among others, that '...levels capture the differences in long-run economic performance that are most directly relevant to welfare...' (Hall and Jones (1999), pg. 85). In particular, in a neoclassical context, where all countries/regions exhibit the same long-run rate of economic growth, it is the difference in TFP levels that is the source of the transitory performance; that is, the lower the TFP level the faster the country/region will grow during the transitory period to reach the common, steady state rate of growth. In an endogenous growth set up, the variation in TFP levels can be used to examine the variation in long-run performance.

Starting with the evolution of TFP growth rates we can see in Table 1 that by 2019 the aver-

age growth rate of TFP was almost one third of the magnitude of average TFP growth in 2001. Given that the magnitude of the robust mean is almost identical to the 'raw' one, it seems that this lower magnitude is not driven by the impact of outliers. Moreover, it can be observed that the amount of regions that exhibited a negative growth rate in 2019 has more than doubled compared to the 2001 percentage. Turning to the map of Figure 3, which depicts the average growth rates for the entire period under examination, a number of interesting insights can be highlighted. Firstly, the average TFP growth for the sample as a whole is equal to 0.993, with a rather large standard deviation equal to 0.69 which points to a large degree of heterogeneity in terms of TFP growth developments across the EU regions. Only 14 regions exhibited negative average TFP growth rates, 10 of which are located in Greece, two in Spain and two in Italy. The regions that attained the highest growth rates for the period as a whole can be located predominantly in the newest Member States in Central Eastern European countries and, mainly, in Bulgaria, Czechia, Poland, Romania, Slovenia and Slovakia.

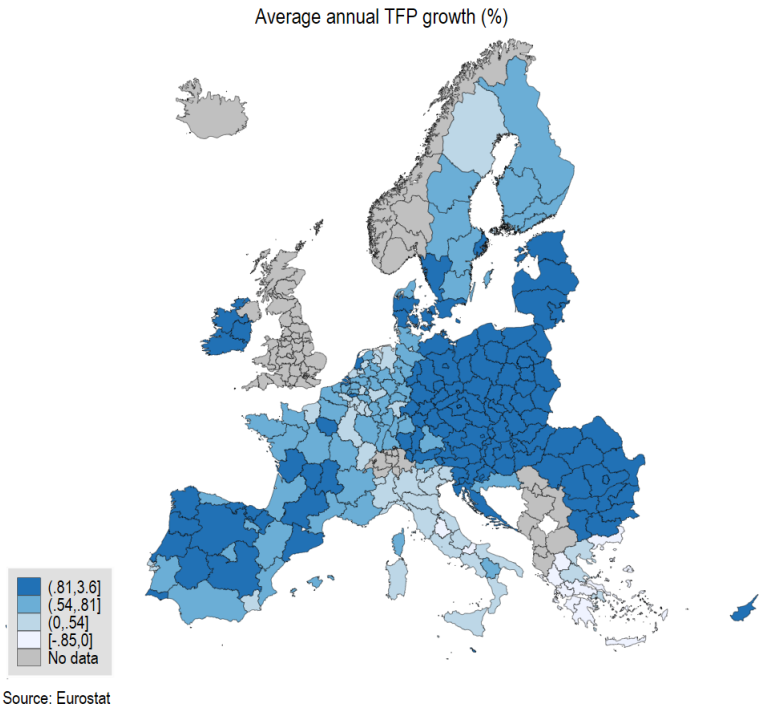
Table 1: TFP growth rates in 2001 and 2019

	Region	**Country**	**2001**	**Region**	**Country**	**2019**
Top-5	FRY3	France	13.77	BE31	Belgium	7.29
	FI20	Finland	10.47	CZ02	Czechia	6.13
	RO41	Romania	10.05	RO32	Romania	5.41
	HU32	Hungary	9.66	PL71	Poland	5.411
	BG42	Bulgaria	9.34	BG41	Bulgaria	5.296
Bottom-5	SE31	Sweden	-1.91	FRY3	France	-3.34
	EL42	Greece	-2.10	IE04	Ireland	-4.31
	BG34	Bulgaria	-3.39	FRY5	France	-4.67
	ES64	Spain	-3.53	EL53	Greece	-7.49
	ES63	Spain	-4.88	IE05	Ireland	-10.55
Sample		Max	13.77		Max	7.29
		Mean	2.191		Mean	0.731
		Robust mean	1.867		Robust mean	0.764
		[t-statistic]	[12.56***]		[t-statistic]	[7.68***]
		Standard Dev.	2.55		Standard Dev.	1.963
		Min	4.88		Min	-10.55
		% < 0	13.1		% < 0	28.9

Notes: Robust means refers to means obtained after weighing down outliers, implemented using the *rreg* routine in Stata. The last line of the Table indicates the percentage of regions that exhibited a negative TFP growth rate in each year.

