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1. Introduction

The convergence of per-capita income across the European regions is one of the most striking issues in the European Union agenda. Recent studies based on historical regional data corroborate that for over half a century, 1950 to 1980/1990, per capita income across Western European regions converged. However, over the past three decades, this evolution has weakened and even reversed. Particularly, since the Great Recession divergence has resumed again as it used to be in the first phases of the industrialization processes. Consequently, a new N-curve between per capita income and regional inequality is emerging in some European economies and in the United States (Ganong and Shoag, 2017).

This upsurge in spatial inequality has been associated with the Information and Communications Technologies (ICT) and with the unequal spatial distribution of the new knowledge-intensive activities. Recent technological change seems to be more intensive in skills based on knowledge than the technological change in the past. For this reason those regions with more developed institutions, social networks based on knowledge or more developed skill labour and capital markets seem to be more prone to attract talent and host the new industries and services (Glaeser et al, 2014). The regions where these specific kind of cities are located seem to become new focus of agglomeration in the developed countries in general, and in Europe in particular. Consequently, the recent upsurge of regional inequality seems to be intrinsically linked to the way the knowledge

intensive technologies propel revival of those urban centres better endowed with several sorts of knowledge related capital (human capital, social capital, research and development activities and networks, universities, knowledge intensive industries, etc.).

This paper focuses on the measurement of regional inequality in the EU-13 since 2000 up to 2015 and tries to answer the question whether the recent upsurge of regional inequality responds to a new technological shock and sets the start of a new inverted-U process in Europe. For this purpose we focus our attention in how some leading regions have increased their distances to the European average. Then distances in terms of labour productivity with regard to the leading regions are split down in the three components of the shift-share analysis, trying to elucidate the relative role of a new structural change process, the role of the technological catch-up with the leader regions and the new patterns of sector specialization in the increase of regional inequality in Europe.

The remainder of the paper is organized as follows. Section 2 briefly reviews the literature on the relationship between economic development, spatial inequality and the role of structural change in the process. Section 3 presents the data gathered to run this research and some descriptive statistics of the evolution of per capita income and labour productivity inequality in the European regions since the 2000 up to 2015 for the NUTS-2 regions of EU-13. We put attention on the potential effect of agglomeration to stretch labour productivity distances between regions. Section 4 performs a shift-share analysis to disentangle the role displayed by the technological gap within industries, the structural change and the regional specialization in the increase of regional disparities. In the concluding remarks our main findings are summarized.

2. Theory and evidence: The link between spatial inequality and the industry mix

The literature on the evolution and determinants of regional disparities rests on the

seminal work of Williamson (1965) that postulated an inverted-U shape relationship between economic development and regional income per capita inequality.[1] In the early stages of industrialization the distribution of economic activity across regions becomes more unequal. The manufacturing and the high value activities concentrate in a handful of advanced regions while the rest of the regions remain linked to agriculture or more traditional manufacturing. Productivity in the modern industries increases more quickly fuelled by technological change and economies of scale and, hence, income per capita grows faster in the industrialized regions than in the traditional ones.

In turn, in more advanced phases of development, the reallocation of factors (capital and labour) between industries and across regions in search for higher remunerations, jointly with technological diffusion across regions, and the compensating effect of economic policy, will tend to mitigate regional disparities and push convergence between regions.

In this respect, the preliminary evidence presented by Williamson (1965) in support of this hypothesis was not robust enough due to the short time span considered. Later on, the use by Kim (1995, 1998) of regional historical data for the United States proved the existence of the inverted-U curve in the long run. In Europe, especially since the publication by Geary and Stark (2002) of a new method to territorialize national GDP across regions, the number of countries with historical regional data has soared.[2] The evidence provided for many countries reveals that, at least since mid 19th century, the Williamson' curve is hold in some countries (Great Britain, Spain or Portugal), while

[1] Based in the famous *Kuznets curve* (Kuznets, 1955) that postulates the same relationship between a country per capita income level and the personal inequality.

[2] In Europe, the first historical studies were based on cross-section or panel data using official databases starting in 1975 or 1980. Their main drawback is to offer a time span too short to detect the potential "structural change effects" to explain the inverted U-shaped pattern. Most of the European regions included in these samples exhausted the "structural change process" in the Golden Age or even before.

others, such as Belgium, Sweden and France, exhibit a persistent decline in regional disparities since the last decades of the 19th century. Historical evidence is still less concluding for Italy where a big North-South divide is held. [3]

More recently, Rosés and Wolf (2019), using normalized historical estimates for 16 European countries[4] and 173 NUTS-2 regions along 1900-2010, conclude that disparities in per capita income declined along 1900-1980, held up in the 1980's and raised again in the last two decades. A similar upturn in regional income inequality emerge when the focus is put on particular country experiences. For instance, the U.S. (Ganong and Shoag, 2017; Klein, 2019), the U.K. (Geary and Stark, 2016), Sweden (Enflo and Rosés, 2015), Spain (Martínez-Galarraga, Rosés and Tirado, 2015) and France (Rosés and Sanchis, 2019) exhibit a clear upturn in regional income disparities since 1980. Other studies based on econometric analysis using cross-country data for the last decades, reveal that the inverted-U curve has been completed and that a new pattern of regional income inequality is emerging.[5]

In the explanation of the U-shaped pattern, the structural change hypothesis prevails. The historical experience of the U.S. regions confirms that the nationwide convergence between agricultural and non-agricultural wages and the faster transition of the labour force in the poorer regions from agricultural to non-agricultural jobs explains overall per capita income convergence across the U.S. states in the 20th century[6]. Similar results have been tested for some European countries, such as Spain, Sweden, Italy and

[3] For Great Britain see Crafts (2005) and Geary and Stark (2016); for Spain, Martínez-Galarraga et al. (2010, 2015); Italy by Felice (2011); Portugal by Badia-Miró et al (2012); Belgium by Buyst (2010 and 2011) and Sweden by Enflo and Rosés (2015). There are alternative estimates for France along the 20th century by Combes et al. (2011), Caruana-Galizia (2013), Bazot (2014) and Rosés and Sanchis (2019).
[4] Austria, Belgium, Denmark, Finland, France, Germany, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, Ireland and United States.
[5] For instance, Barrios and Strobl (2009), Henning et al. (2011), Lessman (2014), Castells-Quintana et al (2015) and Lessman and Seidel (2017).
[6] See Kim (1998); and Caselli and Coleman (2001) and Kim and Margo (2003).

France[7]. Regional disparities grew in the early stages of modern economic growth but then convergence occurred for most of the 20th century, coming to a halt in the last quarter of the 20th century. First, regional inequality increased pushed by industrialization and market integration that concentrated modern industries in a few regions. But in the second half of the 20th century, strong regional convergence was the norm and the reallocation of factors from agriculture to industry in the backward regions seems to make the biggest contribution to the convergence process.

Previous studies based on official databases on regional Gross Value Added (GVA) used to depart from 1975, or even later. These studies found that regional inequality was mainly explained by differences in labour productivity and by the existence of productivity differentials within the same sectors in different regions.[8] The existence of region specific factors strongly related to regional endowments of productive capital, transport infrastructures, and research and development expenditure are more significant in explaining regional differences in productivity than the industry composition (Ezcurra et al., 2005).[9] The weak impact of the industry mix on productivity differentials is seen as a consequence of the exhaustion of the structural change process in Europe in the decades following the Second World War, such as the recent historical studies seem to confirm.

[7] For intance, Sweden (Enflo and Rosés, 2015), Spain (Martinez-Galarraga, Rosés and Tirado, 2015), France (Combes et al, 2011; Díez, Rosés and Sanchis, 2016) and Italy (Felice et al, 2018).
[8] Esteban (2000) arrives to this conclusion performing a shift-share analysis based in data of EUROSTAT (1995) database, for the NUTS-2 regions of Belgium, France, Italy, Portugal, Spain and Germany, with data at 6 sectors level. Lately, Ezcurra et al (2005) arrive to similar results with data for 1977-1999 from Cambridge Econometrics dataset at NUTS-2 level for 15 European countries. Other variants of the shift-share analysis have been explored by Le Gallo et al (2003), arriving to similar conclusions.
[9] In the last decades additional regional specific factors have been gathered around the concept of Territorial Capital. It includes the endowment of climate related factors and natural resources, the quality of live, or the agglomeration economies provided by the cities or industrial districts and other factors such as social capital (informal rules, solidarity…) (Camagni, 2017).

