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Are cities the real engines of growth in the EU?

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Between 2001 and 2021, capital metro regions had the fastest productivity growth in the EU, followed by non-metro regions, while it was much lower in other metro regions. Capitals reduced their sectoral concentration, while the other regions increased it. Our shift-share analysis confirms that capitals relied entirely on productivity growth within sectors, while the other two types benefitted also from shifting jobs to more productive sectors. Our regression analysis showed that convergence and being a capital boosted productivity growth. Population density also strengthened productivity growth, but not enough to prevent other-metro regions from lagging behind the non-metro regions.

Keywords

#growth #productivity #employment #capital #metro #regions #Europe #EU #ARDECO

JEL Classification

E24, O18, O32, P25, R12

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1. Introduction

Studying productivity growth at the regional level is crucial for identifying key local determinants that drive competitiveness, especially in a period of economic slowdown (European Commission, 2022). This phenomenon has sparked a growing body of research aimed at characterising and identifying regions in a development trap (Diemer et al., 2022; Proietti et al., 2022). Conversely, another strand of research has focused on dynamic regions, including "superstar cities", “core cities” and "winner-take-all cities" (Florida et al., 2020; Gyourko et al., 2013), where residents can benefit from agglomeration economies, but often face challenges such as congestion, pollution, and housing unaffordability (Buchholz, 2002; Dijkstra et al, 2013; Hilber and Mense, 2021; Martin et al., 2018; Nijkamp and Kourtit, 2013) which can limit productivity growth in the future.

This underscores the need for a deeper understanding of the factors that drive regional divergence both in -at present- high performing regions and in those in a development trap. While existing research has extensively examined how residents in these territories perceive socio-economic developments and/or vote (Rodríguez-Pose et al, 2024) or access social mobility (Chetty et al., 2016; McNeil et al., 2023), less attention has been paid to the role of the economic structure itself in contributing to this divergence at a high level of regional disaggregation (Bathelt et al., 2024). This is particularly relevant in determining inequality within Europe (Carullo et al., 2025).

This paper aims to address this knowledge gap by analysing regional productivity patterns at the level of metropolitan regions in the EU-27 from 2001 to 2021. Using a shift-share analysis with a 10-sector level of disaggregation, we decompose interregional productivity differentials into "within sector productivity" and "between sector" components. We also investigate the combined impact of the sectoral profile of the economy on productivity growth with variables like population density, region type, employment growth patterns, innovativeness, and transport infrastructure performance. The paper is also to understand whether cities have been the real engines of growth in the European Union (EU) in the last 20 years or not. Fothergill and Houston investigated this phenomenon in 2016 for the UK. Differently in this paper, we also explore the role played to overall labour productivity growth by other territories in the EU, such as non-metros and other metros (non-capital).

This paper bridges two distinct literatures: the first focusing on urban agglomerations, a concept that has been explored by scholars since the late 19th century. Pioneers such as Alfred

Marshall (1890) introduced the idea that cities can drive economic growth by facilitating knowledge spillovers and innovation, which are essential for productivity and competitiveness. Later, Hoover (1948) built on Marshall's work by highlighting the role of economies of scale in urban economic development, while Jane Jacobs (1969) emphasized the importance of urban diversity. Jacobs argued that the co-location of diverse industries and activities can lead to increased innovation and economic vitality, a concept that has been widely influential in urban economics. More recently, McCann and Van Oort (2019) provided a comprehensive and authoritative overview of the theoretical and empirical foundations of urban agglomerations and their impact on economic development, synthesizing the rich and complex literature in this field.

The second literature stream our paper focuses on the impact of sectoral composition and within sectors' productivity on overall labour productivity and also the broader relationship between productivity and employment. In this body of literature, which is more recent than the one on urban agglomeration, Martin et al. (2018) analysed the productivity growth trajectory of 85 British cities between 1971 and 2014, revealing a slowdown in productivity growth, significant structural convergence across cities, and a decline in the degree of specialization. Notably, their findings indicate that structural change had a detrimental impact on productivity in all cities, whereas within-sector productivity was the primary driver of labour productivity growth. In a broader context, Enflo (2010) investigated labour productivity across 89 Western European regions and 51 American states and districts over the 1950-2000 period, demonstrating a more pronounced employment-productivity trade-off in Europe compared to the US. This suggests that productivity growth might also rely on employment rationalisation as also featured in Compagnucci, et al. (2021), especially if product innovation is slower than process innovation.

Studies focusing on the impact of sectoral composition and within-sector productivity in Europe have predominantly been conducted at the NUTS2 level, as this was the primary target of cohesion policy. For example, Gómez-Tello et al. (2020) analysed productivity disparities across NUTS 2 regions, focusing on the period of 2000-2015 for 13 European countries. What distinguishes this work from others is the selection of a benchmark region in the shift-share analysis instead of considering the average region. This choice, following Enflo and Rosè (2015), helped them better highlighting the progress of a group of rich regions in Europe. Le Gallo and Kamarianakis (2011) also explored the relationship between sectoral composition and productivity growth across NUTS2 regions. By combining the classical shift–share analysis with spatial econometrics, they found that the distribution of regional productivity is characterized by positive spatial autocorrelation. Recent studies have shifted towards examining productivity differences also at the NUTS3 level. For example, Kilroy and Ganau (2020) analysed 1321 NUTS3 regions in the EU over the period 2003-2017 also by clustering them in high income, transition, less developed and low-income. They found that the most impactful sectors differ among regions by income level and by long-run growth category. Barrios and Strobl (2009), suggest that technological shocks may also increase the likelihood of observing a more influential structural change in productivity, versus the typically more influential within-sector productivity differentials.

By examining the interplay between urban agglomerations and sectoral composition, our paper contributes to the literature in several ways. First, it provides a novel analysis of productivity growth at a higher level of spatial disaggregation and sectoral detail – at the level of metropolitan regions, covering all EU-27 countries, within a twenty-years period (2001-2021) and for 10 different sectors.

The shift in the analysis toward a higher level of disaggregation, is coherent with the increasing allocation of cohesion funds to integrated territorial investments and sustainable urban development strategies during the 2014-2020 and current programming periods. Second, we disaggregate our analysis by capital (metropolitan) regions, other metropolitan regions, and non-metropolitan regions. This regional breakdown allows us to demonstrate that non-metro regions have been reducing their distance from other metro regions in terms of productivity growth, but some of this convergence can also be linked to partial employment rationalisation in non-metros regions. Third, we show that labour productivity growth has translated into growth in income, particularly in capitals in 2001-2011 and in other-metros in 2011-2021, but less so in non-metros. Finally, we combine the impact of the sectoral composition of the economy with other variables, which are influential according to the literature, such as patent applications and transport infrastructure performance and found evidence of other co-variates that locally influence productivity and might become the target of policies that aim increasing overall productivity.

The remaining of the paper is structured as follows: section 2 first describes the data and trends and then introduces the empirical model. Section 3 presents the results. Section 4 draws the discussion to a conclusion, presents some limitations, avenues for further research and implications for policy making.

2. Data, regional characteristics and empirical strategy

2.1 Data sources

The primary source of data used for this paper is the Annual Regional Database of the European Commission (ARDECO[4]), which provides a more comprehensive and up-to-date dataset compared to its predecessors such as BD.EURS (Gòmez-Tello et al, 2020; Escriba, & Murgui,2014). This comprehensive database provides consistent and harmonized time-series data on demographic and socio-economic statistics, ranging from national to metropolitan levels. ARDECO relies mainly on data from official sources, including Eurostat's 'Regional Accounts' and national or regional statistical offices (Auteri et al., 2024).

The analysis is conducted at the level of metropolitan regions, referred to as "metro" for the remainder of the paper. This unit is based on the Nomenclature of Territorial Units for Statistics (NUTS)[5]. For instance, metros are defined as NUTS level 3 approximations of functional urban areas (FUAs), which have at least 250,000 inhabitants. These comprise a city and its surrounding commuting zone. Each FUA is represented by at least one NUTS3 region. If more than 50% of the population in an adjacent NUTS3 region resides within the FUA, it is included in the same metro. Each metro is named after the principal FUA within its boundaries.

Our analysis covers 960 regions across the EU-27. We examine the data by categorizing them into different typologies: capitals (27), other metros (216), and non-metros (717).[6] Appendix 1 provides some descriptive information in terms of population, employment and GDP (Million PPS) across these three types of regions.

The study manly focuses on population, employment, Gross Domestic Product (GDP) and Gross Value Added (GVA) data, primarily for the years 2001, 2011, and 2021. Both employment and GVA are further broken down into 10 sectors: agriculture, forestry, and fishing; industry (excluding construction); construction; wholesale and retail trade, transport, accommodation, and food service activities; information and communication; financial and insurance activities; real estate activities; professional, scientific, and technical activities; administrative and support service activities; public administration, defence, education, human health, and social work activities; arts, entertainment, and recreation; other service activities;

[4] https://urban.jrc.ec.europa.eu/ardeco/explorer?lng=en. Data downloaded in November 2024.
[5] https://ec.europa.eu/eurostat/web/metropolitan-regions/information-data
[6] Cork is excluded from the analysis.

and activities of households and extra-territorial organizations and bodies. A description of the variables used in the analysis as well as their descriptive statistics are provided in Appendix 2 and 3.

2.2. Relation between income, productivity, employment and population

To start investigating the relation between income, productivity, employment and population, we decompose the GVA per capita growth into the sum of labour productivity, employment and population growth using the following formula:

$$\sum_{j=1}^{m}\left(\frac{Z_{j2021}-Z_{j2001}}{Z_{j2001}}\right) = \sum_{j=1}^{m}\left(\frac{Y_{j2021}-Y_{j2001}}{Y_{j2001}}\right)+\left(\frac{l_{j2021}-l_{j2001}}{l_{j2001}}\right)-\left(\frac{p_{j2021}-p_{j2001}}{p_{j2001}}\right) \quad (1)$$

Where j is the region, *m* is the number of regions of a certain type, with *m*=*n* if the analysis runs on all types of regions. Z_j refers to the GVA per capita (GVA over the number of persons), Y_j to regional labour productivity (GVA over the number of employees), l_j is the number of employees and p_j the population in region *j*.

This decomposition is performed to gain a deeper understanding of the underlying drivers of GVA per capita growth. By breaking it down, we can identify whether the growth is primarily due to increased labor productivity—indicating that workers are producing more output, potentially due to factors like technological advancements—or whether it's driven by a rise in the number of individuals employed. Additionally, it allows us to assess the impact of population growth.

Table 1. Decomposition of GVA per capita growth (%)

	Total	Labour productivity	Employment/ Population	Employment	Population
Capitals	29%	20%	9%	22%	13%
Other-metros	17%	10%	7%	13%	6%
Non-metros	23%	18%	6%	4%	-2%
All	23%	15%	7%	11%	4%

Source: Authors' elaboration on ARDECO database

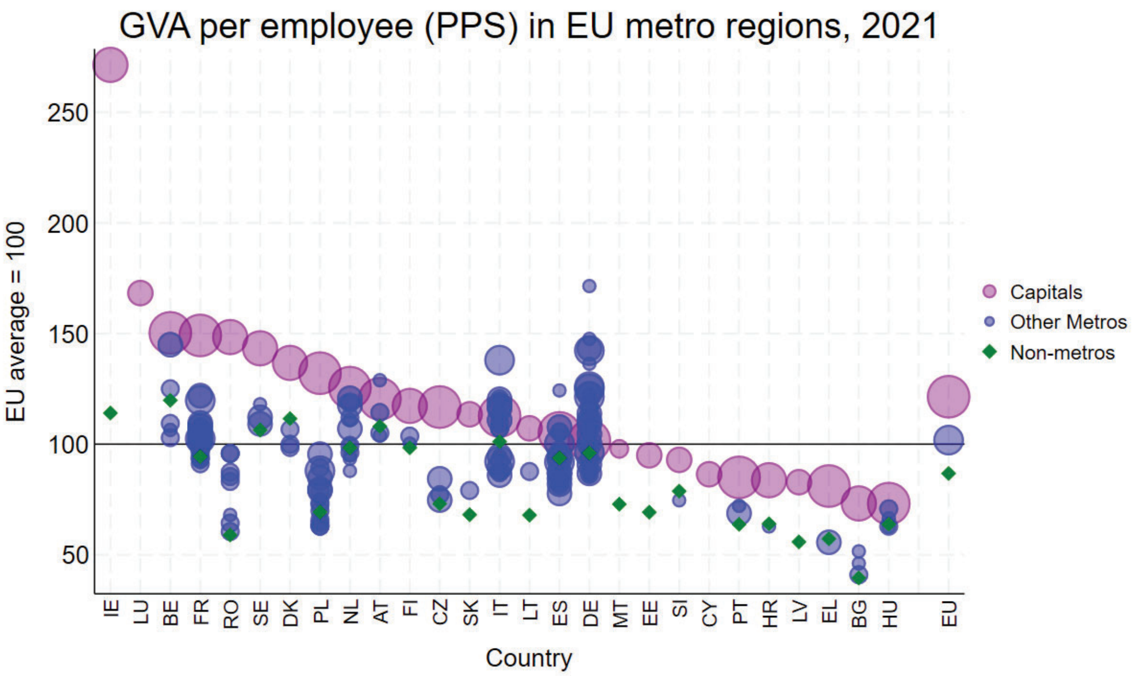
Table 1 shows that when considering all European regions and a long time span namely 2001-2021, labour productivity emerges as the main driver of per capita income disparities, with a share of 15% and coherently with what already found in Esteban (2000).