Turning to the evolution of TFP levels, we observe in Table 2 that the percentage of regions that remained below the EU27 level in 2019 was equal to 57%, an increase of almost 12 percentage points compared to 2001. Overall, the descriptive statistics indicate that the mean relative TFP level fell below unity in 2019, a result that is not driven by outliers. Interestingly, the standard deviation is quite large in both years, indicating significant dispersion of TFP growth rates. The vast majority of regions that were below the EU27 average in 2001 can be located in the Central Eastern European countries as well as countries in the Southern periphery like Greece, Portugal and Spain. It should also be noted that several regions in Germany exhibit a TFP level smaller compared to that of the EU27. While it is the same countries that remain below the EU27 average in 2019, it is of interest to highlight that a large number of regions in Belgium, France, Italy and Spain also exhibit relative TFP levels lower than unity. These developments, combined with the fact that the southern regions exhibited high growth rates in terms of TFP could be an indication of a convergence process that took

Figure 3: Average annual TFP growth



Source: Author's elaboration based on the data calculated following the approach of Section 2. Average TFP growth for the sample is 0.993 (robust mean is equal to 0.884) with a standard deviation of 0.692.

place over the last 20 years in the EU regions - more evidence regarding the existence or not of a convergence process are provided in section 6.

Lastly, in Table 3 we provide a measure of the differences in the ranking of regions in terms of TFP levels and growth rates by comparing changes in the ranking for 2001 and 2019. In particular, we observe some rather significant changes in the ranking of regions in terms of TFP growth rates, whereas in the case of TFP levels these changes are smaller. This indicates that, over time, the path of TFP growth rates was more volatile while the relative constancy of the ranking of TFP levels could be seen as an indication that convergence in TFP is still ongoing.

4.2 Benchmarking regional performance

We continue our analysis of the patterns of TFP across regions by inspecting the distribution of the relevant data presented in the maps in Figures 4 and 5. In particular, Figure 4 depicts relative TFP levels for 2019 while Figure 5 depicts the corresponding TFP growth rates for 2019. As already mentioned, benchmarking the TFP performance of the EU regions in 2019 will facilitate the analysis of the impacts of the pandemic as well as the post-pandemic performance once newest data vintages become available.

As is evident from Figures 4 to 6, there is a large degree of dispersion in terms of TFP performance across the regions of the EU. In particular, in Figure 4, we observe that the vast majority of EU regions have managed to attain positive TFP growth rates (in particular, 172 regions). The largest rates for 2019 can be found in regions of Eastern and Southern Europe and, in particular, Bulgaria, the Czech Republic, Greece, Hungary, Slovakia, Poland and Romania. However, in 2020, the impact of the Covid-19 shock led to a radical shift in the TFP growth patterns. In particular, mean TFP growth in 2020 was equal to -1.637 reflecting the

Table 2: Relative TFP levels in 2001 and 2019

	Region	**Country**	**2001**	**Region**	**Country**	**2019**
Top-5	LU00	Luxembourg	2.55	IE05	Ireland	3.25
	IE06	Ireland	2.22	IE06	Ireland	2.79
	IE05	Ireland	2.03	LU00	Luxembourg	2.11
	NL11	Netherlands	1.99	SE11	Sweden	1.95
	SE11	Sweden	1.91	DK01	Denmark	1.69
Bottom-5	RO11	Romania	0.26	EL41	Greece	0.29
	RO31	Romania	0.24	BG33	Bulgaria	0.287
	RO22	Romania	0.15	BG32	Bulgaria	0.284
	RO41	Romania	0.05	BG42	Bulgaria	0.258
	RO21	Romania	0.037	RO21	Romania	0.238
Sample		Max	2.55		Max	3.25
		Mean	1.033		Mean	0.957
		Robust mean	1.025		Robust mean	0.939
		[t-statistic]	[39.54***]		[t-statistic]	[49.45***]
		Standard Dev.	0.39		Standard Dev.	0.355
		Min	0.037		Min	0.238
		% <EU	45		% <EU	57