However, as suggested by Barrios and Strobl (2009), there is no reason to expect that changes in regional productivity differentials will stop when all the countries become industrialized. In fact, other types of technological shocks, similar to those happened at the starting of the industrialization process, could lead not only to a deeper within industry gap across regions but also to the start of a new structural change process that puts in motion a new wave of regional disparities.

For instance, the recent upsurge in spatial inequality has been associated with the ICT technologies and with the unequal spatial distribution of the new knowledge-intensive activities. Berger and Frey (2014) find that the ICT technologies have traced the performance of the U.S. cities since 1980's. According to them, the new technological change appears biased towards more abstract skills and hence the new jobs emerge in industries and services more knowledge intensive. This technological pattern has altered the economic geography in the American cities, where those endowed with analytical and interactive skills have adapted better to the Computer Revolution than those specialized in routine task industries.

In the same line of reasoning, Glaeser and Resseger (2010) find a strong correlation between labour productivity and city size in cities with high levels of skill while irrelevant otherwise. Those American cities better endowed with institutions and social networks based in knowledge have revealed more resilient to the current challenges. (Glaeser et al, 2014). This kind of urban areas are the ongoing focus of agglomeration of talent, capital and innovation, and hence, of economic activity. Consequently, the agglomeration of the new skill intensive activities in some cities is becoming a new engine of regional income disparities.

The new wave of technological change has promoted new types of services and industries based in high-skill labour at the expense of traditional low-skill activities and resource-intensive industries. This fact is configuring a pattern of specialization in which knowledge-intensive activities are breaking distances between those regions well-endowed to cope the new demands of skills and research and innovation structures and those less ready to attend them. In the next section the new pattern of regional per capita income and labour productivity in Europe is described, along with the increasing relevance in this process of some leading regions, most of them regions where the country capital city is located.

3. Data and measure of regional inequality

3.1. Data

The data used in this paper comes from the BD.EURS (NACE Rev.2) dataset (see Escribá-Pérez et al, 2019). Nevertheless, we modify the original dataset in order to adapt better the available information to the objective of the paper. Specifically, we extend the number of regions and the number of sectors (Table 1), which allow us to do a more exhaustive analysis about the role of the industry-mix in the evolution of regional inequality in Europe.

Our dataset covers 156 regions belonging to 13 EU countries (EU-13).[10] Regions are defined as NUTS-2, except for Germany and the United Kingdom where regions are

[10] Luxembourg and Ireland are excluded from the sample because they are small countries (Luxembourg has one region only). Moreover, it is widely known the fact that Ireland has by far the lowest standard rate of corporation tax on manufacturing among the advanced economies, resulting in multinational companies "locating a very high fraction of the enterprise's global profits in Ireland. Consequently, it could increase national macroeconomic indicators as the gross domestic product (OECD, 2016). Crescenzi and Giua (2016) also excluded from their analysis these two countries.

defined as NUTS-1.[11] The dataset is disaggregated in 10 different sectors according to the NACE Rev. 2 (at one digit): agriculture, forestry and fishing; manufacturing; extractive industries, energy and water utilities; construction; wholesale and retail trade, transport and storage, hotels and restaurants; information and communication; financial and insurance activities; real estate activities; professional, scientific and technical services, administration and support service activities; and non-market services (public administration and defense, compulsory social security, education, human health, social work activities).

Table 1. Dataset

Countries	13 countries Austria (AT), Belgium (BE), Germany (DE), Denmark (DK), Greece (EL), Spain (ES), Finland (FI), France (FR), Italy (IT), The Netherlands (NL), Portugal (PT) Sweden (SE), the United Kingdom (UK)
Regions	156 regions NUTS-1 (DE, UK) NUTS-2 (AT, BE, DK, EL, ES, FI, FR, IT, NL, PT, SE)
Sectors	10 sectors • Agriculture, forestry and fishing (A) • Extractive industries (B), Energy (D) and water (E) utilities • Manufactures (C) • Construction (F) • Wholesale and retail trade (G), Transport and storage (H) and Hotels and restaurants (I) • Information and communication (J) • Financial and insurance activities (K) • Professional, scientific and technical (M) and Administrative and support service activities (N) • Real estate activities (L) • Non-Market services (O-U)
Period	2000–2015

[11] Crescenzi and Giua (2016) and de Dominicis (2011) also combine NUTS-1 and NUTS-2 regions in their respective empirical studies.

Following the BD.EURS (NACE Rev.2) methodology, we get the variables gross value added (measure in €2010) and employment, which allows us to compute the GVA per worker (measure in €2010) at regional level for the 10 different sectors. In order to complete the dataset with the GVA per capita, we get information about regional population from Eurostat (2018). The dataset for this paper spans the period 2000–2015.

3.2. Descriptive analysis

3.2.1. Regional inequality in Per Capita GVA and labour productivity

In this section some basic statistics describe the evolution of regional dynamics in the 156 European regions included in the sample. First, inequality is measured using different indicators. Table 2 reports the coefficient of variation (CV) in column [1], the population weighted coefficient of variation (WCV) in column [2], the interdecile ratio (P90/P10) in column [3], the interquartile index (P75/P25) in column [4] and the Gini and the Theil (GE) indexes in columns [5] and [6] respectively.

Table 2. Inequality Indexes for per capita GVA. NUTS-2 regions, EU-15

year	CV1 [1]	WCV1[1] [2]	P90/P10 [3]	P75/P25 [4]	Gini [5]	Theil GE(0) [6]
2000	0.329	0.343	2.246	1.511	0.177	0.048
2001	0.323	0.335	2.212	1.497	0.174	0.046
2002	0.319	0.331	2.214	1.497	0.172	0.045
2003	0.308	0.312	2.132	1.471	0.166	0.041
2004	0.308	0.313	2.126	1.481	0.166	0.041
2005	0.311	0.318	2.078	1.474	0.167	0.042
2006	0.311	0.316	2.159	1.513	0.167	0.042
2007	0.311	0.322	2.179	1.507	0.167	0.043
2008	0.312	0.312	2.184	1.467	0.168	0.041
2009	0.306	0.302	2.170	1.405	0.164	0.039
2010	0.321	0.316	2.278	1.450	0.173	0.043
2011	0.332	0.326	2.389	1.492	0.181	0.046
2012	0.344	0.340	2.497	1.474	0.188	0.049
2013	0.351	0.345	2.624	1.450	0.192	0.051
2014	0.346	0.351	2.553	1.458	0.188	0.051
2015	0.344	0.365	2.525	1.462	0.187	0.053
2000-2015[2]	0.292	0.407	0.784	-0.220	0.368	0.679

Note: [1] The Williamson Index when the Coefficient of Variation is population weighted. [2]Annual average growth rates for 2000-2015.

In general, results in Table 2 denote an increase in the dispersion between the 156 regions of EU-15 in terms of CV, WCV, P90/P10, Gini and Theil indexes in 2000-2015; but a decrease in terms of the P75/P25 range. According to the CV and the WCV the 156 European regions have scattered more about the European average between 2000 and 2015 and, consequently, *σ-convergence* has been prevented. Contrarily, regions ranged between the first and the third quartiles are in 2015 closer than they were in 2000. Consequently, it seems that the area in the central part of the distribution has squeezed and the distance between the first and the third quartile has shortened.

As these results are not concluding enough, it is interesting to explore the pattern followed by other inequality indexes. The Gini and the Theil ones provide more accurate measures of inequality than the CV and the WCV because they compute all the distances between any pair of regions in the distribution, and not only the dispersion with regard to the average. Additionally, both have the ability to reflect in their values any change in the relative position of the regions independently they concern to regions located both above or both under the mean.[12]

As can be observed in Table 2, the two indexes report an increase of inequality for the whole period, but especially since 2007. The Gini Coefficient grew at an average annual rate of 0.368% for 2000-2015 and the Theil (0) at 0.679 %. These results are consistent with the P90/P10 range that grew at 0.784% per year. It suggests that distances between the two poles of the distribution have increased and consequently, distances between any region inside the distribution and the two poles too. The simple consideration

[12] One of the most interesting properties required to a good inequality index is to fulfil the "Dalton Criteria". It consists on reflecting in the value of the index any regressive distribution of income between two pair of individuals (regions in our study), independently both individuals are positioned above or both under the average. This property is not satisfied by the CV, the WCV or by the interquartile or interdecile ratios.

of this fact could explain the higher push-up of the Theil and the Gini indexes when compared with the CV or the WCV which only record distances with regard to the mean.