Given the extended timeframe considered in this analysis, it is possible to recognize that the observed variation in labor productivity incorporates broader economic transformations, particularly technological advancements and procedural innovations. This is particularly the case in non-metro regions, where labour productivity (18%) is the dominant driver of GVA per capita growth. Employment growth (4%) being quite modest, and population growth negative (-2%) due to negative natural change and/or net outmigration.

Instead, in capitals the largest contributor to GVA per capita growth is employment (22%). Growth in employment (13%) is a major contributor also in other-metros, but their productivity growth (10%) is half that of capitals (20%) and almost half that of non-metros (18%). When employment is the dominant driver of GVA per capita growth, this means that the labor market is dynamic and able to attract higher-skilled workers and support more efficient labor allocation.

At the EU level, capitals have the highest labour productivity (121), followed by other-metros (102) and with non-metro last (87) in 2021 (Figure 1). This pattern is replicated in most Member States with the capital as the top performer, except in Austria, Italy, Spain and Germany (Figure 1). 13 Member States (Austria, Belgium, Croatia, Germany, Denmark, France, Greece, Hungary, Italy, Spain, Poland, Slovenia and the Netherlands) have a metro region that has a lower productivity than the non-metro average. This shows while the average other-metros productivity is higher than non-metro one, some other-metro perform worse than the non-metros.

Figure 1: GVA per employee (PPS) in EU regions, 2021[7]



Source: Authors' elaboration based on ARDECO database (2024)

2.3. Labor productivity across regions

Looking at labor productivity growth across all region types, it is evident that, over the past 20 years, labor productivity has consistently increased, accompanied by a growing number of regions that are outperforming the average. Appendix 4 illustrates the changes in GVA per worker through a series of boxplots. As visible from the horizontal line in the boxes, the median value of productivity has been increasing over time. The dimension of the box has remained stable, but the number of outliers at the top of the distributions (represented by values above 1.5 times the interquartile difference) has increased.

Instead, by examining labour productivity growth by region type, we observe that GVA per worker has increased across all three categories indicating broad-based productivity gains over the period. However, important differences emerge within each group. Other metros show

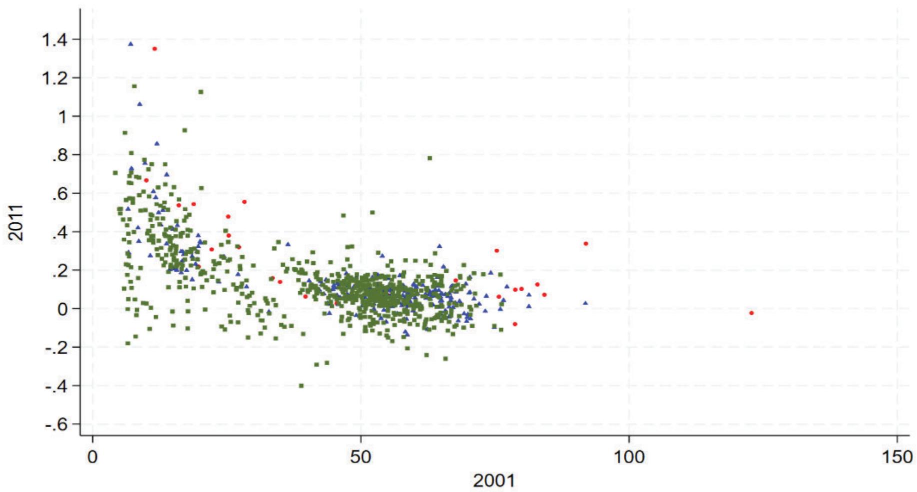
[7] The graph is ordered by decreasing GVA per employee in purchasing power standard (PPS) in capitals

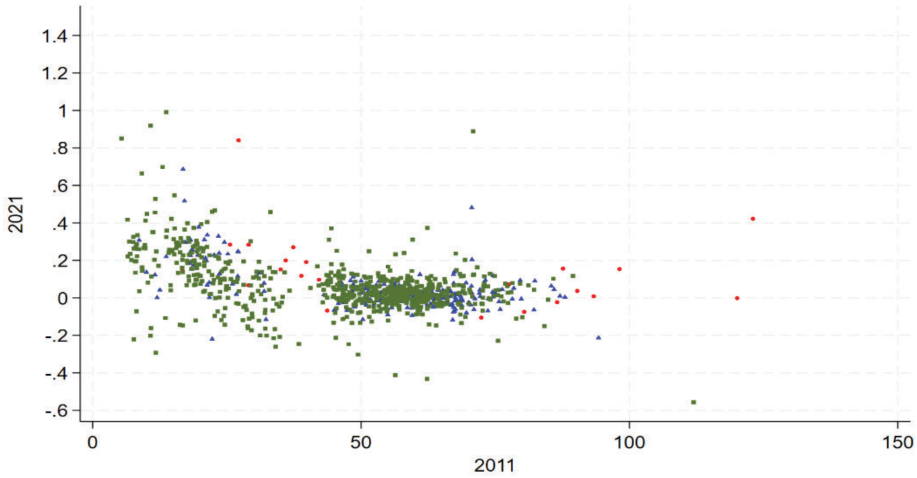
a relatively concentrated distribution but include several low-performing outliers. These low-performing metros suggest that not all urban areas have equally benefited from economic growth. Non-metros are more dispersed, with fewer extremes, though some outliers at the top suggest pockets of strong productivity potentially due to local industry specialization or resource-based activities. Capital regions, while few, display the widest internal variation. This variation may stem from national-level economic roles, differing policy environments, or regional disparities in infrastructure and investment (Appendix 5).

A separate analysis of the periods 2001–2011 and 2011–2021 reveals notable productivity patterns. In both decades, a strong negative relationship is observed between initial labour productivity levels and subsequent GVA per worker growth. Specifically, regions with lower initial productivity tended to experience faster productivity growth, suggesting a process of convergence. Conversely, some regions that exhibited high productivity growth during the first period experienced stagnation or even declines in the subsequent decade. Instead, the 2011–2021 period is marked by a general slowdown in productivity growth across regions (coherently with Evenhuis, et al., 2021; Goldin et al., 2024; Rodríguez-Pose and Ganau, 2022).

In addition, Figure 2 shows that capitals are the top performers in 2001-2011 while in the 2011-2021 period, only those that in 2011 had higher productivity levels outperformed non-metros and other metros. In the 2011-2021 period, non-metros with high productivity levels in 2011, outperformed other metros, indicating a shift in growth dynamics and suggesting heterogeneous regional development patterns.

Figure 2 Relationship between initial labour productivity (x-axis) and productivity growth (between the initial period mentioned in the x-axis and the final one mentioned in the y-axis)





Source: Authors' elaboration on ARDECO database (2024)

2.4. Sectoral specialisation and economic composition of European regions

One approach to examine the relationship between labour productivity growth and sectoral specialization is through the Hirschman-Herfindahl Index (HHI). This index measures the deviation of actual sectoral composition shares from an equal allocation of shares, providing a quantitative assessment of sectoral concentration (Rhoades, 1993).

The Hirshman- Herfindal index is measured as the sum of the squared sectoral shares:

$$HHI_{mt} = \sum_{i=1}^{10} s_{mt}^{2} \qquad (2)$$

Where *m* is the region typology, including all types of regions or only capitals, non-metros or other-metro, s_i is the share of employees working in sector i *(i*=1,…, 10) and t is the period analysed. The HHI values, in this context, range from a minimum of 0.1 (1/10), when shares of all sectors share are identical, to 1, when a region is totally specialised in one single sector.

Table 2 presents the average HHIs for capital, non-metros, and other-metros over the 2001-2021 period. HHI values reveal a notable divergence in the patterns observed among different regional types. Capitals had a decreasing HHI over the 2001-2021 period, while non-metros and other-metros saw an increasing HHI during the same time interval (respectively 41% and 39%).

Table 2. Share of capitals, non-metro and other-metros in terms of HHI change over the 2001-2021 period

Sectoral specialisation 2001-2021	Decreased	Stable[8]	Increased
Capitals	37%	33%	30%
Non-metros	36%	23%	41%
Other-metros	35%	26%	39%

Source: Authors' elaboration on ARDECO database (2024)

Figure 3 presents the Hirschman-Herfindahl Index (HHI) for all capital cities and other-metros in 2001, revealing a notable degree of heterogeneity within countries. A key observation from the map is that metros in Eastern Europe[9] generally exhibited higher HHI values than those in other EU27 countries, implying a greater sectoral concentration of economic activity in these regions. Additionally, the data suggest that HHI tended to be higher in medium-to-small sized metros compared to larger metro areas coherently with previous studies such as Dijkstra et al., (2013).

To deepen our analysis of employment, we examined its relationship with the sectoral composition of regions. Analyzing all types of EU-27 regions (Figure 4), we found that the number of employees decreased in sectors such as agriculture, forestry, and fishing; industry (except construction); and financial and insurance activities. Employment remained stable in construction and real estate activities, while it increased in wholesale and retail trade, transport, accommodation, and food service activities; information and communication; professional, scientific, and technical activities; administrative and support service activities; public administration, defence, education, human health, and social work activities; arts, entertainment, and recreation; and other service activities.