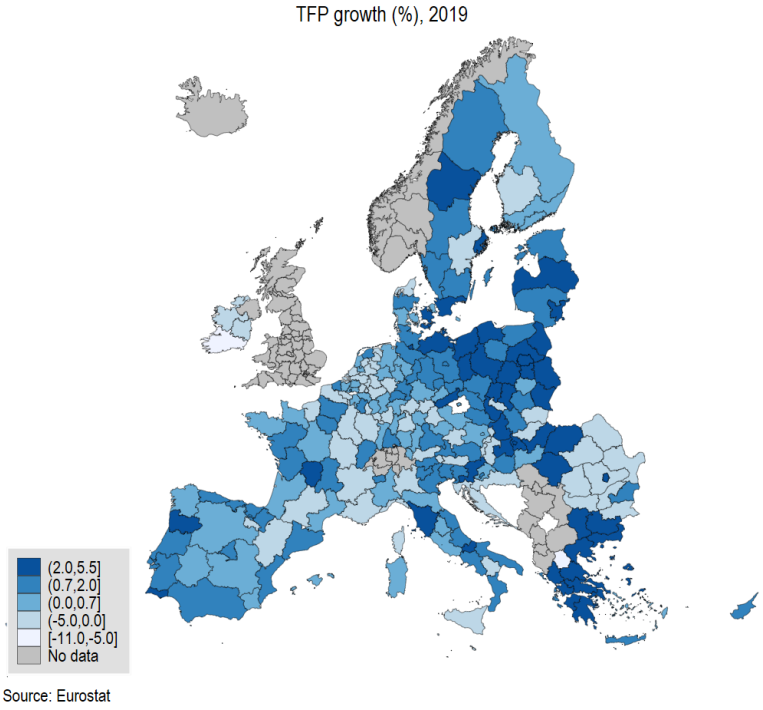
Notes: Sample of N=242 regions. Robust means refers to means obtained after weighing down outliers, implemented using the *rreg* routine in Stata. The last line in the Table depicts the percentage of regions whose TFP level was below the EU27 one in each year.

Table 3: Rank differences between 2001 and 2019

	Level	**Growth**
Mean	42	74
Median	25	63.5
1st Quartile	11	29
2nd Quartile	50	108
IQR	39	79
Spearman	0.85	0.05

Source: Author's own calculations.
Note : IQR denotes the inter-quartile range. Spearman refers to the Spearman rank correlation coefficient, calculated for the TFP growth rates of 2001 and 2019 (and, for the relative levels, respectively).

Figure 4: TFP growth rates for 2019



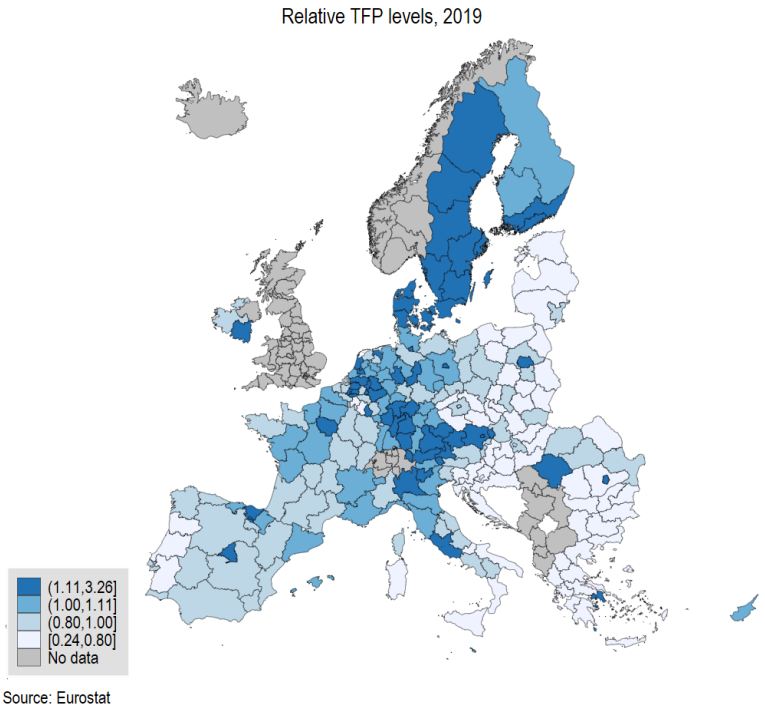
Source: Author's elaboration based on the data calculated following the approach of Section 2.