3.2.2. Kernel density functions

To shed further light on the distributional changes happened in the poles of the distribution, Figure 1 shows the Kernel densities of per capita GVA and labour productivity for 2000 and 2015. Regional incomes are plotted on the x-axis, while the associated density is presented on the y-axis. The per capita GVA distribution presents a positive skew with the tail on the right hand side. This Kernel function barely moves to the right between 2000 and 2015, while regional incomes have compressed around the European mean and the head of the distribution inflates. These facts indicate that there are not substantial changes around the mean and that the observed increase in income inequality comes out of the upper tail of the distribution.

Following Duro and Esteban (1998) we have proceeded to break down the Theil index into two factors: the participation rate (EMP/POP) and the labour productivity (GVA/EMP)[13] to explore whether the regional disparities in per capita GVA are due to divergent trajectories in the demographic patterns of the regions or to labour productivity.[14] The Theil decomposition reveals that around 75% of regional disparities in per capita GVA are explained by disparities in labour productivity, while the

[13] Originally, Duro & Esteban (1998) broke down the Theil index of regional per capita income into four factors: (i) labour productivity, (ii) participation rate, (iii) active over working-age population rate, and (iv) working-age over total population rate. We only broke down into employment rate and labour productivity.

[14] Furthermore, the labour productivity is preferred to per capita GDP to avoid some distortions caused the way variables are measured (Eurostat, 2005). GDP is estimated at workplaces while people are counted where they live and may move to work across regions. Furthermore, the "per worker" measurement avoids counting people who do not work such as retirees and other collectives.

employment rate copes a modest 20-25%.[15] These shares have remained quite stable across the fifteen years analysed and are consistent with Duro and Esteban (1998)'s conclusion that most of regional disparities arise from regional differences in labour productivity. Hence, in what follows we will focus our analysis in the evolution of labour productivity.

Figure 1 also contents the labour productivity Kernel density functions for 2000 and 2015. Now, the positive skew of the distribution disappears and the function behaves more normally than in the pc GVA case; the distribution moves more clearly to the right and the two poles of the distribution inflate. Briefly, slight economic growth in Europe in the fifteen years analysed has caused convergence around the EU-13 average while increased distances between the average and the richest regions in per capita GVA terms. Consequently, when regional inequality is explored in labour productivity terms polarization emerges as a defining fact across the European regions.[16]

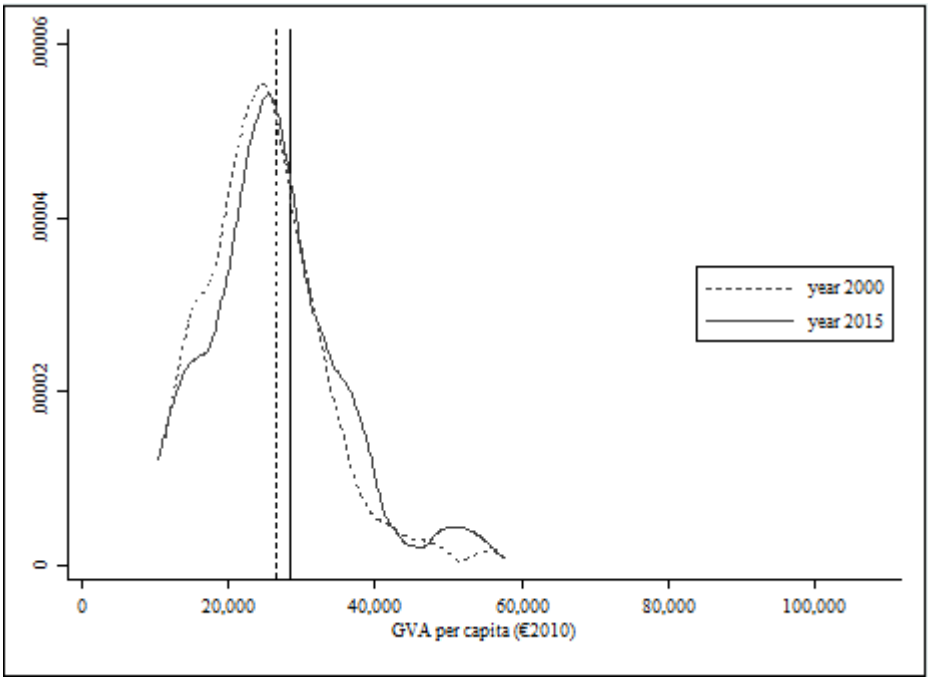
[15] Algebraically, the Theil index of per capita GDP is decomposed into a population-weighted sum of the inequality indices of labour productivity (LP), the participation rate (PR):

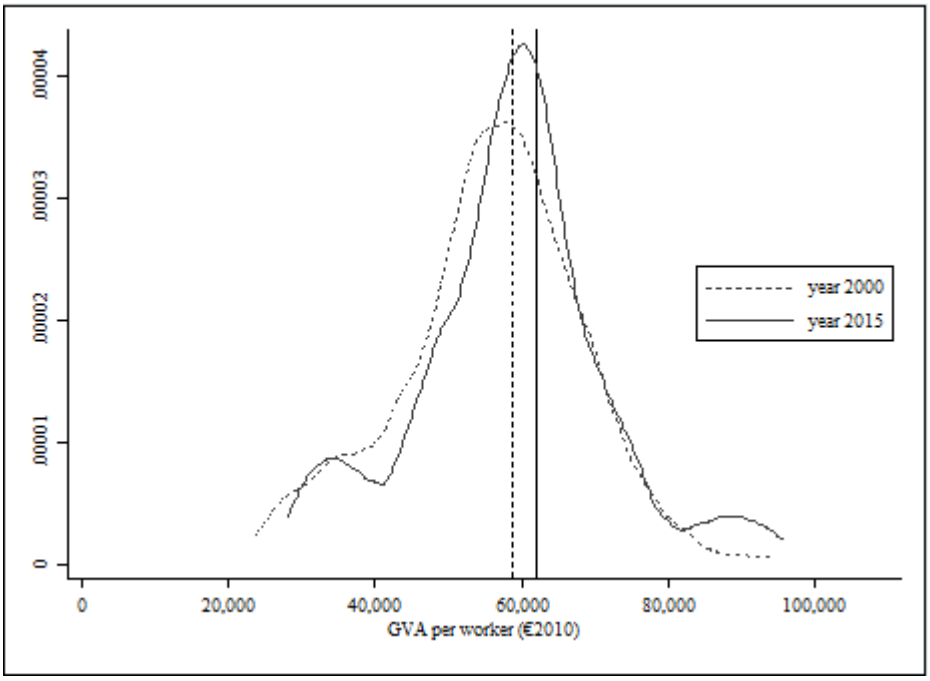
$$(x,s) = \sum_i s_i \log\left(\frac{\mu}{x_i}\right) = \sum_i s_i \left\{\log\frac{GVA/EMP}{GVA_i/EMP_i} + \log\frac{EMP/POP}{EMP_i/POP_i}\right\}$$

where s_i denotes the share of region i in the total EU-13 population, μ is EU-13 average of per capita income, and x_i is regional average of per capita income.

[16] Ezcurra and Pascual (2007) studied the relationship between regional polarization and economic development in the European Union.

Figure 1. Kernel distribution GVA/Population and GVA/EMP



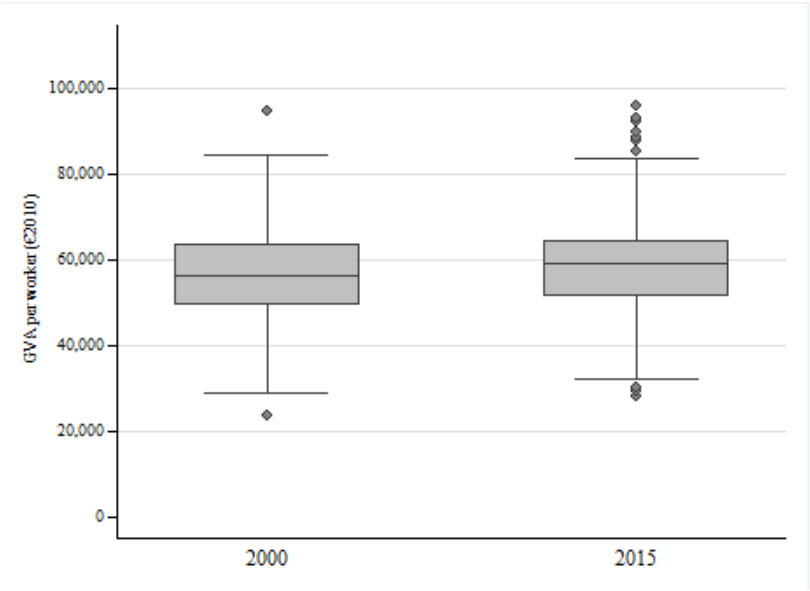


SOURCE: Own elaboration with data described in section 2.