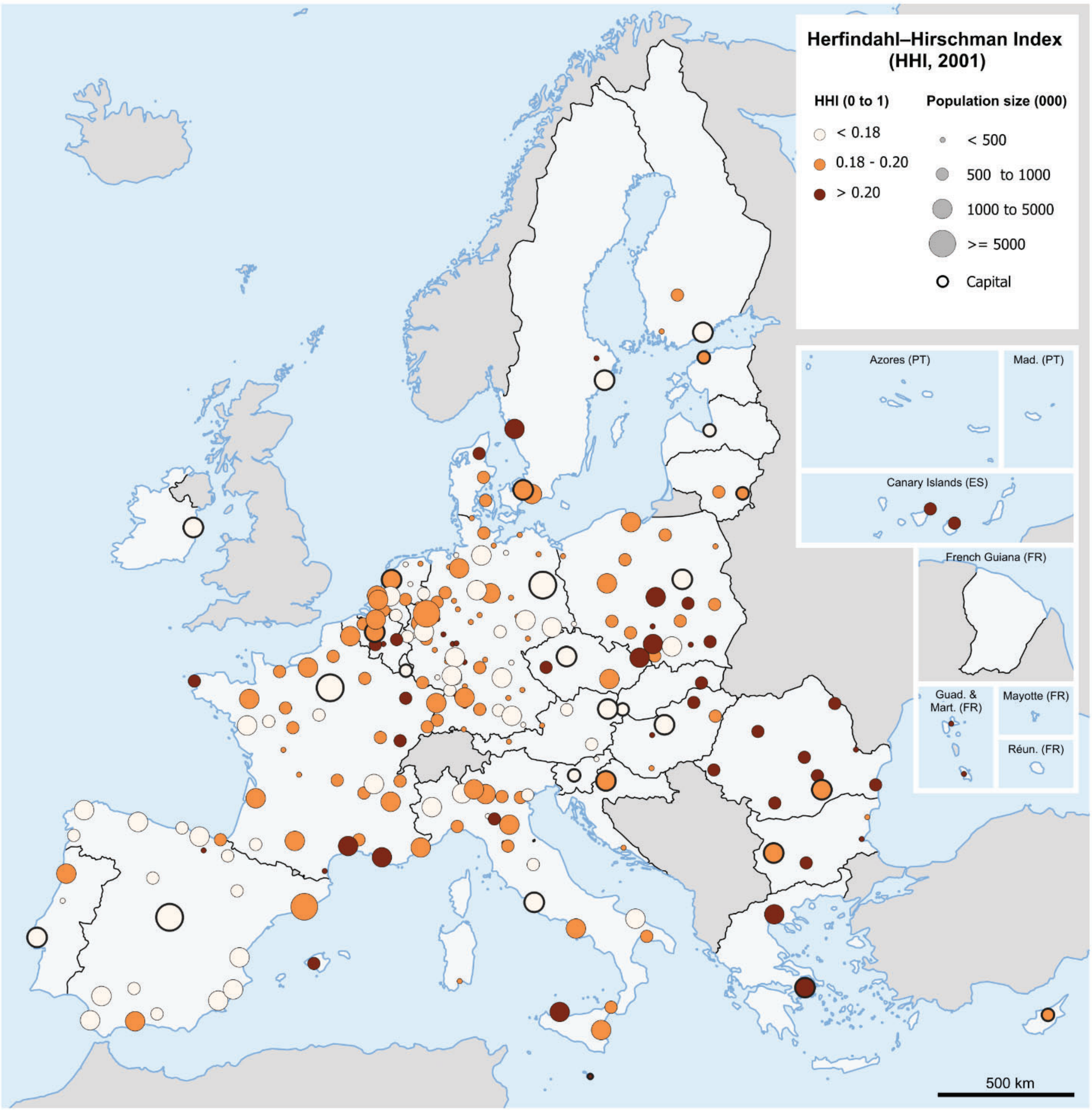
When we look at the sectoral composition of capital, other metros, and non-metros the picture is varying more (Figure 5). For instance, the four leading sectors in capital and other-

[8] The change in the Herfindahl-Hirschman Index (HHI) over the 2001-2021 period is considered stable if the difference between HHI in 2021 and HHI in 2001 (HHI2021 - HHI2001) is equal to 0.00. A decrease/increase in HHI is only considered significant if the change is at least 1%.

[9] Eastern Member States: BG, CZ, EE, HR, LV, LT, HU, PL, RO, SI, SK
Southern Member States: EL, ES, IT, CY, MT, PT
North-western Member States: BE, DK, DE, IE, FR, LU, NL, AT, FI, SE

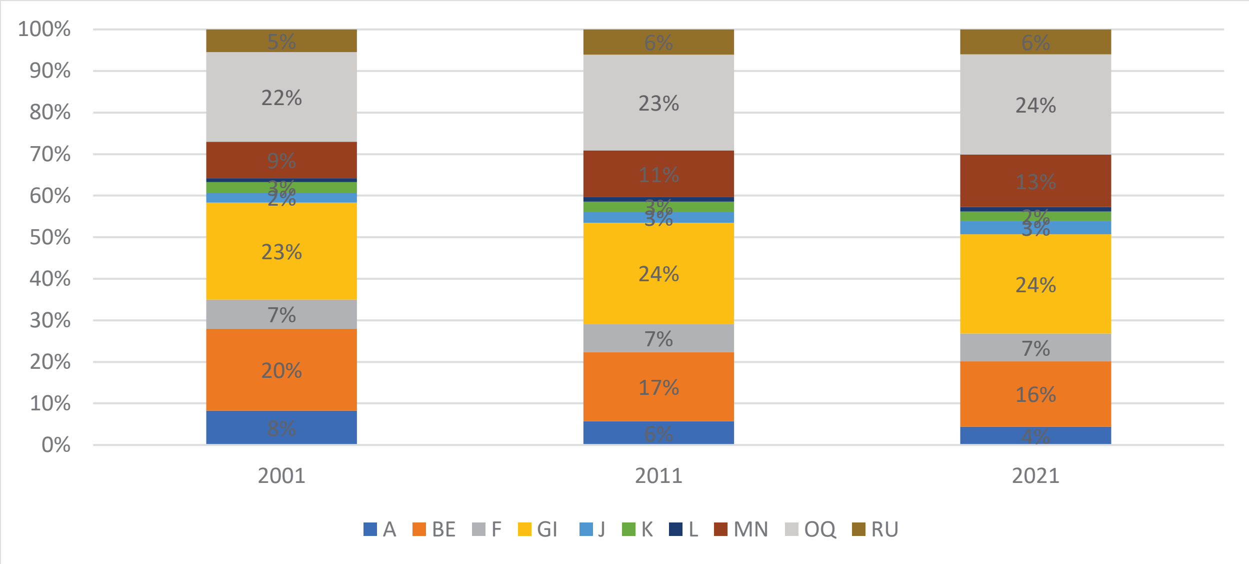
metros in 2021 were I) wholesale and retail trade, transport, accommodation, and food service activities; II) public administration, defence, education, human health, and social work activities; III) industry (except construction); and IV) professional, scientific, and technical activities administrative and support service activities. Instead, the leading sectors in non-metros were I) wholesale and retail trade, transport, accommodation, and food service activities; II) public administration, defence, education, human health, and social work activities; III) industry (except construction); and IV) agriculture, forestry, and fishing. Analysing the 2001-2021 dynamics, we found that two sectors: professional, scientific, and technical activities and support service activities and public administration, defence, education, human health, and social work activities - grew across all region types. In contrast, industry (except construction) declined in all region types, although it still accounted for 20% of employees in non-metros, compared to 15% in other metros and 9% in capitals. Finally, wholesale and retail trade, transport, accommodation, and food service activities increased in non-metros, remained stable in other metros, and decreased in capitals.

Figure 3. Herfindahl-Hirschman Index (HHI) in EU27 capitals and other metro regions in 2001



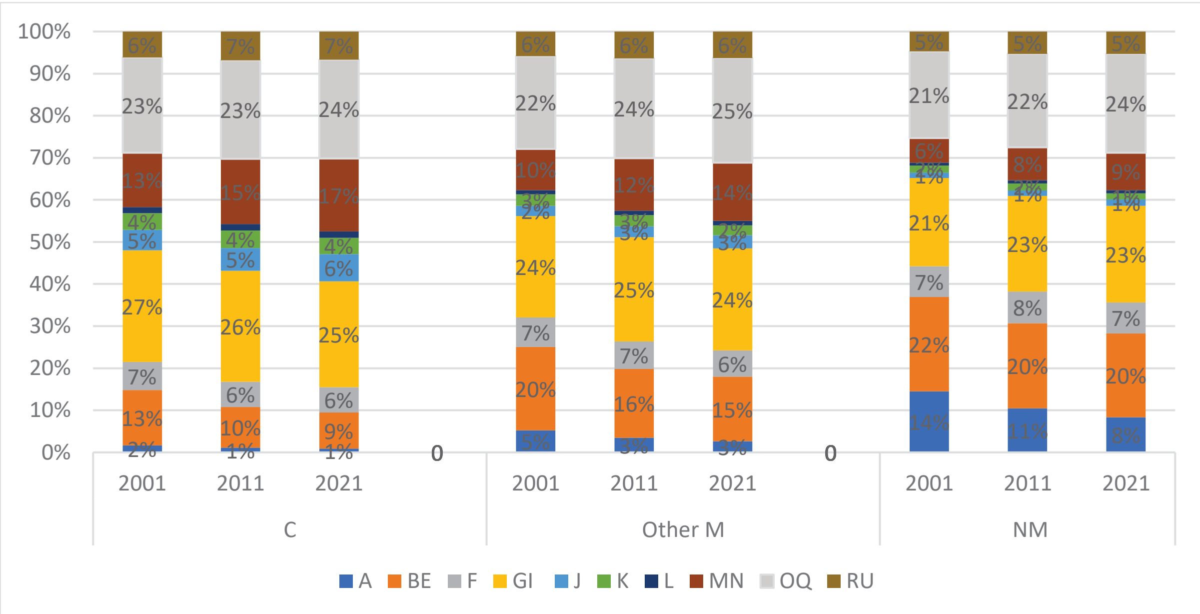
Source: Authors' elaboration on ARDECO database (2024)

Figure 4. Sectoral composition in European regions in 2001, 2011 and 2021[10]



Source: Authors' elaboration on ARDECO database (2024)[11]

Figure 5. Sectoral composition in European regions, by type in 2001, 2011 and 20218