fact that more than 75% of the EU regions (188 out of 242) exhibited negative TFP growth rates. Moreover, the large standard deviation (equal to 3.085) indicates that the impact of the pandemic shock was rather heterogeneous, and potentially exacerbated the already documented large dispersion in TFP growth rates. The bulk of the regions that were able to attain positive rates are located mainly in the Northern periphery (regions in Belgium, Denmark, Germany and Sweden) and in Ireland. These preliminary evidence suggest that the impact of the pandemic shock was rather severe and was transmitted across almost all EU regions.

Turning to the inspection of TFP levels in Figure 5, we observe that almost 40% of the European regions exhibits a TFP level higher than that of the EU27, with such regions being predominantly located in the Northern periphery of the EU (and, in particular, in Austria, Belgium, Denmark, Germany, the Netherlands and Sweden) and in Ireland, along with some French and Spanish regions. On the contrary, regions that are lagging in terms of TFP levels are mainly found amongst countries of the Southern periphery of the EU and the new Member States. This includes countries like Bulgaria, Croatia, the Czech Republic, Greece, Hungary, Portugal, Slovakia and Slovenia were all the regions exhibit TFP levels lower than the EU27 average (with the exception of some capital regions). It is also worth mentioning that in some of the largest EU economies like France, Italy and Spain, more than 50% of their regions rank below the EU27 TFP level. Some preliminary evidence for 2020 indicate that the overall picture has remained unaltered. The Southern periphery of the EU along with the new Member States are characterized by relatively low TFP levels, along with some single-region countries (e.g. Cyprus and Malta) that also fell below the EU average.

In order to gain a better insight into the extent of TFP dispersion both within- and across countries, we visualize the relevant data in Figure 6. The Figure plots the country average of TFP for 2019 along with the regional TFP levels by country. As is evident, there is a large degree of heterogeneity across both dimensions. As already shown in Figure 5, the old mem-

Figure 5: TFP levels for 2019



Source: Author's elaboration based on the data calculated following the approach of Section 2.

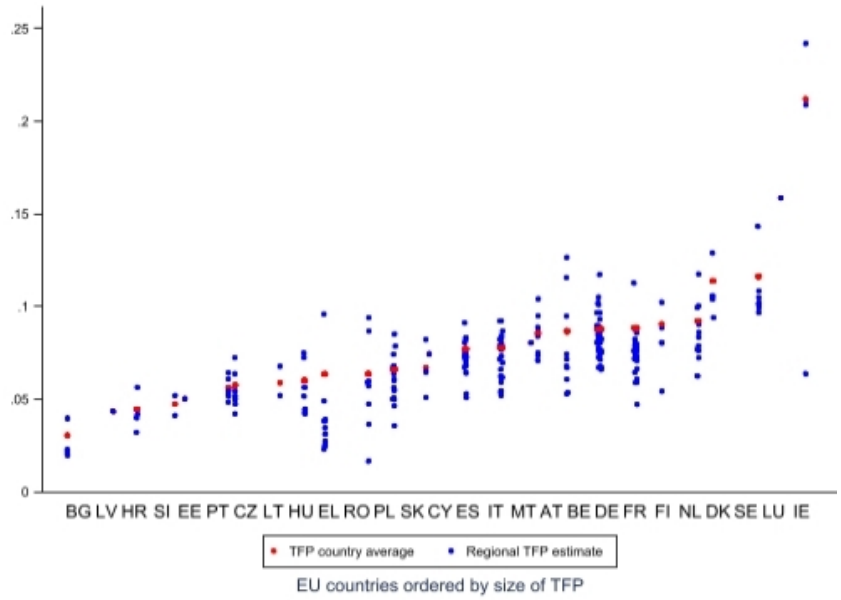
ber states (including, among others, Austria, Belgium, Germany and Netherlands) appear to have the largest average TFP level for 2019, while the newest member states (mainly, Eastern European countries) exhibit the lowest levels of TFP. As can be gleaned from the Figure 6, within-country dispersion is quite significant in almost all countries.