3.2.3. Regions at the two poles of the distribution

The box-plot diagram in Figure 2 let visualize the changes in the regional distribution of per worker GVA with more detail and identify movements in the poles of the distribution. The box contains 50% of the probability mass distribution. Therefore the bigger the box, the bigger is dispersion in regional GVA per worker. The horizontal line inside the box represents the median value and the extreme values of the vertical lines outside represent 1.5 times the interquartile distance; the small circles represent the outlier regions. The size of the box has barely shrunk between 2000 and 2015 while the median value has soared. In 2000, the unique outlier region at the top pole of the distribution was London; by 2015, other six regions swell this rank (Brussels, Bravant-Wallon, Hovedstaden, Île-de-France, Groningen and Stockholm). This group of regions inflates the upper tail of the Kernel function represented in Figure 1. At the opposite pole, Norte and Centro, both in Portugal, were in 2000 the outliers at the bottom pole and in 2015 a Greek region, Anatoliki-Makedonia-Thraki, added to the group of lower outliers. The evidence provided until now points to the ongoing relevance of a bunch of top regions that push up regional disparities and a bunch of poor regions that break away from the central part of the distribution.

Figure 2. Box-plot diagram GVA per worker in the European regions, 2000 and 2015



Source: Main text.

Table 3 ranks the European regions according to their labour productivity in 2015 to observe what has happened at the poles. In this year the top-10 regions are London, Île de France, Stockholm, Brussels, Hovedstaden, Groningen, Brabant-Wallon, Antwerpen, Vlaams-Brabant and Noord-Holland. With the exception of London, all these regions have increased their distance to the EU-13 with regard 2000. They are around 33% to 63% above the EU-13 in 2015. On average, their distance to the EU-13 average has increased by 10 percentage points with regard to 2000. Additonally, in that year only two of them were above 50% of the EU-13 average (London and Brussels), but in 2015 other four regions sums up to this group (Île de France, Stockholm, Hovedstaden and Groningen). It is interesting to note that the top-5 regions in 2015 correspond to regions where the capital city of the corresponding country is located: London (UK), Île de France

(France), Stockholm (Sweden), Brussels (Belgium), Hovedstaden (Denmark) and Noord-Holland (the Netherlands).[17]

Table 3. Ranking of Labour Productivity at NUTS-2, 2000-2015 (EU-13=1)

TOP-10					
ISO	**Region[1]**	**2000[3]**	**Ranking_2000**	**2015[4]**	**Ranking_2015**
UKI	London	1.70	1	1.63	1
FR10	Île de France	1.38	5	1.59	2
SE11	Stockholm	1.44	3	1.57	3
BE10	Bruxelles-Capitale / Brussels Hoofdstedelijk Gewest	1.52	2	1.53	4
DK01	Hovedstaden	1.43	4	1.51	5
NL11	Groningen	1.32	9	1.50	6
BE31	Prov. Brabant Wallon	1.37	7	1.45	7
BE21	Prov. Antwerpen	1.30	10	1.43	8
BE24	Prov. Vlaams-Brabant	1.29	11	1.40	9
NL32	Noord-Holland	1.20	24	1.33	10
BOTTOM-10					
ISO	**Region[2]**	**2000**	**Ranking_2000**	**2015**	**Ranking_2015**
EL52	Kentriki Makedonia	0.59	147	0.59	147
PT15	Algarve	0.55	151	0.59	148
EL65	Peloponnisos	0.59	146	0.58	149
EL43	Kriti	0.53	153	0.58	150
EL63	Dytiki Ellada	0.54	152	0.58	151
EL61	Thessalia	0.56	149	0.56	152
EL54	Ipeiros	0.56	148	0.55	153
EL51	Anatoliki Makedonia, Thraki	0.52	154	0.52	154
PT16	Centro (PT)	0.43	155	0.50	155
PT11	Norte	0.42	156	0.48	156

Note: [1,2] Regions in this column are ordered according to the 2015 ranking in the last column. [3,4] These two columns represent labour productivity of the region with regard to EU-13=1 in 2000 and 2015, respectively.

By contrast the bottom-10 regions are under 59% of the EU-13 for 2000-2015, and on average they have shortened their distance to EU-13 by 2 percentage points, from 53% of EU-13 in 2000 to 55% in 2015. This group is made up of some Greek regions (Kentriki

[17] Rosés and Wolf (2019) find that the capital regions of Europe seem to have increased their size in Europe relative to others in terms of population, employment and GVA. When observed along the 20th century, the recent upsurge of capital cities in Europe arrives after a period of decline comprised between 1945 and the 1980s, in line with the long run evolution of regional inequality in Europe.

Makedonia, Algarve, Peloponnisos, Kriti, Dytiki Ellada, Thessalia, Ipeiros, Anatoliki Makedonia, Thraki) and some Portuguese regions (Centro and Norte). Again, the increase in European regional inequality seems to be driven by a group of regions that grew more than the average and that is mainly made up of the capital regions of the richest European countries, with the exception of Berlin.

In fact, the regions of the top-ten belong to the richest countries in Europe. Figure 3 plots regional labour productivity for each country compared with the EU-13 average and the rest of EU-13 regions for 2000-2015. The coloured solid line denotes the EU-13 average, the black dots represent regions within each country, and the grey vertical dots represent the rest of the European regions considered. The figure let to appreciate regional dispersion within the country as compared with dispersion across the EU-13 regions. It is possible to distinguish three sets of countries. First, those with some outstanding regions at European level and with most of the regions above the EU-13 average: France, The Netherlands, Belgium, Sweden, Denmark and the UK. Second, countries with most of the regions around the European average, with an outstanding region at national level but not necessarily outstanding at European level: Germany, Austria and Finland. Third, countries whose regions are mainly located under the EU-13 average. In this group Spain and Italy had at least one region above the EU-13 average, while Greece and Portugal had all the regions below the EU-13 average.

The first group of countries contain the Very High (VH) income regions of Europe, that is to say, those whose GDP per capita is over 50% of the European average, according to the criteria of Ianmarino et al (2019). Measured in labour productivity terms, only a handful of regions in Europe would belong to this group and all of them are located in

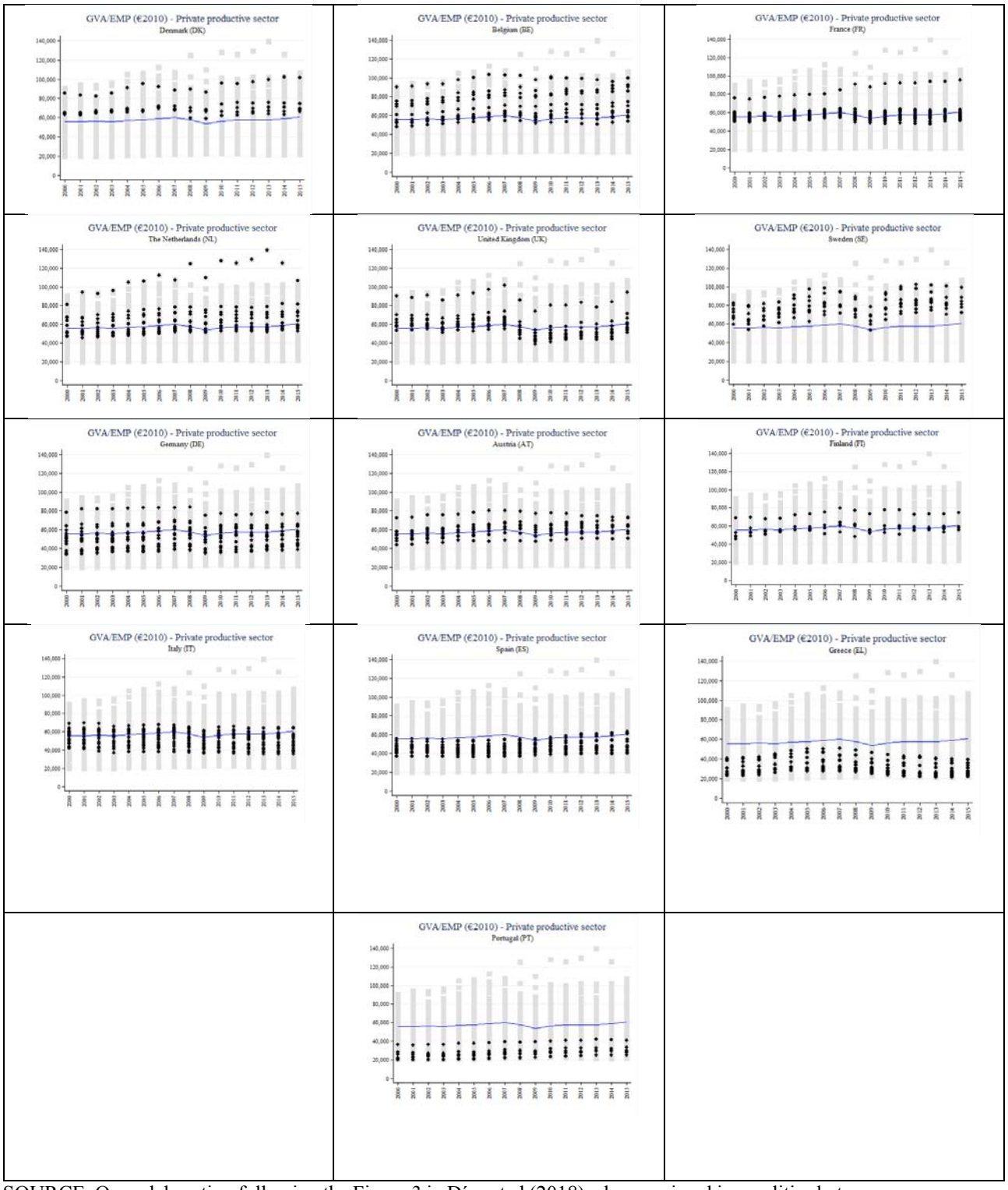
our first group of countries.[18] The VH productivity regions enclose a number of large cities, most of them capital cities, such as London, Paris, Brussels, Stockholm and Copenhagen. It is interesting to outline that, with the exception of Germany and Sweden, regional disparities are increasing inside most of the countries where the VH productivity regions are located (United Kingdom, France, The Netherlands and Denmark)[19]. We guess that this outstanding result is related with the revival of the big cities in Europe and the emergence of new engines of agglomeration.