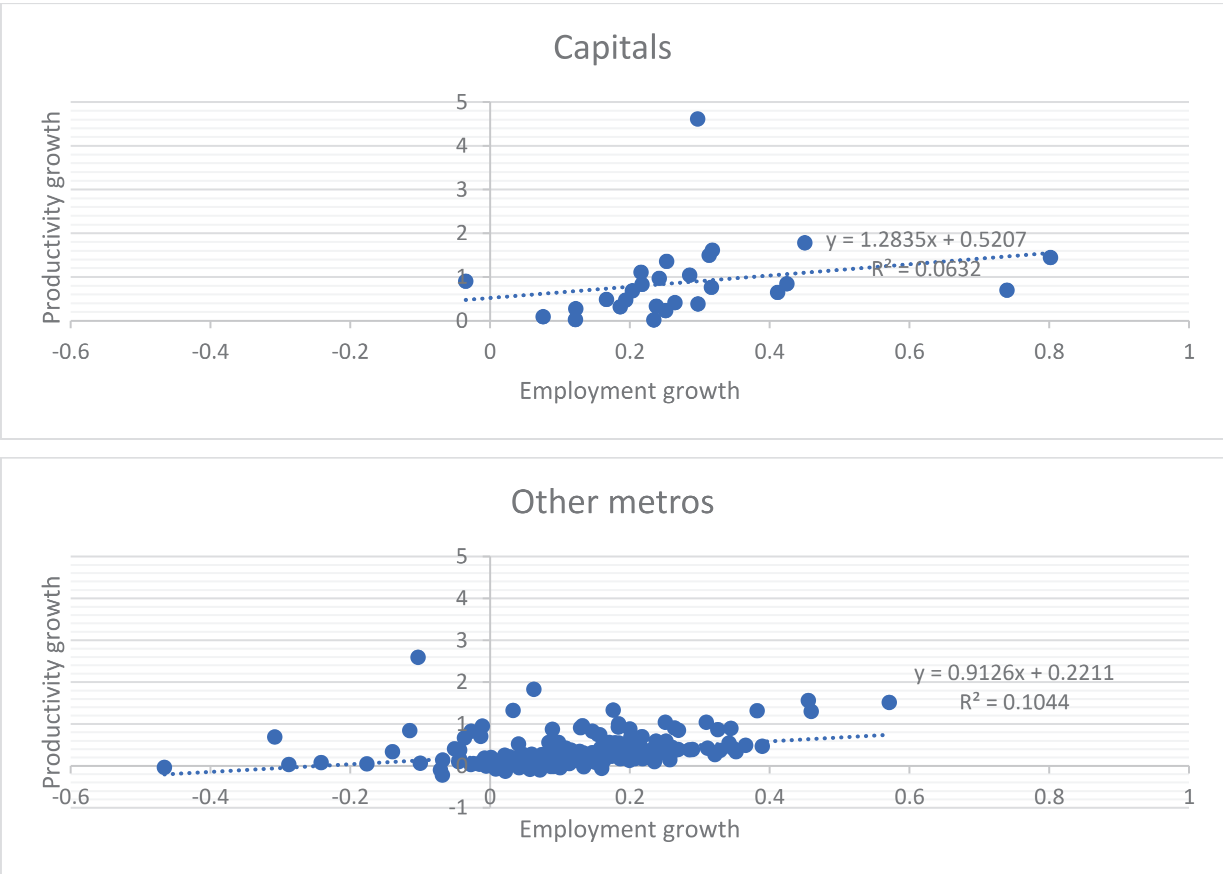


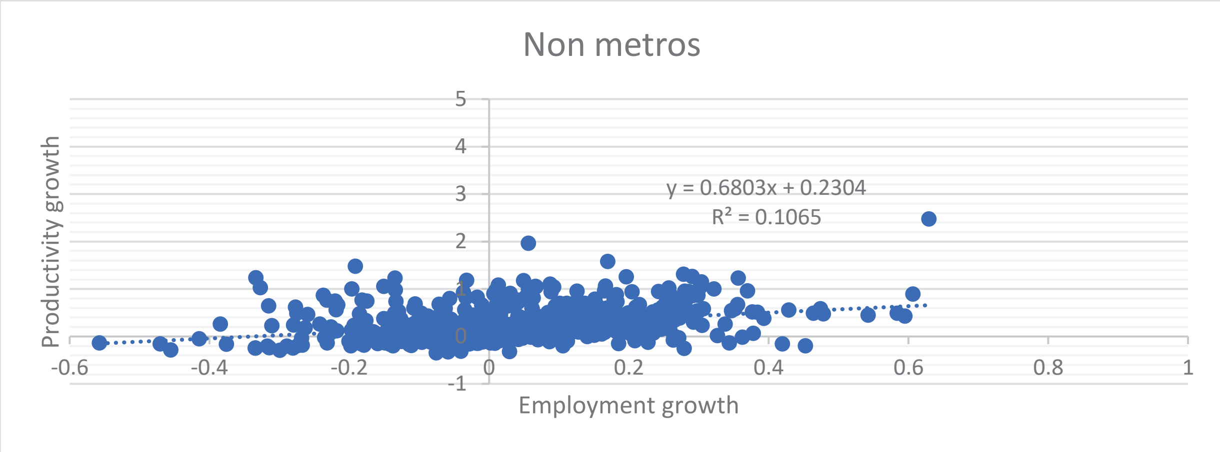
Source: Authors' elaboration on ARDECO database (2024)

[10] The statistical significance of the differences has been tested using the z-test.
[11] Ten sectors' disaggregation: A corresponds to agriculture, forestry and fishing; BE to Industry except construction; F to construction; GI to wholesale and retail trade, transport, accommodation and food service activities; J to information and communication; K to financial and insurance activities; L to real estate activities; MN to professional, scientific and technical activities, administrative and support service activities; OQ to public administration, defence, education, human health and social work activities; RU to and arts, entertainment and recreation and other service activities

Both in capitals and in other-metros, productivity and employment growth were positively correlated in the 2001-2021 period and in most of these regions employment grew. Productivity and employment growth were also positively correlated in non-metros, but with a less strong relationship, and many of these regions experienced employment reductions (Figure 6). Employment reductions in non-metro regions were primarily due to changes in the agricultural and the industrial sectors.

Figure 6. Employment growth and productivity growth in capitals, non-metros and other-metros (2001-2021)





Source: Authors' elaboration on ARDECO database (2024)[12]

Table 3. Change in employment shares and average annual rate of change in labour productivity per sector between 2001-2011 and 2011-2021 (based on NUTS3 data)

	Change in employment share in % points		Annual av. rate of change in lab. productivity in %	
Sector	**2001-2011**	**2011-2021**	**2001-2011**	**2011-2021**
Agriculture, forestry and fishing	-2.53	-1.32	0.66	0.34
Industry except construction	-3.10	-0.87	1.19	1.27
Construction	-0.23	-0.18	-0.40	-0.18
Wholesale and retail trade, transport, accommodation…	1.01	-0.36	1.44	0.88
Information and communication	0.14	0.58	4.97	6.25
Financial and insurance activities	0.04	-0.27	1.22	0.51
Real estate activities	0.07	0.02	2.03	1.08
Professional, scientific and technical activities…	2.48	1.43	1.71	2.55
Public administration, defence, education…	1.52	1.04	1.23	0.66
Arts, entertainment and recreation; other service activities…	0.61	-0.08	1.13	-0.88

Source: Authors' elaboration on ARDECO database (2024)

[12] Guyane has been excluded from the non-metro graph

2.5 A shift-share sector analysis

To investigate the contribution of labour reallocation across sectors to total productivity - the "between" or "structural" component - and improvements in productivity within individual sectors – the "within" component, this paper uses a shift-share sector analysis technique following Krüger (2008) and Martin et al.(2018).

More in detail, productivity growth over the period 2001-2021 is decomposed as follows:

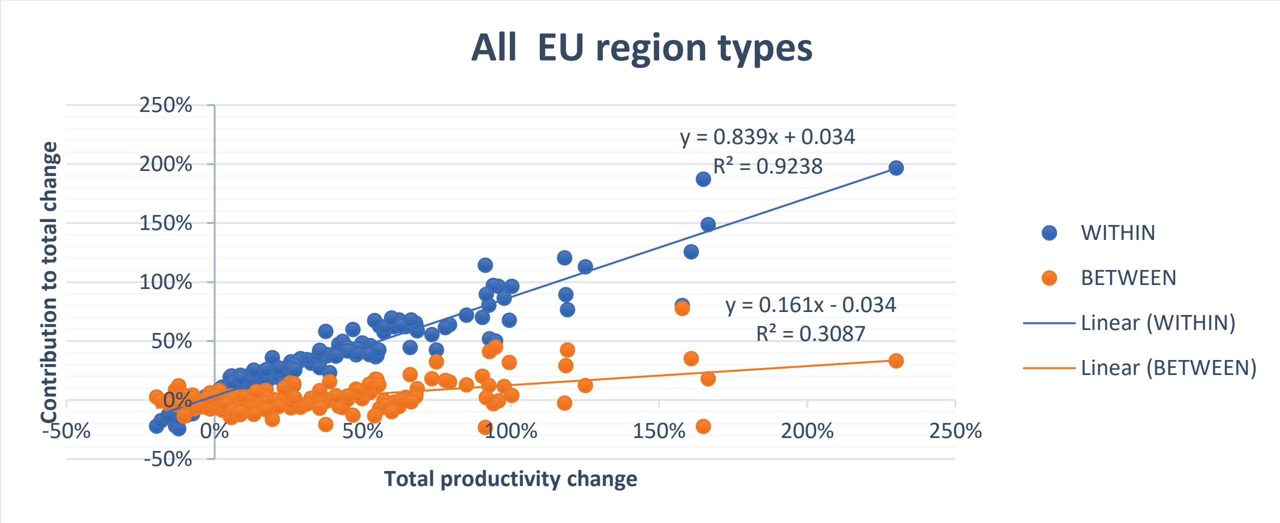
$$\left(\frac{Y_{j2021}-Y_{j2001}}{Y_{j2001}}\right) = \frac{\sum_{i=1}^{10} s_{ij2001}(y_{ij2021}-y_{ij2001})}{Y_{j2001}} + \frac{\sum_{i=1}^{10}(s_{ij2021}-s_{ij2001})(y_{ij2001}-Y_{j2001})}{Y_{j2001}} + \frac{\sum_{i=1}^{10}(s_{ij2021}-s_{ij2001})(y_{ij2021}-y_{ij2001})}{Y_{j2001}} \quad (3)$$

Where Y_j refers to the region total labour productivity (GVA over total employment), y_{ij} to sector's i labour productivity in region j and s_{ij} is sector i's share of region j. In the equation, the first term on the right-hand side represents the within sector components of productivity, while the second and third terms together represent the between sector shift in regional productivity growth, also known as the structural component of productivity' growth.

3. Results

This section presents the results of the shift-share analysis, highlighting the key findings and their implications. Starting from Figure 7, it illustrates the contribution of labour reallocation across sectors -the "between" or "structural" component- as well as the improvements in productivity "within" individual sectors across all 960 regions in the EU-27. The results of the shift-share analysis are first presented in general terms, followed by a breakdown across capitals, other-metros, and non-metros. The findings reveal a pronounced dominance of the within-sector contribution to overall productivity change, which is coherent with previous research (O'Leary & Webber, 2015; Gòmez-Tello et al., 2020; Martin et al, 2018).

Figure 7: Decomposition of regional productivity growth into "within" and "between" sector components

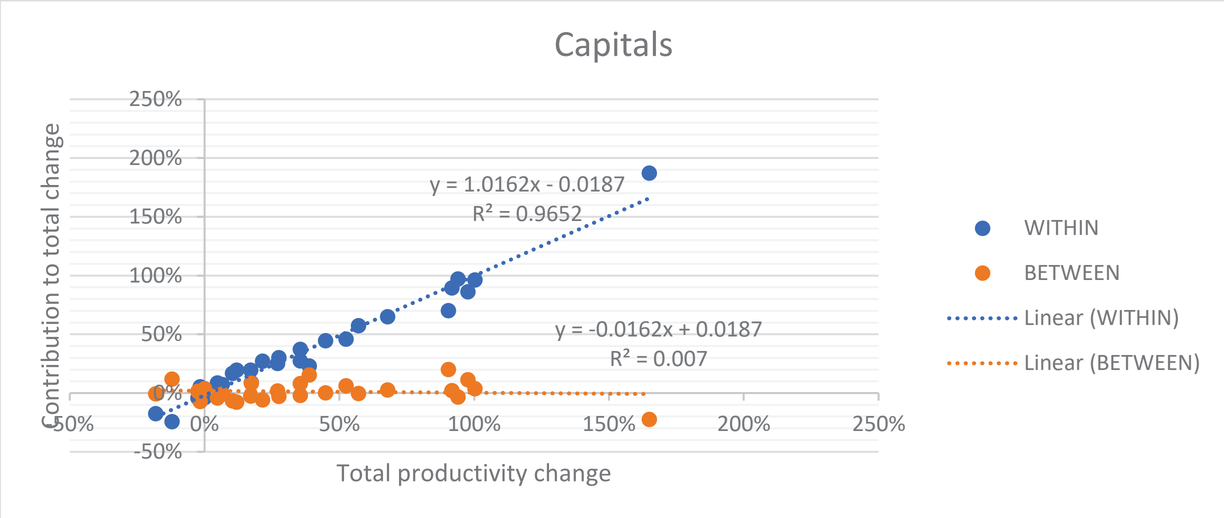


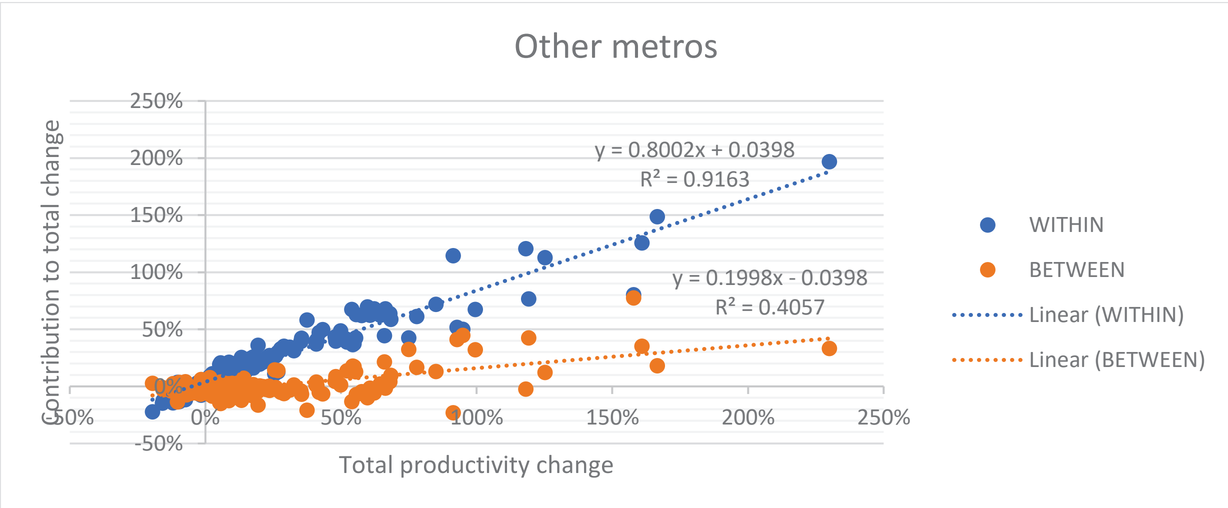
Source: Authors' elaboration on ARDECO database