5 Development accounting

As already mentioned in the introduction, measures of TFP have been extensively utilized in empirical analyses as determinants of the economic performance of regions. In this section, we expand on this issue by examining the role of TFP in a wider context: specifically, we examine whether TFP has any role to play in explaining the observed differences in output. We do this via utilizing the so-called 'development accounting' approach – see Caselli (2005) and Klenow and Rodríguez-Clare (1997). In particular, this technique allows us to obtain a quantification of the proportion of income differences across regions that are not attributed to capital and labour (i.e. the factors of production). That is, we are able to provide an answer to the question: what is the percentage of cross-region income differences that is due to differences in TFP? To our knowledge, in a regional context, this approach has also been followed by Beugelsdijk et al. (2018), who apply the technique to a sample of EU regions for 2007. We now briefly present the core ideas behind the development accounting approach – the interested reader is referred to Caselli (2005) for a detailed presentation. Rewriting equation 1 in its intensive form, i.e. in per hour worked terms, we have:

$$y_{it} = A_t k_t^{\alpha} \tag{9}$$

Figure 6: TFP levels dispersion across and within countries in 2019



Source: Author's elaboration based on own data.

Then, based on the above expression the following indicator can be computed based on a standard variance decomposition approach:

$$V_t = \frac{\text{var}(\ln y_{it}^m)}{\text{var}(\ln y_{it})} \tag{10}$$

where $\ln y_{it}^m$ is the log of the level of income assuming that $A = 1$ in equation 9. That is, $y_{it} = k_t^\alpha$ denotes the case where the level of production efficiency (i.e. TFP) is the same across all regions. Essentially, under this approach, we can examine how the observed differences in income across regions compare to a case where all regions had possessed the exact same level of technological efficiency. Note that, in this counter-factual case, the above ratio would be equal to one. As such, any value lower than one will show the extent of the differences across regions. In particular, the lower the value of the ratio the higher the impact of technological efficiency (i.e. TFP) in the observed differences.

The results of this exercise, conducted for three alternative time periods and for various regional groupings are summarized in the following Table 4.

Table 4: Development accounting results (%)

	2007	2012	2019
All regions	39.7	46.7	34.7
Euro area regions	36.7	39.6	27.2
'North' regions	55.4	40	35.1
'South' regions	50.1	49.1	43.1

Source: Author's own elaboration.
Note : 'South' regions includes the regions of the following countries: Bulgaria, Croatia, Cyprus, Greece, Hungary, Italy, Portugal, Romania and Spain.

The first row of the Table shows that, when all the regions of the EU are considered, the share of the variation in output per hour worked explained by the factors of production was almost 40% in 2007, right before the eruption of the Global Financial Crisis. The share increased by 6 p.p. in the aftermath of the crisis, as a result of a significant increase in the numerator of equation 10. However, in 2019, the share decreased to 34.7%, due to a significant decline in the variance of the factor-only component. Some preliminary results indicate that in 2020, when the initial phase of the Covid-19 pandemic had already unfolded, the ratio further declined to 30.7%. A similar trajectory can be observed when we focus on the regions of the Euro area (row 2 of the table). Even though the share of the variation attributed to the factors of production increased somewhat in the aftermath of the crisis of 2008, by 2019 the share had declined by almost 13 percentage points. As a result, TFP accounted for more than 70% of the observed regional income differences. In 2020, the ratio further declined to by 7 p.p. leading to TFP accounting for almost 80% of the observed income differences.

When we group the regions into those belonging to the 'North' and the 'Southern' periphery of the EU, we observe that while in 2007 more than 50% of the variation in regional output was explained by factor inputs, the post-crisis period paints a radically different picture. In particular, by 2019 the relevant share had declined significantly and ranged between 35% in the southern regions and 43% in the northern ones, while in 2020 both shares declined even further.