[18] This classification is quite consistent with that proposed by Ianmarino et al (2018) distinguishing between Very High (VH), High (H), Medium (M) and Low (L) per capita income regions. Very High GDP per capita regions are those over 150% of the EU average; High income regions, those with 120-149% of the EU average; Medium GDP per capita regions, with 75-119% and Low regions, with less than 75% of EU or national averages.

[19] Several indexes have been used to calculate within country disparities: CV, WCV, P90/P10, P75/P25 ant the Theil. Additionally, the Theil decomposition of overall regional disparities in a "within-country effect" and a "between-country" effect reveals that for 2000-2015 an increasing part of regional disparities across European regions are generated inside the country. The "within-country effect" has risen from 39.89% of the overall distances to 45.89%.

Figure 3. Regional Labour Productivity by country as compared

with NUTS-2 regions in EU-13



SOURCE: Own elaboration following the Figure 3 in Díez et al (2018) where regional inequalities between South-Western economies (Portugal, Spain, France and Italy) along 1860-2010 is analyzed.

4. The shift-share analysis

During the past two decades, several studies coincide in attributing differences in labour productivity between European regions to intrinsic structural characteristics of the regions rather than to their own industry mix.[20] These region-specific productivity differentials uniform across sectors have been related with intrinsic characteristics of the regions such as their endowments of human and physical capital, the investment in R&D, and even their institutions; otherwise, the exhaustion of the structural change process during the Golden Age years explains the weak role of the industry mix in the convergence process of the last three decades.

But now, it is supposed that the current wave of globalization and technological change could be changing the economic structure of the regions and their capability to absorb the new technologies (Ianmarino et al, 2019). By the one hand, cutting-edge technologies stimulate the development of finance, knowledge-intensive industries and advanced services. These activities offer new chances for investment and job creation. The new jobs are more intensive in the use of highly skilled workers than the traditional routine-tasks activities used to be and, therefore, the new activities will tend to concentrate in large metropolitan areas where the firms could meet their demands and hire skilled workers in high-turnover labour markets.

Simultaneously, automation and the advance of globalization across the world could be damaging the competitive advantages of the medium and low incomes regions in Europe. When compared with the richest regions, these regions have traditionally enjoyed lower congestion costs and attracted less skill demanding activities. But now the

[20] Esteban (2000), Ezcurra et al (2005), Le Gallo et al (2003), Le Gallo and Kamarianakis (2011), Batog and Batog (2007).

global value chains propelled by the ICT's technologies, jointly with the long-distance transport improvements and the lowering of trade barriers have removed some manufacturing activities from medium and low incomes regions in Europe towards new emerging regions in the Asian countries. Hence, the richest European regions, by the one hand, and the remaining regions, by the other, seem to be confronting the new wave of technological change and globalization in drastically opposite ways.

In this section we propose to decompose the variation in labour productivity across the European regions following the shift-share methodology developed by Caselli and Tenreyro (2006) in order to disentangle which part of the recent upsurge in labour productivity inequality in Europe comes from a "within-industry effect" (technological divergence with the leading regions), a "between-industry" effect (a new pattern of specialization in the leading regions) or a "structural change" effect (labour reallocation across sectors). This method consists on measuring differences in labour productivity (y) of each region *i* with regard to the leading region, *L,* between *t* and *t-1*:

$$\Delta \frac{y_t^i - y_t^L}{y_t^L} = \frac{y_t^i - y_t^L}{y_t^L} - \frac{y_{t-1}^i - y_{t-1}^L}{y_{t-1}^L} \tag{1}$$

Caselli and Tenreyro (2006) take as benchmark a hypothetic "average region". Notwithstanding, in order to take into account the increasing polarization observed in Europe in the period analysed, we have followed Enflo and Rosés (2015)'s work, where a leading region is taken as reference. Algebraically:

$$\Delta \frac{y_t^i - y_t^L}{y_t^L} = \sum_{j=1}^{J} \bar{s}_{jt}^i \Delta \left(\frac{y_{jt}^i - y_{jt}^L}{y_t^L} \right) +$$

$$\left[\sum_{j=1}^{J}\left(\frac{\bar{y}_{jt}^{i}}{y_{t}^{L}}\right)\Delta s_{jt}^{i}-\sum_{j=1}^{J}\left(\frac{\bar{y}_{jt}^{L}}{y_{t}^{L}}\right)\Delta s_{jt}^{L}\right]+\sum_{j=1}^{J}\left(\bar{s}_{jt}^{i}-\bar{s}_{jt}^{L}\right)\Delta\frac{y_{jt}^{L}}{y_{t}^{L}} \quad (2)$$

where *j* denotes the sector, *i* denotes the region, *L* the leading region and s_{jt} the share of sector *j* in the total productive value added of the region *i*. In our study five benchmark regions are considered separately. They correspond to the top-5 regions in EU-13 according to labour productivity in 2015 (see Table 2). All of them exhibit a labour productivity level well above 50% of the European average (EU-13=1): London (1.63), Île de France (1.59), Stockholm (1.57), Brussels (1.53) and Hovedstaden (1.51).

The shift-share analysis splits down differences in labour productivity across regions in three major components, as can be observed in equation 2. First, the *within-industry* component represents the labour-productivity catch-up or divergence of each sector *j* with its equivalent in the leading region, weighted by the average share of employment in sector *j*. Second, the *labour reallocation term* measures the convergence resulting from labour flows across sectors and the convergence with the productive structure of the leading region. And third, the *between-industry* component captures in which extent the pattern of specialization followed by the leading region has increased distances with regard to the other regions. The left side of equation 2 denotes convergence with the leading region when sheds a positive sign; otherwise, divergence. The different terms of the right hand side represent also convergence or divergence in terms of the "within-industry", "labour reallocation" and "between industry" components depending upon their respective signs are positive or negative.

The study is based on the comparison of the 155 European NUTS-2 regions belonging to EU-13 with regard to each leading region taken separately and the results

are summarized in Figures 4 and 5.[21] We have disaggregated the value added of the productive economy in ten activities corresponding to the three basic sectors: agriculture; industry (extractive industries and utilities, manufacturing and construction); and services (retail, trade and other market services; information and communication services; finance and professional activities; real state services and non-market services).