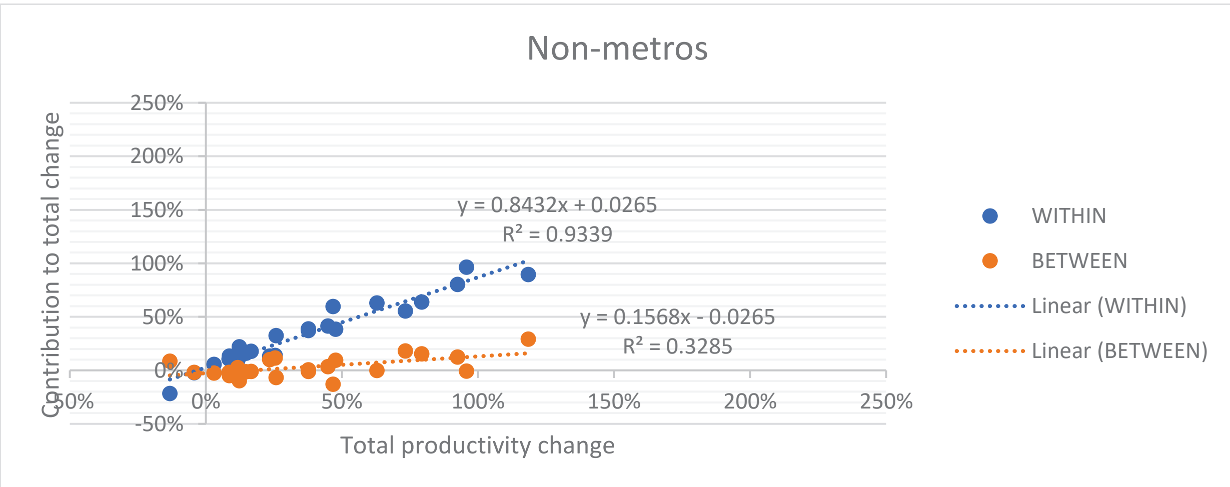
Decomposing the analysis by regional types, which is new in the literature, reveals a stronger contribution of the within-sector component to total productivity growth in capitals, where the structural component is also negative (Figure 8). This suggests that, over the past 20 years, capital cities have added more employment to sectors with lower productivity growth than in those with a higher productivity. This pattern aligns with Moretti (2012), who argues that highly skilled jobs generate a multiplier effect, increasing demand for local service providers. The observed link between structural change, production reallocation to services, and low productivity growth also confirms recent evidence from Duernecker et al. (2024) on the U.S.

Our analysis suggests that the within sector component is stronger in both other-metros and non-metros. Finally, both in non-metros and other-metros, the structural component is positive, in contrast to the slightly negative structural component observed in capitals.

Figure 8: Decomposition of productivity growth into "within" and "between" sector components for capital, other metro and non-metros







Source: Authors' elaboration on ARDECO database

An in-depth analysis of all the determinants of productivity growth is beyond the scope of this paper. Besides this, some descriptive statistics might offer complementary insights to understand productivity growth better. To do so, the paper combines the impact on productivity growth of the sectoral composition of the economy with variables related to population, innovation and local transport infrastructure performance according with the following formula:

$$\Delta Y_{j2021} = \beta_0 + \beta_1 \log(Y_{j2001}) + \beta_2 (NonNegEmplChange)_{j2021-2001} + \beta_3 (HHI_{j2001}) + \beta_4 (\boldsymbol{X}) + \delta_j + \gamma_t + \varepsilon_{jt} \quad (4)$$

Where $\Delta Y_{i2021} = \log(Y_{i2021}) - \log(Y_{i2001})$, which corresponds to labour productivity growth over the period 2021-2001 for region j, while baseline controls are: the labour productivity at the beginning of the period expressed in logarithmic terms $\log(Y_{j2001})$ to capture relative convergence; $(NonNegEmplChange)_{j2021-2001}$ the employment growth rate over the 2001-2021 period in terms of a dummy variable which takes the value of 1 if employment has recorded a positive or null growth, and zero otherwise. This variable assesses whether productivity growth is occurring in the context of shrinking or growing employment; and the Hirshman-Herfindal index, which captures the sectoral concentration in a region (HHI_{j2001}) and according with the literature might impact labour productivity negatively (Savagar, et al, 2024).[13]

Other controls include, the sectoral composition of employment: $(Empl\ share\ Agriculture_{j2001})$, $(Empl\ share\ Industry_{j2001})$, $(Empl\ share\ Construction_{j2001})$, $(Empl\ share\ Wholesale_{j2001})$, $(Empl\ share\ Information_{j2001})$, $(Empl\ shareFinancial_{j2001})$, $(Empl\ share\ Real\ estate_{j2001})$, $(Empl\ share\ Professional_{j2001})$, $(Empl\ share\ Public_{j2001})$, $(Empl\ share\ Arts_{j2001})$ and $(PopWeightedDensity_{j2001})$, which is a proxy for measuring agglomeration economies.

[13] We also tested the inclusion as independent variable of the percentage point change of the Hirshman-Herfindal index instead of using the HHI in 2001. Results confirm that an increase in the HHI are associated with a decrease in labour productivity growth.

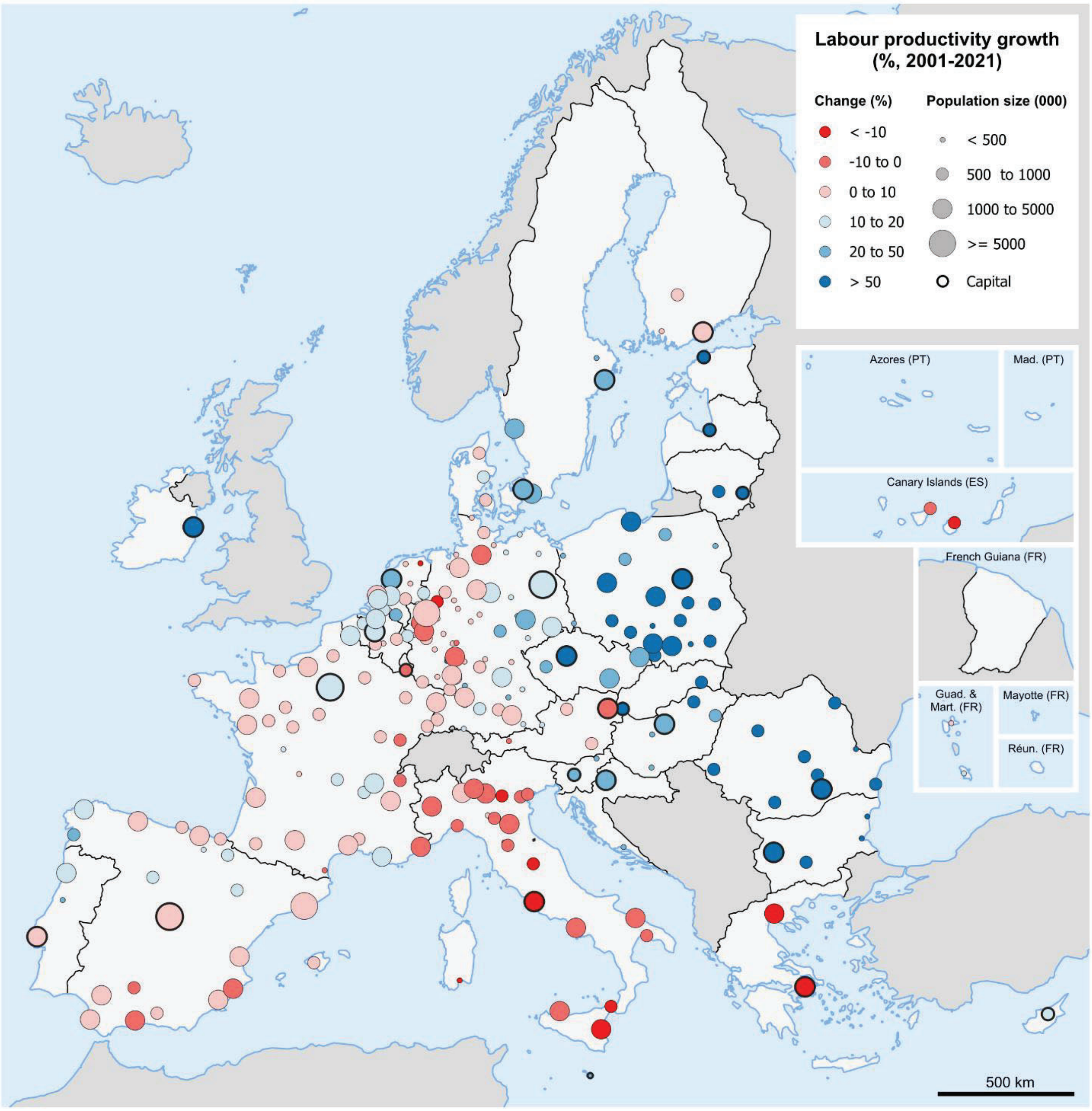
Population density has already been demonstrated to be a particularly influential variable on productivity (Duraton and Puga, 2020). In this paper we try a refined measure of population density (population weighted density) and measure its influence on productivity. The main differences of population weighted density from simple population density are the following: first, it only considers populated spatial units in an area; second, spatial units with higher population contribute more to the weighted average of an area. $WPD_{area}=(\Sigma(P_i)^2)/(\Sigma P_i)$, when 1-sqkm grid cells[14] are used as spatial units, and where WPD stands for population weighted density of a larger area, and P_i stands for population in grid cells.

The number of patents over 100,000 inhabitants is included as a measure of innovativeness, which is usually associated with higher growth (Martin et al., 2018)[15] together with the type of region (capitals, other metros and non-metro). We complement the assessment with a variable called road transport performance ($Roadtransp\_perf_{j2021}$). Road transport performance is a ratio of accessibility and proximity measured for a specific area. It provides information on the quality (e.g., density, connectivity, and average speed) of the transport network while comparing a real situation of an area with its potential. An EU-wide application of this variable can be seen in Dijkstra et al. (2019). These kind infrastructure-related indicators have been used in the literature that focused on cities where high-quality infrastructure tend to facilitate faster economic growth (Crescenzi and Rodríguez-Pose (2012). Finally, δ_c and γ_t are country or European macro regions (Eastern, North-Western and Southern) and time-fixed effects, which allow to control for unobserved factors affecting contextually all regions in a country/macro-region or all regions in the same year and ε_{jt} is the error term.

[14] See, Census Grid 2021 by GEOSTAT at https://ec.europa.eu/eurostat/web/gisco/geodata/population-distribution/geostat

[15] In this study, we were unable to assess the impact of entrepreneurship on productivity due to the lack of available data covering the extended period of 2001–2021, as well as the EU-level coverage and the high level of disaggregation required. To the best of our knowledge, the only available data pertains to high-growth enterprises in the most recent years. We attempted to include this variable in our regression analysis; however, it turned out to be statistically insignificant.

Figure 9: Labour productivity growth (2001-2021)



Source: Authors' elaboration on ARDECO database

Figure 9 illustrates the labour productivity growth in capital cities and other-metros in the EU27 between 2001 and 2021. A visual examination of the map reveals some regional trends, including higher productivity growth in Eastern Europe (coherently with Psycharis et al., 2020). Additionally, there is a notable degree of heterogeneity within countries between capital cities and other-metros, although they often fall within the same labour productivity group. For instance, Italy and Austria are characterised by negative productivity growth.