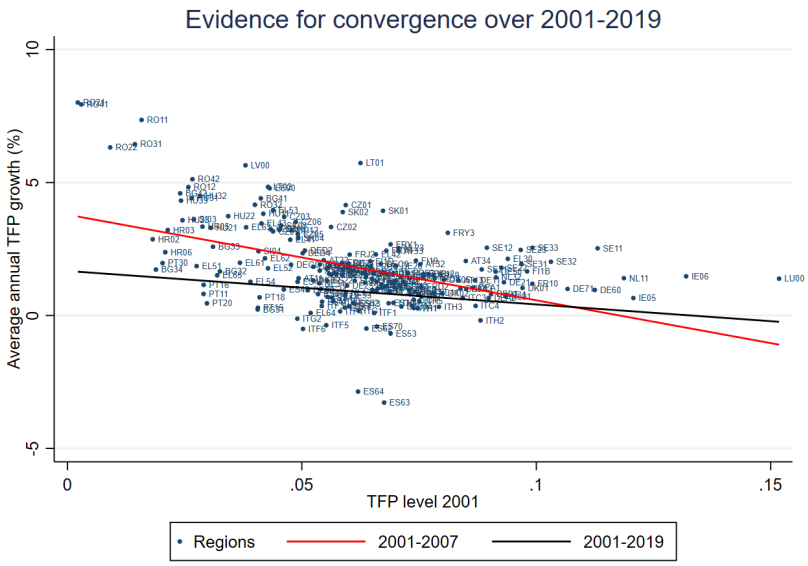
Overall, the results of the development accounting exercise indicate that the observed differences in regional output are less likely to be attributed to differences in the endowments of the factors of production; rather, they seem to mainly emerge due to differences in TFP, corroborating the evidence presented in Beugelsdijk et al. (2018). This finding highlights the importance of TFP as a determinant of cross-region income differences and shows that further research is necessary in order gain insights into the reasons behind regional TFP differences.

6 A look into convergence

Regional convergence has been one of the main policy targets of the EU, and is mainly examined in terms of the regional gap in income per capita. In this note, using our estimates of TFP levels and growth rates, we examine whether there are preliminary evidence of convergence in terms of TFP. In particular, we assess whether regions that initially had a low level of TFP subsequently exhibited higher TFP growth rates during the period under examination. The relevant data are plotted in Figure 7. As can be gleaned from the graph, for the period up to 2007, there is a strong negative correlation between the initial level of TFP and subsequent TFP growth (see the slope of the red line). This correlation can be interpreted as suggesting that convergence in TFP was taking place, with regions that were initially lagging being able to catch up with frontier regions. However, focusing on the period as a whole, we observe that this negative correlation is significantly weakened (the slope of the black line is significantly flatter). This indicates that the crisis of 2008 exerted a significant negative impact on TFP that caused a slowdown on its growth trajectory. Once combined with the evidence presented in section 3 regarding the negative TFP growth trend across the EU regions, this set of evidence implies that the convergence process came to a halt.

Moreover, once we group regions based on the Cohesion policy criteria (less developed, in transition and more developed) –see Figure 8– we observe that in the period up to the global financial crisis there was a strong convergence process ongoing (with less developed regions exhibiting, on average, more than double in magnitude TFP growth rates compared to more developed regions). However, in the post crisis period the convergence process lost

Figure 7: Do countries with lower TFP levels grow faster?



Source: Author's own elaboration based on own calculations Eurostat data.

its dynamic as these groups exhibit rather similar growth rates.