On average the 155 European regions have diverged by -0.91% from the Region of Brussels (Brussels), -5.74% from Hovedstaden (Copenhagen), -14.73% from Ile de France (Paris) and -8.73% from Stockholm. Surprisingly, the shift-share analysis shed a balance of convergence with the richest region of Europe, the Greater London, by 3.45% between 2000 and 2015. This unexpected result is mainly attributable to the depreciation experienced by the British currency with regard to the euro since 2000. Labour productivity in the region of London was 1.70 the European average in 2000, fell to 1.35 in 2009 and resumed progressively up to 1.63 in 2015. Consequently, the European regions have shortened their distances with London between 2000 and 2015. This optimistic result is in part a monetary illusion, and convergence in real terms is still questionable. In order to avoid the plausible bias entered by the monetary effect in the shift-share analysis, in what follows we won't consider London as a reference region.

[21] For the shake of clarity in Table 4, and in Figures 4 and 5, we have named the leading regions by their capital city name. For instance, London refers to Inner London; Brussels to the Region of Brussels; Copenhagen to Hovedstaden; Paris to Île-de-France and Stockholm to the Stockholm region.

Figure 4. Convergence in Labour Productivity with the top-5 European regions 2000-2015

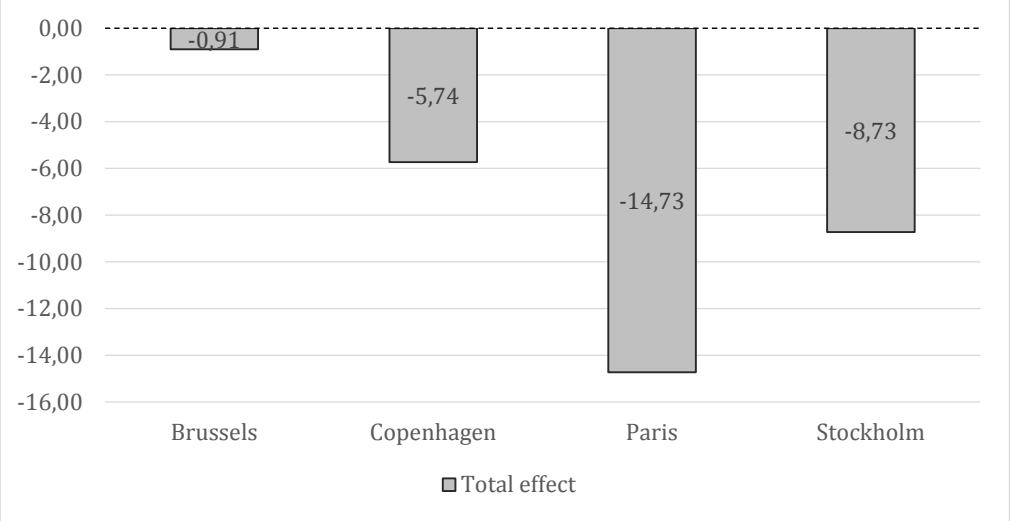
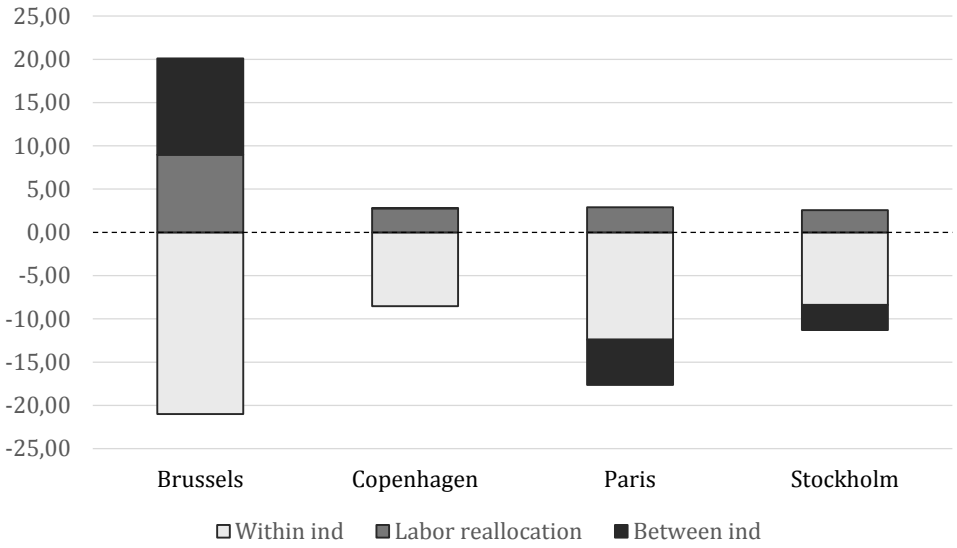


Figure 5. Convergence in the shift-share components, 2000-2015



SOURCE: See the text. The positive sign represents convergence with the leading region; the negative sign, divergence.

Anyway, returning to the results of the shift-share analysis, the decomposition assigns most of the divergence to the "within-industry" component (Figure 5). In the

literature this component represent the "productivity differential" related with intrinsic regional attributes that make some regions more productive than others.[22] In dynamic terms, the negative sign of this component denotes that the technological gap between the leading region and the rest has increased between 2000 and 2015. Table 4 details the magnitude of the "within-industry" component by industries. In general, all the leading regions have increased the within-industry distances with the rest of regions in manufacturing, IC services and finance. These activities are the most seemingly related with the new wave of technological change and confirm the hypothesis postulated above. In the remaining activities, such as agriculture, the retail and professional services we find mixed results, although the negative sign also prevails.

Intense divergence in the "within-industry" component is usually related to divergence in the "between-industry" component, as can be found in the case of Île-de-France or Stockholm. A negative sign of this component is a consequence of a greater specialization in the leading region in those activities where the region is more competitive, or where the productivity has increased with regard to the average. When we look underneath the total "between-industry" effect, we find that the leading regions have specialized more intensively than the other regions in IC services, finance and manufacturing, that it is to say, in those sectors more prone to IC technologies. Then, the negative "between industry" effect sign is mainly attributable to a pattern of specialization mainly based in those activities more related with the incorporation of new technologies.

[22] The differences observed across regions in the ratio of capital per worker, the stock of human capital or the technological level are the main sound candidates to explain differences in productivity between regions.

Table 4. Shift-share components by industry and leading region, 2000-2015

	Within-industry									Labour reallocation	Between industry
	Agricult	Utilities	Manuf	Const	WRTAF	IC serv	Finance	Prof serv	TOTAL	TOTAL	TOTAL
Bruxelles	-4.36	3.64	-12.16	-1.77	-2.46	-0.24	-1.94	-0.04	-21.01	8.96	11.14
Hovedstaden	-1.32	9.20	-12.74	-0.56	-0.06	-2.64	-1.97	1.51	-8.53	2.78	0.02
Île de France	1.13	-0.48	-2.99	1.94	-3.58	-1.91	-0.76	-1.75	-12.41	2.90	-5.22
Stockholm	-0.36	1.78	-6.87	2.44	-2.94	-1.57	-1.56	-1.62	-8.39	2.56	-2.90

Source: Own elaboration, see the main text.

The second term of Equation 2 represents the movement of the labour force from one of the ten sectors to another in search for better job opportunities. As can be observed in Figure 5 the "labour reallocation" effect has been positive but practically negligible in the four cases analysed. We find two potential explanations for this nonentity contribution of the "structural change" to the overall divergence. One of them has to deal with the counterbalancing forces operating simultaneously in the leading and the medium and less developed regions with regards to the changing composition of the productive structure. While the low and medium productivity regions tend to emulate the productive structure of the head regions throughout a process of terciarization (convergence), the richest regions are reallocating workers towards the emerging high knowledge intensive industries and services (divergence). The final balance is a weak process of convergence.