Instead, other countries, such as France, Spain, Germany, and Portugal, exhibit internal heterogeneity, with metros displaying both positive and negative growth rates. Capital cities typically have higher growth rates than other-metros, although there are exceptions, such as Rome, Lisbon and Madrid, which have lower labour productivity growth rates than other metros in their respective countries over the 2001-2021 period.

The results of the regression analysis are presented in Table 4, which includes the outcomes of various models.[16] Model 1 comprises labour productivity at the beginning of the period, expressed in logarithmic terms $\log(Y_{j2001})$, the dummy variable $(NonNegEmplChange)_{j2021-2001}$, the 2001 weighted population density $(PopWeightedDensity_{j2001})$, the initial Herfindahl-Hirschman index (HHI_{j2001}), and macro-regional fixed effects.

The results of Model 1 show that $\log(Y_{j2001})$ is significant and negatively related to the initial labour productivity, indicating that regions with higher productivity in 2001 are associated with a decrease between 0.18%-0.39% in the growth rates during the 2001-2021 period. The (HHI_{j2001}) and $(NonNegEmplChange)_{j2021-2001}$ are also significant and negative, suggesting that higher sector concentration and increasing employment rates have hindered productivity growth. For example, if employment growth was driven by the creation of low-productivity jobs, this did not contribute to overall labour productivity growth. The indicator $(WeightedPopDensity_{j2001})$ is significant and positively related to productivity growth, implying that regions with higher population concentrations tend to have higher labour productivity growth. Furthermore, being located in Eastern Europe was conducive to higher labour productivity growth during the 2001-2021 period compared to being in North-Western or Southern Europe.

Model 2 is one of the most powerful together with Model 5. Compared to Model 1, it substitutes macro-regional fixed effects with country fixed effects; in addition, it adds the type of region (being a capital, other-metro, or non-metro), and an indicator of road transport performance. As a result, $(NonNegEmplChange)_{j2021-2001}$and

[16] Appendix 7 presents the correlation matrix among the coefficients included in the various specifications

$(WeightedPopDensity_{j2001})$ lost significance. However, $\log(Y_{j2001})$and (HHI_{j2001}) maintain their significance and sign. Being a capital is a significant feature for higher productivity growth. However, we found no significant difference in the impact of being a non-metro or a metro -but not a capital- on productivity growth in most of the specifications.

The country dummies are also significant predictors of labour productivity growth over the 2001-2021 period.[17] The model includes $log(Patents_{j2001})$. Patents are significantly and positively correlated with labour productivity growth. Road transport performance is positively and significantly related to labour productivity growth. Model 3 replicates Model 2 but substitutes country-fixed effects with macro-regional variables. Model 4 introduces the sectoral composition of employment and excludes the indicator of road transport performance.

The sectors positively and significantly related with labour productivity growth are construction, wholesale and retail, real estate and Information and Communication Technologies (ICT). When sectoral variables are added to the model, the coefficient of Patents becomes non-significant. Appendix 7 presents a visual representation of employment in ICT across European capitals and other-metros, as one of the most influential factors for productivity growth. Model 5, replicates model 4, while removing macro-regional variables in favour of country fixed effects. It has the highest R-square (0.788). Additionally, initial productivity, HHI and type maintain their significance and sign in Model 5. The sectors: construction and ITC remain positively and significantly related with labour productivity growth. Finally, Model 6 replicates Model 2 but without $(WeightedPopDensity_{j2001})$. [18]

[17] The tables with the full list of countries' fixed effect are available upon request.

[18] In additional specifications (available upon request) we also tested the use of proxies of agglomeration economies other then $(WeightedPopDensity_{j2001})$, such as the number of inhabitants of the largest settlement in a certain region. Our results are robust to these specifications.
We also checked the inclusion of a different variable concerning employment change. Namely, we dropped nonNEGemplchang and introduced the percentage change in employment in the 2001-2021 period. Results are robust also to this specification.

Table 4. Regression results[19]

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
VARIABLES	logDEP	logDEP	logDEP	logDEP	logDEP	
logGVAperW2001	-0.230***	-0.335***	-0.215***	-0.180***	-0.399***	-0.333***
	-0.0172	-0.0295	-0.0213	-0.0234	-0.0328	-0.0294
nonNEGemplchang	-0.0493***	-0.0118	-0.0256**	-0.0228**	-0.00904	-0.011
	-0.0117	-0.00959	-0.0105	-0.0101	-0.00914	-0.00955
Pop weighted density_2001	8.05e-06***	-5.96E-09	4.94e-06**	7.08e-06***	1.74E-06	
	-2.20E-06	-2.40E-06	-2.45E-06	-2.42E-06	-2.56E-06	
Hirshman-Herfindal index 2001	-1.153***	-0.697***	-0.728***	-0.470**	-0.668***	-0.670***
	-0.128	-0.168	-0.196	-0.219	-0.19	-1.67E-01
Sh_empl_2001_Agriculture				0.151	-0.00732	
				-0.221	-0.261	
Sh_empl_2001_Industry				0.292	0.430*	
				-0.233	-0.247	
Sh_empl_2001_Construction				1.049***	0.623**	
				-0.293	-0.287	
Sh_empl_2001_Wholesale & retail				-0.546**	-0.126	
				-0.248	-0.278	
Sh_empl_2001_Inform & Com				1.781***	1.377**	
				-0.582	-0.556	
Sh_empl_2001_ Finan & insurance				0.698	1.845***	
				-0.648	-0.617	
Sh_empl_2001_Real estate				3.159***	0.73	
				-1.128	-1.316	
Sh_empl_2001_ Prof & technical				-0.0115	0.218	
				-0.248	-0.335	
Sh_empl_2001_ Public admin				-0.0116	-0.0249	
				-0.269	-0.29	
Road Performance 2021		0.000628*	0.000436			0.000674**
		-0.00032	-0.00033			-0.00031
Other metros		-0.0109	-0.0196*	-0.0119	-0.00727	-0.0113
		-0.00931	-0.0111	-0.0108	-0.00916	-0.00854
Capitals		0.107***	0.0923***	0.0821***	0.0866***	0.107***
		-0.0255	-0.0272	-0.0291	-0.0271	-0.0231
NorthWest Europe	-0.0617**		-0.0940***	-0.0694**		
	-0.0263		-0.0276	-0.0301		
Southern Europe	-0.273***		-0.258***	-0.241***		
	-0.0244		-0.0286	-0.0325		
logPATinhab2001		0.0180***	0.00784*	-0.00278	0.00506	0.0172***
		-0.00381	-0.00409	-0.00482	-0.00414	-0.00374
Country FE	NO	YES	NO	NO	YES	YES
Constant	1.352***	1.729***	1.270***	0.884***	1.709***	1.705***
	-0.0655	-0.146	-0.114	-0.227	-0.275	-0.144
Observations	955	763	763	763	763	764
R-squared	0.646	0.763	0.617	0.666	0.788	0.762

Source: Authors’ elaboration on ARDECO database

Appendix 8 illustrates the impact of including a variable to better understand the effect of having a city or town of a specific population range (reference group population<=100,000). The results suggest that regions classified as metro, capital, or non-metro, with a population

[19] *** $p<0.01$, ** $p<0.05$, * $p<0.1$

between 500,000 and a one million, experience higher labor productivity growth compared to smaller or the larger regions. However, this effect becomes less visible when country fixed effects are incorporated into the model.

Appendix 9 provides insights into the relationship between labour productivity growth and the indicators of accessibility, proximity, and road transport performance by replicating Model 2. Results suggest that both road accessibility (average number of people within a 90 minutes' drive by car) and proximity (number of people within a 120 km radius or buffer) taken alone, are not significantly related to labour productivity growth. This is surprising as both could be interpreted as a measure of agglomeration economies. However, some other indicators such as population density, city size and the typology capital, other-metro and non-metro also capture some aspects of agglomerations. Road transport performance, which captures the ratio between accessibility and proximity, is positively related to labour productivity growth. This suggest that the quality of the road infrastructure, i.e. its capacity to connect people, matters for productivity growth.

Finally, Appendix 10 presents the analysis conducted separately for the 2001-2011 and 2011-2021 periods, based on the Models 2 and 5. In particular, the initial productivity level and being a capital are confirmed to be influential variables on productivity growth in both periods. Instead, the Hirschman- Herfindahl index has a significant impact only in the 2011-2021 period. Finally, an examination of the sectoral composition of employees reveals that the share of employees working in industry and information and communication technology is significant and positively related with labour productivity growth only in the 2011-2021 period. Instead, the share of employees working in finance and insurance is conducive to more growth in labour productivity in both periods.

4. Conclusions

This study presents a comprehensive examination of productivity growth patterns across capitals, other metros and non-metros in the EU-27, spanning two decades (2001-2021) and incorporating a 10-sector level of detail.

Our findings reveal that capital metro regions exhibit the strongest growth rates. Decomposing economic growth into its constituent parts, we found that productivity growth was the primary driver of economic expansion in non-metros, whereas employment growth played a more important role in capitals and other metros. Our analysis further highlights that capitals have decreased their sectoral concentration level between 2001-2021, whereas other metros and non-metro regions have increased their concentration.

A shift-share analysis reveals that productivity growth "within sectors" was the primary source of overall labour productivity growth in all three types of regions, although its relative importance varied. In capitals, we observe a negative structural component, which indicates that over the past 20 years capital cities have experienced more employment growth in sectors with lower productivity.

Our regression analysis yields several key insights too. Firstly, we find evidence of convergence, as regions with lower initial productivity levels have experienced higher rates of productivity growth. Secondly, capital metro regions, which often concentrate economic and political power, tend to exhibit higher productivity growth. Given the agglomeration benefits, we expected to find higher labour productivity growth in other metros as compared to their non-metro counterparts, but this was not the case. Productivity growth in other-metros was almost half that of non-metros. Furthermore, the econometric analysis did not find a significant difference between the two types of regions. Our results suggest that patenting activity, the employment share in ICT, construction and finance, and infrastructure quality have a substantial impact on subsequent productivity growth.

While our analysis provides a detailed and nuanced understanding of productivity growth patterns at the metro level, data limitations necessitated choosing some variables instead of others. For example, we used workplace-based employment over total population instead of the employment rate (employed individuals as share of the working age population). We did not include the share of employed persons with tertiary education (inter alia investigated by Glaeser et al., 2004), R & D expenditure and the role and quality of institutions (Charron et al., 2024; Rodríguez-Pose and Ganau, 2022 and Rodríguez-Pose, 2013) because they are only available at a more aggregate regional level (NUTS2). Including those missing indicators would probably improve our models' ability to capture the full complexity of productivity growth patterns in EU metros.

Despite some limitations, our findings contribute to the literature both on agglomeration economies and labour productivity inequalities, by highlighting the importance of understanding the nuances of productivity growth patterns at the local level. Specifically, our work underscores the need to I) assess why other metro regions have underperformed over the past two decades II) understand what is driving the high productivity growth in capitals and III) analyse whether convergence is likely to continue for non-metro regions or whether it is likely to stall once the benefits of shifting to more productive sectors have been maximised.

Our findings also emphasize the need for further research. Future studies might investigate the impact of Foreign Direct Investments (FDI) inflows on local labour productivity (following Bruno et al., 2023; Crescenzi and Iammarino, 2017; Gregori et al., 2024). Another potential avenue for further research is to explore the impact of teleworking patterns on regional productivity and competitiveness. While some seminal studies have started investigating this phenomenon (Luca et al., 2025; OECD, 2020b; Sostero et al., 2024), there is still scope for further investigations.

Our findings are expected to have useful implications for regional development policy. They are particularly important in the context of the debate on EU's evolving cohesion policy. While in the past, cohesion policy expanded its focus beyond the traditional NUTS2 regions to include a clear urban dimension. The current proposals for the next programming period would rely on national plans covering multiple funds. Our study highlights the different productivity growth trends and sectoral composition of capitals, other metro and non-metros. This suggests that tailored approaches to address the distinct challenges and opportunities of different regional contexts is likely to be more successful. The findings are also highly relevant for identifying strategies to enhance European competitiveness by embracing regional specificities and their endogenous potential (Capello and Rodríguez-Pose, 2025). By harnessing these funding opportunities and adopting a place-based approach, policymakers can create targeted interventions that address regional disparities, promote inclusive growth, and enhance the competitiveness and prosperity of regions.