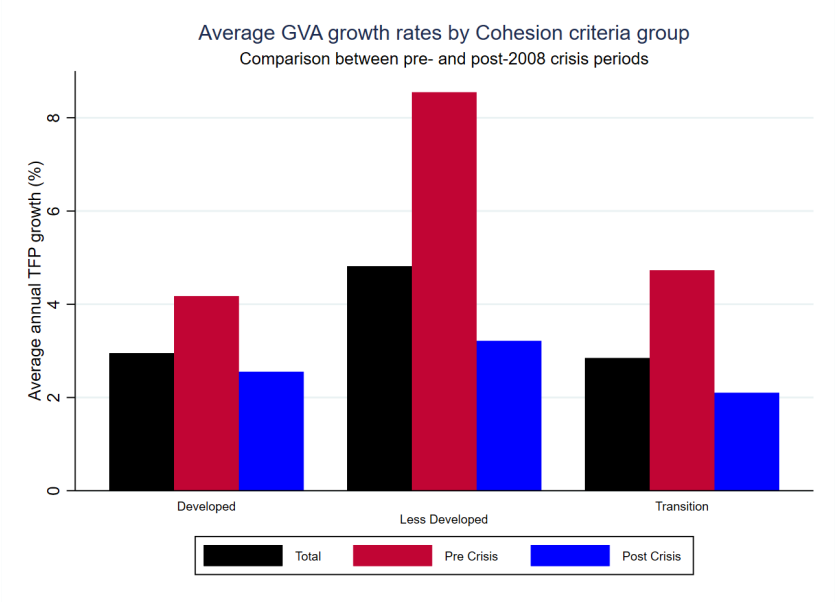
7 Conclusion

This technical report presents estimates of TFP levels and growth rates for the EU NUTS2 regions over the 2000-2020 period, based on the latest available data from Eurostat, utilizing a new dataset of (estimated) regional level capital stocks. It benchmarks the performance of the EU regions to 2019, while it also presents some preliminary evidence of the impact of the first stages of the covid-19 pandemic on the productivity performance of the EU regions.

The evidence presented suggest that both for the EU and the Euro area, the evolution of TFP growth has been following a downward trend, with productivity remaining below the pre-2008 crisis levels. Moreover, it is evident that there exists a significant degree of heterogeneity in terms of TFP developments across regions and groups of regions. The largest TFP growth rates seem to be concentrated in regions in the Eastern and Southern periphery of the EU, while at the top of the TFP levels distribution one can find regions predominantly located in the Northern periphery of the EU.

An application of the development accounting technique highlighted that around 50 to 80% of the cross-region income differences should be attributed to TFP, depending on the grouping of the EU regions according to different criteria. Moreover, descriptive evidence suggest that, initially, for the period up to 2007 there was a strong negative correlation between initial TFP levels and TFP growth, which could be considered as indicating a convergence process in play. Nonetheless, the global financial crisis of 2008 seems to have exerted a very large negative impact on the evolution of regional TFP, causing a slowdown in its growth trajectory and thus leading to a significantly weakened convergence process. This set of evidence indicates that future research should focus on the analysis of the factors behind the differential productivity evolution as well as the analysis of convergence in productivity. This will allow for the formulation of policy suggestions aimed at enhancing TFP growth.

Figure 8: TFP growth rates across Cohesion Policy groups



Source: Author's own elaboration based on own calculations Eurostat data.

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A TEDv

The Territorial Economic Data viewer (TEDv) is a data visualization platform including territorial statistics of the different Research and Innovation (R&I) EU funding programmes and beyond. It has been developed by the Regional Economic Monitoring (REMO) pillar of the Territorial Data Analysis and Modelling (TEDAM) team of the European Commission's Joint Research Centre (JRC).

The TEDv includes territorial statistics from Cohesion Policy (supported by European Structural and Investment Funds - ESIF), Horizon Framework (Horizon 2020 and Horizon Europe) and Recovery and Resilience Facility (RRF) included in the Next Generation EU. These statistics are displayed across three dashboards: (i) the Regional dashboard, (ii) the Sectorial dashboard, (iii) the Comparison dashboard.

Beyond EU funding indicators, the TEDv also reports territorial socio-economic and demographic statistics displayed in the 'Regional info-sheet' dashboard. For more details about the data and methods behind the TEDv see Marques Santos et al. (2023).

The TFP indicators described in this Working Paper are available in the section 'Economic indicators' of the 'Regional info-sheet' dashboard. In this section, users can choose a NUTS 2-level region (version 2021) and a time-period to obtain a visualization of TFP growth rates, as shown in the following screenshot (Figure 9). In this example, we pre-selected the Greek region of Attica (EL30) – which corresponds to the capital region of the country - and the 2008-2019 period. Moreover, this selection also allows visualizing the investment ratios (i.e. the investment intensity) in this region, which are compared with the corresponding ratios for Greece and the EU27.

Figure 9: Example of TEDv visualisation: Regional info-sheet, 'Economic indicators'– Greek region Attica (EL30)

Source: TEDv (extracted on 15/05/2023).

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