In the "labour-reallocation" component the increasing share of services in the non-leading regions win out the emerging presence of modern activities in the leading regions. The size of modern sectors is still not big enough to have a determining impact on total "labour reallocation". Moreover, one can consider that the new sectors are not still properly measured in the statistics. For instance, the high level of aggregation of the manufacturing industry could be masking part of this "structural change" occurring in the most advanced regions. Hence, in spite of we have broken down the economic structure of the regions in ten activities to capture a potential new "labour reallocation" effect, the current level of disaggregation still fails in taking a defined picture of it, at least for manufacturing. Consequently, part of the "reallocation effect" towards the new IC

industries remains hidden inside the "within-industry" effect yield by manufacturing in all the leading regions.[23]

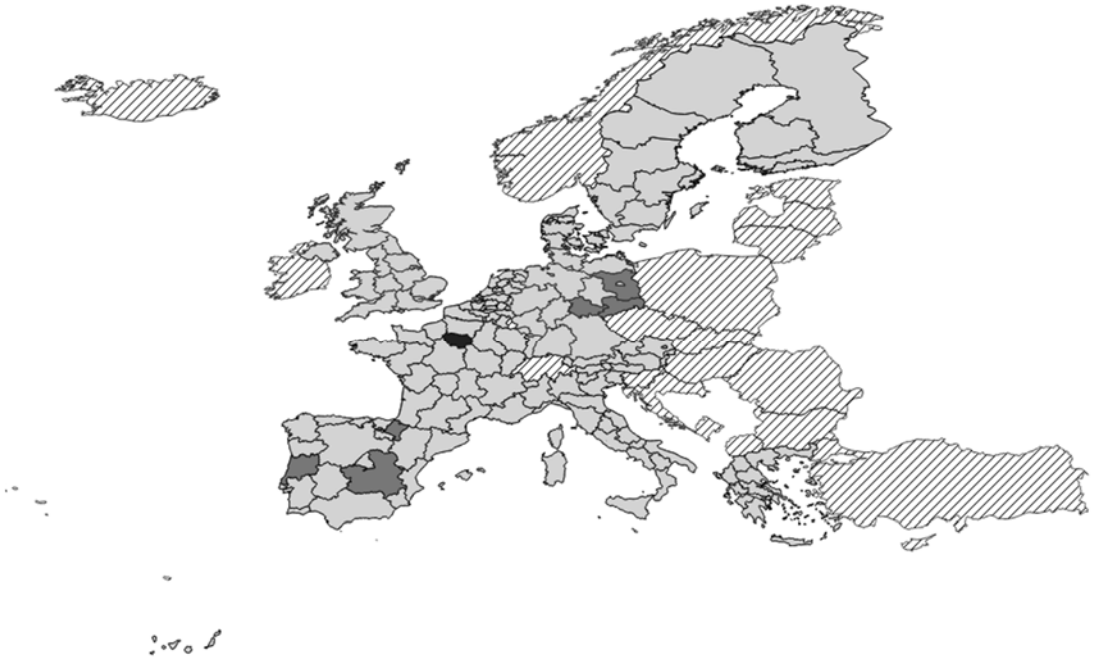
Finally, the "between-industry" component can be interpreted as that part of regional divergence derived from the specialization of the leading region in the most productive industries, as compared with the other regions. We find a negative "between-industry" effect in Ile de France and Stockholm. The negative sign denotes that the leading regions tend to specialize more intensively than the others in those industries where productivity is increasing more than the average. Additionally, we find that most of the negative effect arises from three activities very close to the new wave of technological change: the extractive and energy industries, the IC services and finance. In general all the leading regions considered in our study exhibit a negative sign (divergence) in these sectors with regard to the non-leading regions, denoting a higher specialization in these industries. This important result gives support to the hypothesis that the current rise of regional disparities in Europe is mainly driven by some regions where large metropolitan capital cities are located and where the local conditions seem to be more favourable to attract the new industries. The exploitation of some urban agglomeration economies could act as a focus of attraction of knowledge intensive industries and services.

Finally, in Maps 1 to 4 we have plotted the spatial distribution of the total "shift-share" effect and its broken-down in the three components (within-industry, labour reallocation and between-industry). The main objective is to identify specific patterns

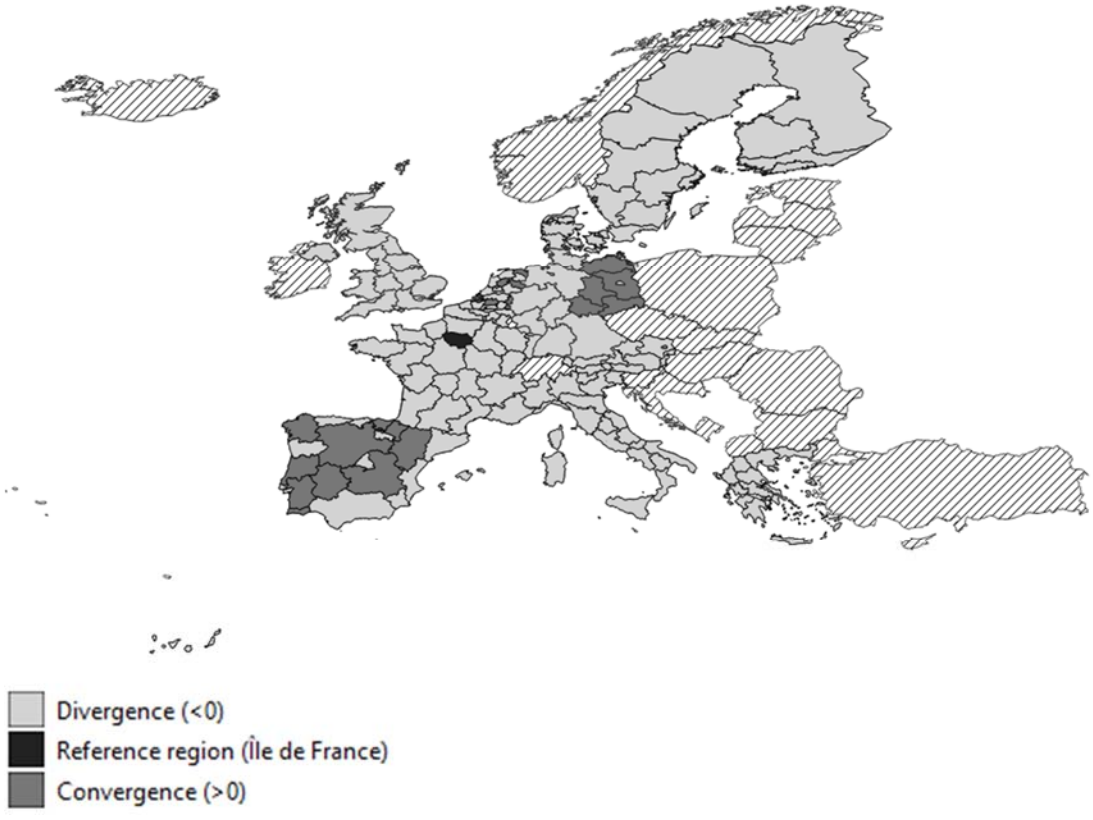
[23] O´Leary and Webber (2015) arrived to similar conclusions in an analysis based on 181 European regions for 1980-2007. They find that the role of structural change in European regional productivity growth was far from negligible, and substantially stronger for those regions at the top of the distribution.

through the sign of each component that have to deal with spatial location of the region and with its level of development.

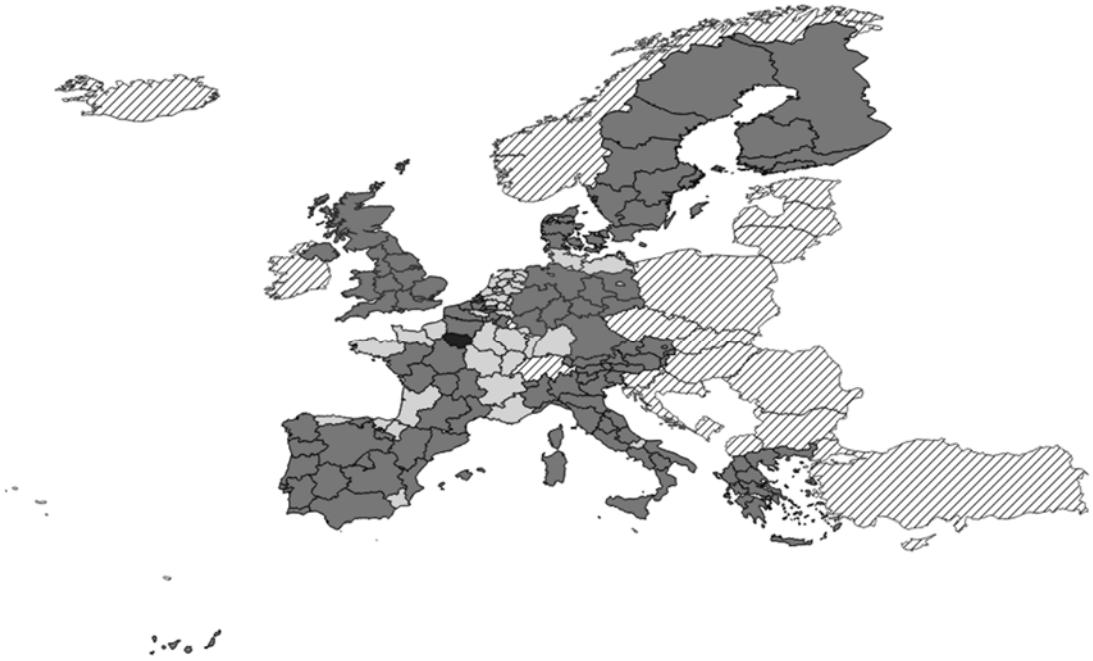
Map 1. Total shift-share convergence. Ile de France as reference region