Appendix 1

Table A1: Population, employment and GDP in capitals, non-metros and other metros

	Population	Employment	GDP (Million PPS)
Non-metros	41%	37%	32%
Other metros	43%	44%	45%
Capitals	16%	19%	23%

Source: authors' elaboration on ARDECO database

Appendix 2

Table A2: Variable's description

Variable	Description	Unit	Source
Population			
Average annual population	Average annual value	*Persons*	ARDECO
Economics			
Gross Value Added (GVA)	Constant prices	Million EUR2015	ARDECO
Gross Value Added by industry	Constant prices	Million EUR2015	ARDECO
Employment			
Total employment	Workplace based, n. of employed persons	Thousands of persons	ARDECO
Employment by industry	10 NACE sectors	Thousands of persons	ARDECO
Controls			
Patent applications to the European Patent Office by priority year	Intellectual property	Number	EUROSTAT
Population weighted density	A measure of residential population density	Person / square km	Author's calculation
Proximity	Number of people within a 120 km radius or buffer	Number of people	Author's calculation
Road accessibility	Number of people within a 90 minutes' drive by car	Number of people	Author's calculation
Road transport performance	The ratio between accessibility and proximity (Accessibility / Proximity *100)	Indexed value (0 to 100)	Author's calculation
Hirshman- Herfindal Index (HHI)	This index measures the deviation of actual sectoral composition shares from an equal allocation of shares	Indexed value (0.1-1)	Author's calculation
Population in the most populated settl 2001	Settlements are villages, towns and cities identified based on the DEGURBA using a grid- based population data	Number of people	Author's calculation

Source: authors' elaboration

Appendix 3

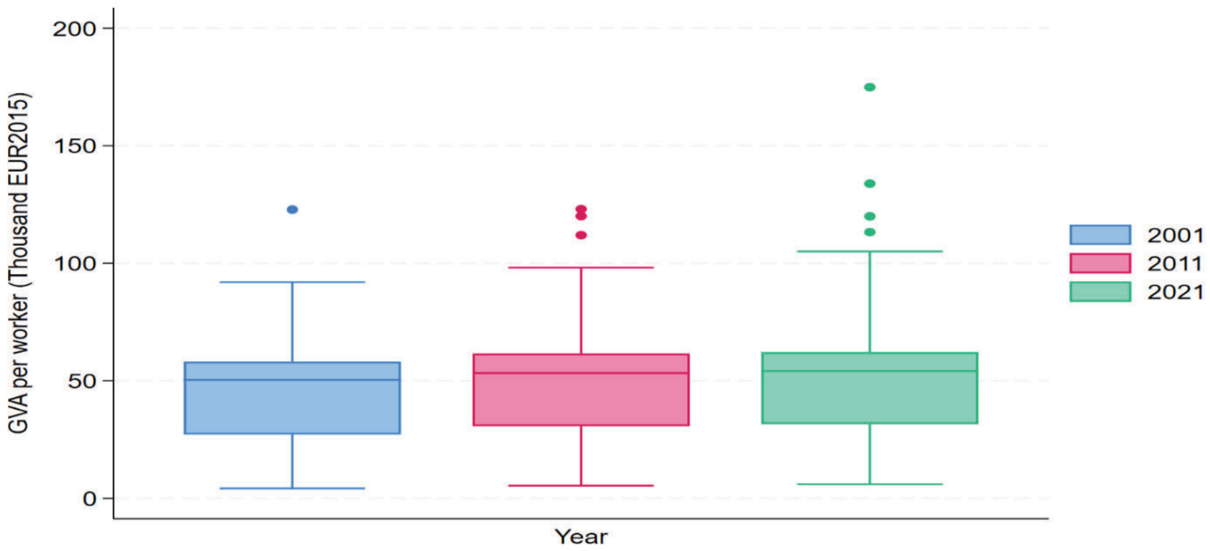
Table A3: Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
GVA at constant prices(Million EUR2015)_2001	960	9577.74	22951.65	117.1	492176.6
GVA at constant prices(Million EUR2015)_2011	960	10990.99	26518.96	171.7	570709
GVA at constant prices(Million EUR2015)_2021	960	12273.02	29875.74	162.1	627060.5
Average annual population(persons)_2001	960	446002.7	659475	8700	1.11e+07
Average annual population(persons)_2011	960	458570.2	702251.7	10700	1.19e+07
Average annual population(persons)_2021	960	463423.1	733116	11290	1.23e+07
Total Employment(thousands)_2001	960	196.31	327.3183	2.8	5935.2
Total Employment(thousands)_2011	960	203.79	349.2156	3.8	6114.3
Total Employment(thousands)_2021	960	217.9698	385.7988	3.9	6661.7
Patent applications_2001	766	59.28603	195.1454	.11	2926.99
Patent applications _2011	836	61.20992	178.9013	.0000216	3022.38
Population Weighted Density_2001	955	2716.876	2271.7	362.269	18437.97
Population Weighted Density_2011	955	2613.284	2237.002	356.1705	18723.02
Population Weighted Density_2021	955	2554.258	2121.795	339.8202	18281.97
Proximity_2021	958	6642700	5397244	11290	2.90e+07
Road Accessibility_2021	958	5145179	5085948	7305.094	2.77e+07
Road Transport Performance _2021	958	69.74464	18.37301	11.09203	98.87619
Population in the most populated settlement 2001	909	154100.5	444339.5	1922	8680498
Hirshman- Herfindal index_2001	960	.2032182	.0450549	.1449216	.5857536
Hirshman- Herfindal index_2011	960	.1963517	.03036	.1454273	.4149791
Hirshman- Herfindal index_2021	960	.1969198	.0254389	.148992	.3946412

Source: authors' elaboration

Appendix 4

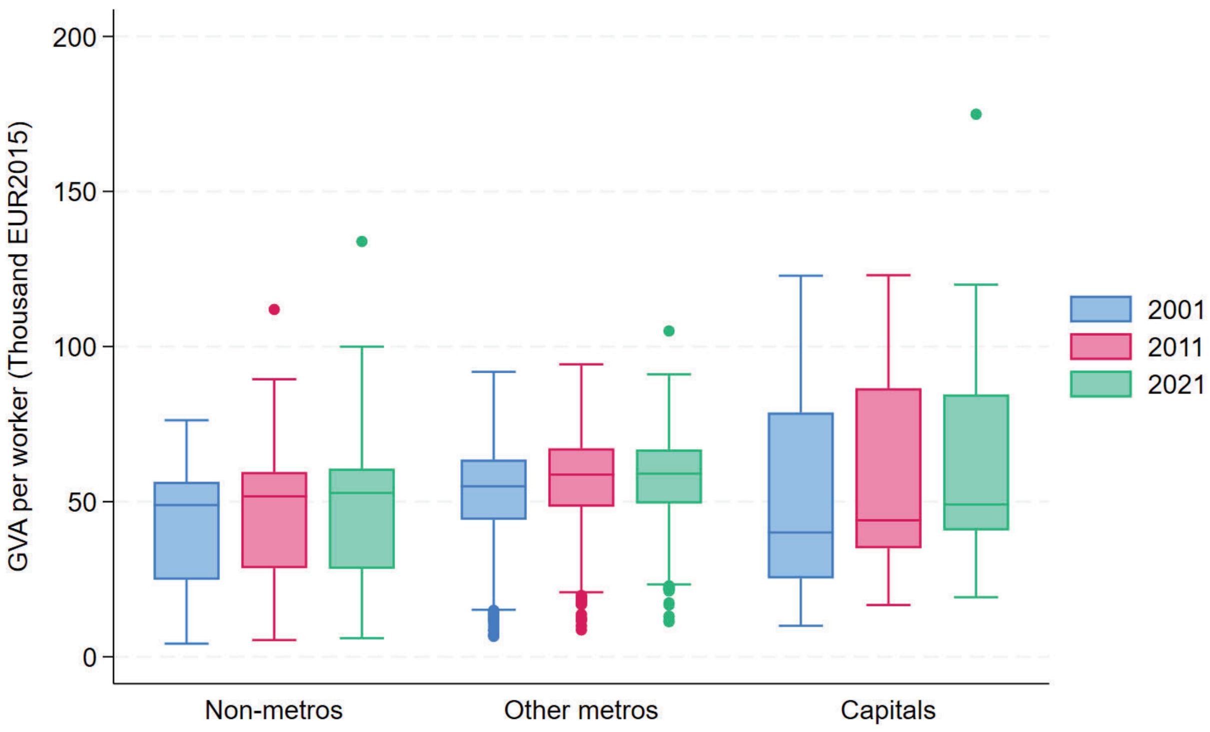
Figure A1: Box-plot diagrams: GVA per worker in European regions (all regions types) in 2001, 2011 and 2021



Source: authors' elaboration on ARDECO database (2024)

Appendix 5

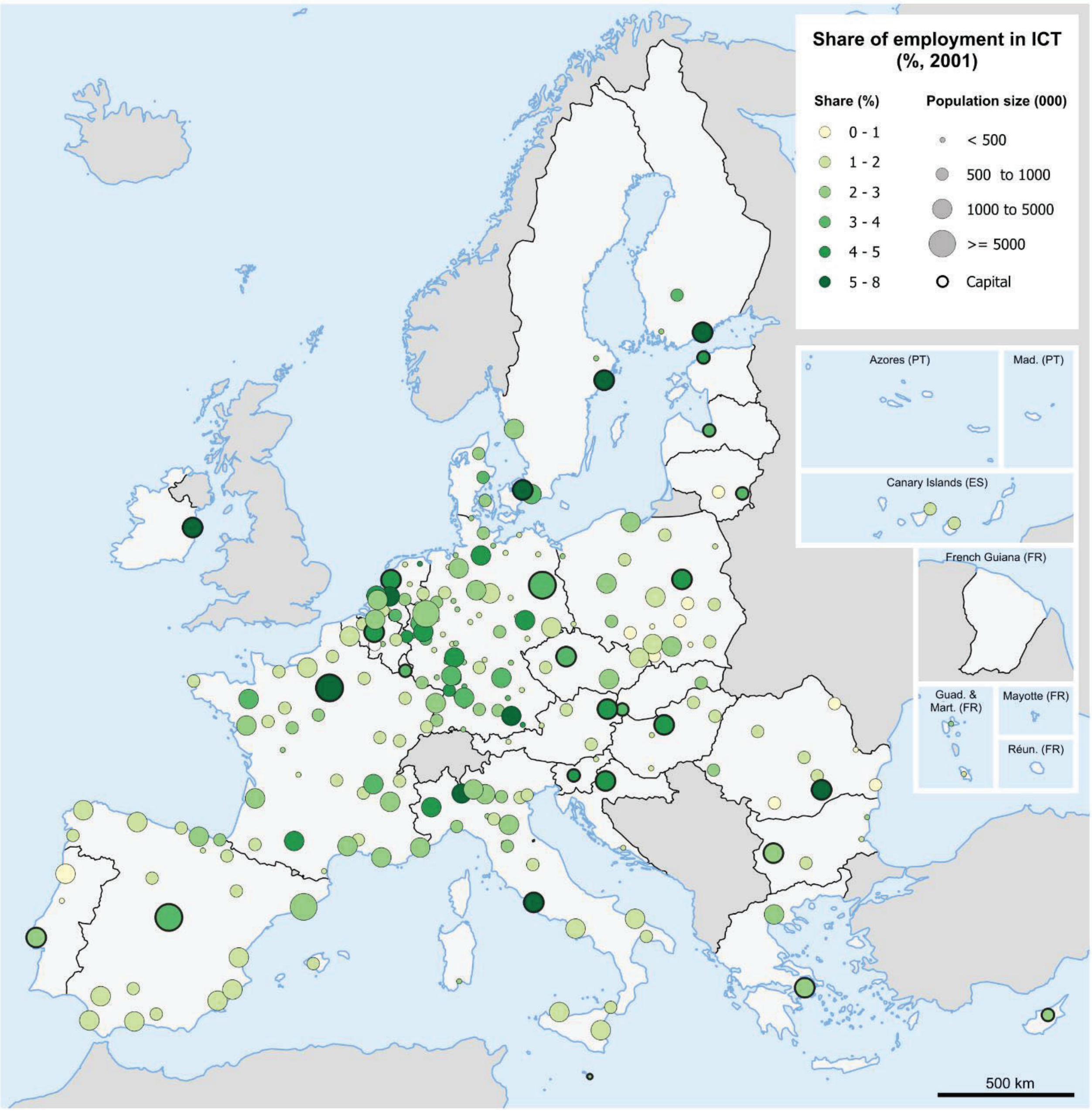
Figure A2: Box-plot diagrams: GVA per worker by region type in 2001, 2011 and 2021



Source: Authors' elaboration on ARDECO database (2024)

Appendix 6

Figure A3: Share of employment in ICT (% in 2001)



Source: Authors' elaboration on ARDECO database (2024)

Appendix 7.