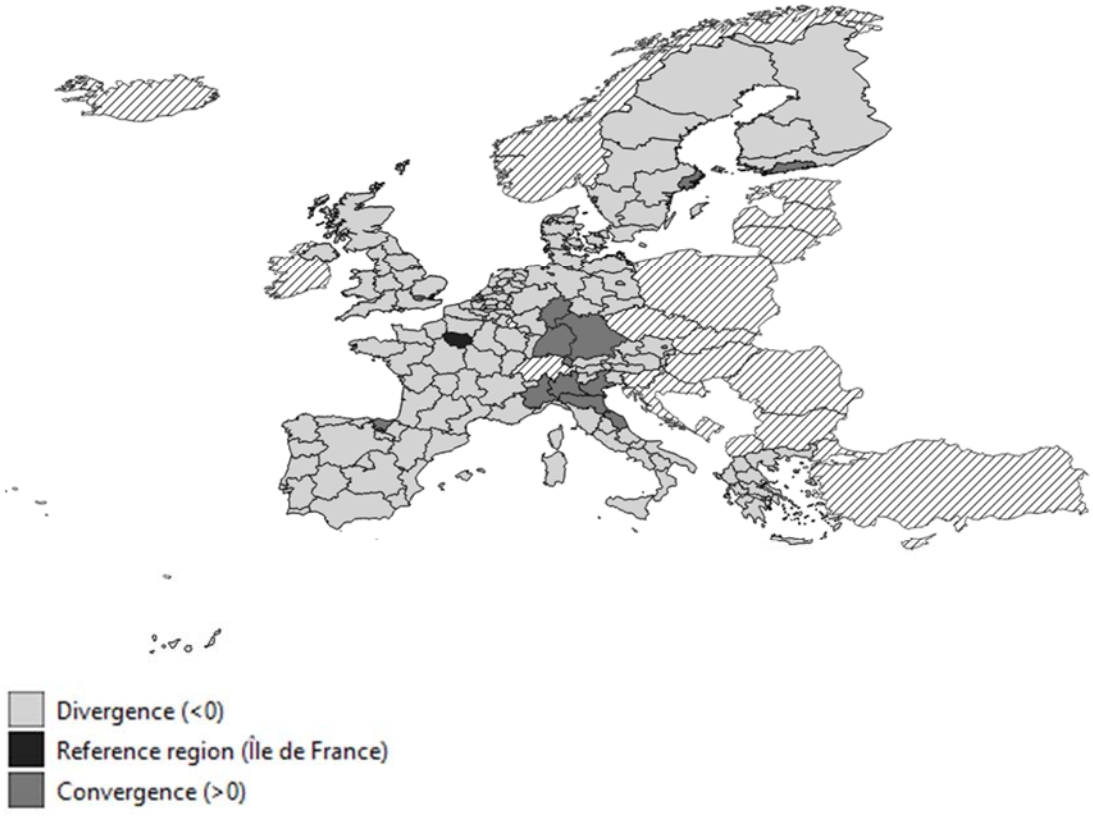
Map 2. “Within-industry” component. Ile de France as reference region.



Map 3. “Labour reallocation” component. Ile-de-France as reference region



Map 4. “Between-industry” component. Ile-de-France as reference region



For brevity reason, we have represented only the results with regard to Ile-de-France (Paris). The reference region is coloured in black, while divergent regions are light grey-coloured, and convergent regions are dark grey-coloured. The negative sign (divergence) dominates Map 1 where the "total shift-share" is plotted, that it is to say, Ile-de-France is getting distance in terms of labour productivity with most of the European regions. The exceptions are some of the poorest regions in Spain (Castilla-La Mancha), Portugal (Centro) and the Eastern part of Germany (Branderburg, Sachsen and Thüringen) that have come through its backwardness levels and have reduced their distances with the leading region.

Map 2 confirms that the "total shift-share" effect is dominated by divergence arising from the "within-industry" component. Again, most of the regions in Europe are diverging from Ile-de-France due to a higher technological advance in this leading region. Simultaneously, only some of the most backward regions in Europe, located in Portugal, Spain and Eastern Germany, have progressed enough to catch-up with the leader, possible by taking advantage of their backwardness or by benefiting from European redistributive policies. Map 4 where the "between-industry" effect is drawn reinforces the spatial distribution of the "within-industry" effect. Divergence with regard to Ile-de-France dominates the map, confirming that this leading region is becoming more specialized in high productivity industries when compared with the middle and low incomer regions. However, when compared with the richest regions in Europe the dark grey colour (positive sign) dominates the map (London, Stockholm, Helsinki; Bremen, Hamburg, Baden-Würthemberg, Bayern, Hessen; Piemonte, Lombardia, Veneto, Emilia-Rogmana and Marche) are becoming more specialized in the most productive sectors than Ile-de-France.

Finally, in Map 3 “labour-reallocation” convergence with Ile-de-France dominates across the European regions. Although positive, this effect is not high enough to counterbalance the divergent forces coming from the technological advance and the subsequent pattern of specialization. Hence Map 1, where the three effects are summarized, reveals that most of the European regions have diverged with Ile-de-France, and only some backward regions in Portugal, Spain and the Eastern part of Germany have achieved convergence with this leading region. The results obtained for Ile-de-France could be extended to the other leading regions.

4. Conclusions

In this paper we analysed the evolution of regional income disparities in 13 European countries over 2000-2015 at NUTS-2 level. The results obtained confirm the upsurge of regional income inequality in Europe. Additionally, we observe that it has been mainly driven by the fast progress of some of the richest regions in Europe, while low and middle income regions get closer to the European average in 2015 than they used to be in 2000; simultaneously, an increasing number of the low income regions are getting trapped at the bottom pole of the distribution. Therefore, a more polarized structure of income distribution emerges. These results are in line with the idea of a N-curve between per capita income and regional inequality observed for the United States (Ganong and Shoag, 2017) and connect with the long run trend observed for the European regions (Rosés and Wolf, 2019).

The same arguments that Williamson (1965)’s used to explain U-inverted relationship between per capita income and regional inequality in the past could be extrapolated to explain the consequences of the new technological wave on regional disparities (Barrios and Strobl, 2009). At first stages of industrialization, unequal

structural change was the main source increasing inequality across regions (Williamson, 1965). Now other types of technological shocks could entail structural changes that alter productivity and have a dissimilar impact across regions (Barrios and Strobl, 2009). Nowadays cutting-edge technologies are more knowledge-intensive than the traditional ones and generate activities more intensive in the use of highly skilled workers and the exploitation of R&D networks. These new activities tend to concentrate in large metropolitan areas where the firms could meet their demands for high skilled workers and capital in high-turnover factor markets and could at the same time benefit from the advantages of market size.

The dynamic shift-share study performed taking as reference the regions identified as productivity leaders in Europe let to conclude that these regions, most of them capital cities homes, have increased labour productivity more than the average in 2000-2015. And their success has been mainly conducted by a bigger increase in productivity within most industries (within-industry effect) and a higher specialization in the most dynamic industries (between-industry effect). The divergence in terms of the within-industry effect extents to most industries, but especially to those more closely related with the new wave of technological change (manufacturing, IC services, finance, professional services and retail services). Meanwhile the between industry effect reveals that the prosperity in the richest regions of Europe could be linked to a pattern of specialization the most productive industries.

The descriptive study of regional disparities and the shift-share analysis addressed in this paper run in support of some sort of technological shock that is affecting differently the European regions and that tends to concentrate the new activities in the richest regions of Europe, where the biggest cities are located. Notwithstanding these highlighting results, the sign of the "labour reallocation" effect does not let us to confirm, at least by

now, that the "structural change" is becoming a central force to explain the new upsurge in European inequality, as it used to be in the past.

We are aware of the weaknesses derived from the use of a level of sector disaggregation that do not let to capture interesting changes in the productive structure, specially inside the manufacturing sector. The official statistical offices also recognize problems to correctly identify, measure and define the new sectors, jobs and capital. Lastly, and not less relevant, it is possible that the concept of "structural change" based in the idea of labour reallocation is getting obsolete in an era of technological change less intensive in job creation. Whether the under-representation of the "structural change" in the explanation of overall changes in regional inequality is a question of time, data or concept are matters that should be addressed in future research agendas.

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