Table A4: Correlation matrix[20]

	logGVA perW2001	nonNEGe mplchang	Pop_weig_ dens_2001	Pop2001St	HHI 2001	logPA Tinhab 2001	Road Perf 2021	empl_ Agric2001	empl_I nd2001	empl_Co nstr2001	empl_W holesale 2001	empl_Inf &Com2001	empl_Fina n&ins2001	empl_Rea l est2001	empl_Prof & tech2001	empl_Publi c adm2001
logGVAper W2001	1															
nonNEGe mplchang	-0.1159	1														
Pop_weig_ dens_2001	-0.1457	-0.0495	1													
Pop2001St	0.0322	0.0174	0.5636	1												
HHI 2001	-0.31	-0.0137	-0.151	-0.1249	1											
logPATinh ab2001	0.7	0.0584	-0.2719	-0.0048	-0.0898	1										
Road Perf 2021	0.4067	-0.0601	0.2396	0.2381	-0.2861	0.3967	1									
empl_Agri c2001	-0.6457	-0.0238	-0.0457	-0.1346	0.2352	-0.5982	-0.4856	1								
empl_Ind2 001	-0.1776	0.0501	-0.2013	-0.1707	0.3824	0.1471	-0.0916	-0.0647	1							
empl_Cons tr2001	0.0145	-0.0584	0.0827	-0.0678	-0.3917	-0.2112	0.0634	-0.0058	-0.1232	1						
empl_Whol esale2001	0.1916	0.0573	0.322	0.198	-0.2492	0.0011	0.1778	-0.3292	-0.3996	0.1116	1					
empl_Inf& Com2001	0.274	0.1167	0.252	0.4159	-0.2508	0.4183	0.3019	-0.4036	-0.1214	-0.1509	0.1993	1				
empl_Fina n&ins2001	0.4195	0.0533	0.1536	0.2649	-0.3116	0.4017	0.3782	-0.4073	-0.1611	-0.1944	0.3152	0.4951	1			
empl_Real est2001	0.1043	-0.0095	0.1207	0.2529	-0.0722	0.1575	0.1078	-0.3405	-0.2084	-0.1627	0.1565	0.3366	0.2385	1		
empl_Prof & tech2001	0.5229	-0.016	0.1575	0.2852	-0.3065	0.4305	0.5739	-0.528	-0.3727	-0.1613	0.2379	0.3744	0.4895	0.3428	1	
empl_Publi c adm2001	0.2945	-0.0443	-0.164	-0.0425	-0.0345	0.1337	0.0103	-0.2812	-0.547	-0.1911	-0.1073	0.0093	-0.0841	0.3027	0.2696	1

Source: Authors' elaboration on ARDECO database (2024)

[20] With pwcorr, sig listwise. In green p<0.01

Appendix 8

Table A5: Regression results with population range classes

	Model 1 rep	Model 2 rep	Model 3 rep	Model 4 rep	Model 5 rep	Model 6 rep
logGVAperW2001	-0.230***	-0.338***	-0.223***	-0.182***	-0.399***	-0.336***
	-0.0172	-0.0298	-0.0216	-0.0235	-0.0332	-0.0298
nonNEGemplchang	-0.0493***	-0.013	-0.0221**	-0.0201**	-0.00933	-0.0122
	-0.0117	-0.00967	-0.0105	-0.01	-0.0092	-0.00965
Pop weighted density_2001	8.05e-06***	-1.88E-07	4.86e-06*	7.38e-06***	1.88E-06	
	-2.20E-06	-2.52E-06	-2.56E-06	-2.49E-06	-2.65E-06	
Hirshman-Herfindal index 2001	-1.153***	-0.672***	-0.696***	-0.402*	-0.645***	-0.645***
	-0.128	-0.17	-0.197	-0.22	-0.192	-0.168
Sh_empl_2001_Agriculture				0.0842	-0.0184	
				-0.224	-0.263	
Sh_empl_2001_Industry				0.227	0.421*	
				-0.235	-0.248	
Sh_empl_2001_Construction				1.081***	0.631**	
				-0.293	-0.289	
Sh_empl_2001_Wholesale & retail				-0.604**	-0.132	
				-0.248	-0.279	
Sh_empl_2001_Inform & Com				1.810***	1.402**	
				-0.584	-0.561	
Sh_empl_2001_ Finan & insurance				0.746	1.874***	
				-0.645	-0.62	
Sh_empl_2001_Real estate				2.458**	0.701	
				-1.16	-1.322	
Sh_empl_2001_ Prof & technical				-0.126	0.176	
				-0.254	-0.343	
Sh_empl_2001_ Public admin				-0.0784	-0.0276	
				-0.27	-0.292	
Road Performance 2021		0.000564*	0.000378			0.000599*
		-0.000331	-0.000331			-0.000322
Other metros		-0.0147	-0.0391***	-0.0315**	-0.0108	-0.0158
		-0.0112	-0.0133	-0.0127	-0.0108	-0.0108
Capitals		0.103***	0.0797***	0.0710**	0.0850***	0.102***
		-0.0271	-0.0289	-0.0302	-0.0281	-0.0259
NorthWest Europe	-0.0617**		-0.0749***	-0.0559*		
	-0.0263		-0.0286	-0.0304		
Southern Europe	-0.273***		-0.245***	-0.240***		
	-0.0244		-0.0292	-0.0324		
logPATinhab2001		0.0178***	0.00915**	-0.00198	0.00491	0.0171***
		-0.00383	-0.00412	-0.00481	-0.00415	-0.00375
100000<pop<=250000		0.0109	0.00057	-0.00962	0.0054	0.011
		-0.0116	-0.014	-0.0134	-0.0112	-0.0116
250000<pop<=500000		0.0142	0.0241	0.0211	0.0118	0.0147
		-0.0132	-0.0151	-0.0148	-0.0127	-0.0132
500000<pop<=1000000		0.0147	0.0413**	0.0405**	0.0123	0.0162
		-0.017	-0.0183	-0.0182	-0.0164	-0.017
pop>1000000		0.0209	0.0293	0.0176	0.00921	0.0212
		-0.0214	-0.0236	-0.0233	-0.0208	-0.021
Country FE	NO	YES	NO	NO	YES	YES
Constant	1.352***	1.731***	1.284***	0.929***	1.704***	1.708***
	-0.0655	-0.147	-0.115	-0.228	-0.276	-0.145
Observations	955	763	763	763	763	764
R-squared	0.646	0.763	0.622	0.672	0.788	0.763

Source: Authors' elaboration

Appendix 9

Table A6: Regression results with details on transport performance, accessibility and proximity

	Model 2	Model 7	Model 8
VARIABLES	logDEP	logDEP	logDEP
logGVAperW2001	-0.335***	-0.335***	-0.337***
	-0.0295	-0.0298	-0.0297
nonNEGemplchang	-0.0118	-0.0144	-0.0141
	-0.00959	-0.0095	-0.00949
Pop weighted density_2001	-5.96E-09	1.02E-06	1.10E-06
	-2.40E-06	-2.34E-06	-2.33E-06
Hirshman-Herfindal index 2001	-0.697***	-0.726***	-0.729***
	-0.168	-0.168	-0.168
logPATinhab2001	0.0180***	0.0184***	0.0178***
	-0.00381	-0.00391	-0.00393
Other metros	-0.0109	-0.00854	-0.00837
	-0.00931	-0.00925	-0.00925
Capitals	0.107***	0.114***	0.115***
	-0.0255	-0.0255	-0.0254
Road Performance 2021	0.000628*		
	-0.000323		
Road accessibility 2021		8.51E-10	
		-9.96E-10	
Road Proximity 2021			1.27E-09
			-9.60E-10
COUNTRY FE	YES	YES	YES
Constant	1.729***	1.773***	1.770***
	-0.146	-0.144	-0.144
Observations	763	763	763
R-squared	0.763	0.762	0.762

Source: Authors' elaboration

Appendix 10

Table A7: Regression results presented separately for 2001-2011;2011-2021

	Model 9A	Model 9B	Model 10A	Model 10B
VARIABLES	logDEP20012011	logDEP20112021	logDEP20012011	logDEP20112021
logGVAperW2001	-0.209***		-0.269***	
	-0.0208		-0.0234	
nonNEGemplchang2001-2011	-0.0178***		-0.00926	
	-0.00663		-0.00651	
Pop weighted density_2001	4.18E-07		-2.94E-07	
	-1.64E-06		-1.83E-06	
Hirshman-Herfindal index 2001	-0.123		0.0445	
	-0.118		-0.135	
logPATinhab2001	0.0127***		0.00415	
	-0.00264		-0.00295	
logGVAperW2011		-0.172***		-0.207***
		-0.0204		-0.0231
nonNEGemplchang2011-2021		-0.0272***		-0.0351***
		-0.00711		-0.00718
Pop weighted density_2011		9.38E-07		3.04E-06
		-1.88E-06		-2.08E-06
Hirshman-Herfindal index 2011		-0.695***		-0.709***
		-0.137		-0.16
logPATinhab2011		0.0135***		0.00898***
		-0.00261		-0.00287
Other metros	0.0026	-0.00695	0.00128	0.000459
	-0.00652	-0.00695	-0.00653	-0.00728
Capitals	0.0985***	0.0484**	0.0739***	0.0529**
	-0.018	-0.0193	-0.0193	-0.0219
Sh_empl_2001_Agriculture			-0.276	
			-0.185	
Sh_empl_2001_Industry			-0.00803	
			-0.175	
Sh_empl_2001_Construction			0.229	
			-0.205	
Sh_empl_2001_Wholesale & retail			-0.146	
			-0.197	
Sh_empl_2001_Inform & Com			0.609	
			-0.396	
Sh_empl_2001_ Finan & insurance			0.785*	
			-0.441	
Sh_empl_2001_Real estate			0.281	
			-0.94	
Sh_empl_2001_ Prof & technical			0.0156	
			-0.238	
Sh_empl_2001_ Public admin			-0.406**	
			-0.206	
Sh_empl_2011_Agriculture				0.141
				-0.228

Sh_empl_2011_Industry				0.380*
				-0.224
Sh_empl_2011_Construction				0.434
				-0.268
Sh_empl_2011_Wholesale & retail				0.0673
				-0.247
Sh_empl_2011_Inform & Com				0.819*
				-0.452
Sh_empl_2011_ Finan & insurance				1.020**
				-0.51
Sh_empl_2011_Real estate				0.842
				-1.115
Sh_empl_2011_ Prof & technical				-0.131
				-0.263
Sh_empl_2011_ Public admin				0.207
				-0.262
27.COUNTRY_FE	YES	YES	YES	YES
Constant	1.108***	0.979***	1.329***	0.876***
	-0.102	-0.103	-0.195	-0.24
Observations	763	834	763	834
R-squared	0.703	0.565	0.73	0.586

Source: Authors' elaboration

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