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Challenges and opportunities for territorial cohesion in Europe

Contributions to the 9th Cohesion report

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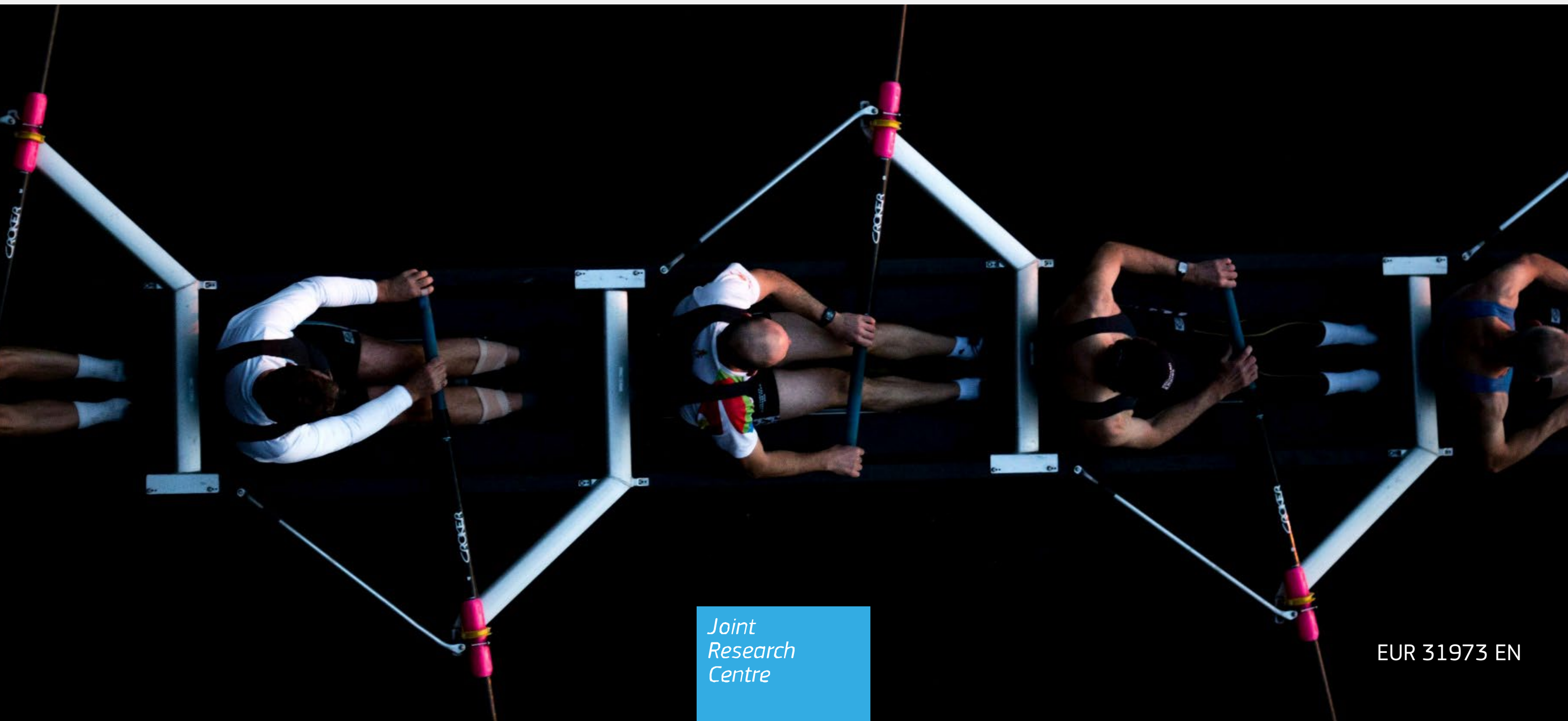

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Contents

Abstract

This report assembles a series of separate scientific contributions to the European Commission's Ninth Report on Economic, Social and Territorial Cohesion. The report includes seven short research papers providing background and insight under three broad topics with relevance to European regional and urban policy: Urbanisation and regional economic trends; Transport and digital accessibility; and Sectoral analyses (renewable energy and tourism). Each short paper documents a novel research or analysis based on the most recent data available, thus providing up-to-date and timely evidence on issues with a strong territorial dimension.

Although covering a very diverse range of topics, the contributions articulate interrelated challenges and opportunities to promote territorial cohesion in Europe. These are related to, for example, the increasing urbanisation and implications for transport and mobility, population decline in rural areas, regional economic convergence/divergence trends, the improving access to broadband in the EU, the potential role of rural areas for the green transition and tourism as a heterogeneous but overall resilient industry contributing to many EU regional economies. An efficient Cohesion Policy should envisage targeted, place-based investments that consider these and other challenges and opportunities.

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Executive summary

Cohesion Policy plays an important role in supporting public and private investments in EU's regions, seeking to promote economic, social, and territorial development and reduce disparities in development, wealth, and living standards across its Member States and regions. Monitoring territorial cohesion is necessary to evaluate whether the objectives of the policy are being accomplished and to fine-tune future Cohesion Policy design.

This report, contributing to the 9th Cohesion Report published in early 2024, assembles a series of separate scientific contributions/analyses from the Joint Research Centre – Territorial Development unit. Focusing on three broad topics – urbanisation and regional economic trends, transport and digital accessibility, and sectoral analyses (renewable energy and tourism) – the report offers up-to-date and timely evidence on current issues with a strong territorial dimension. By providing insights into current challenges and opportunities and their territorial expression, this report aims to support a more targeted, place-based Cohesion Policy.

The principal takeaways per chapter are as follows:

Chapter 2 - Urbanisation and Rural Population Decline

Newly available time-series of population data for the period 1961-2021 shows that the EU has experienced a relatively steady urbanisation process in this period. Currently, approximately 71% of population lives in urban areas (cities, towns and suburbs). Urban areas promote innovation and productivity but also face challenges such as pollution and social cohesion issues. In contrast, rural regions are grappling with population decline, services and infrastructure maintenance challenges. The distribution of population across the urban-rural spectrum calls for place-based adaptation solutions.

Chapter 3 - Regional Economic Convergence/Divergence

Regional economic convergence has stalled since 2009. Projections suggest a moderate increase in regional economic disparities by 2040, with a significant amount of uncertainty, indicating the need for robust regional development to resume the convergence path.

Chapter 4 - Car Travel Demand

Car usage varies significantly across the EU, with rural areas displaying higher shares of car use compared to urban areas. Policies that increase car usage costs may disproportionately affect rural residents and meet resistance, especially if there is a lack of viable transport alternatives.

Chapter 5 - Time Lost Due to Road Congestion

There are marked spatial differences in road travel speeds across the EU. Travel speeds tend to be lower for the residents of urban areas. In absolute terms, urban residents tend to experience less speed loss in morning peak conditions. However, the limited speed loss affects a large share of the population. This emphasizes the need to continue improving urban mobility with a range of different solutions and transport modes.

Chapter 6 - Broadband and digital Accessibility

Broadband access is a requirement of the digital transition of regions and territories and, increasingly, a condition for development. Broadband connectivity has improved across the EU, with rural areas showing significant catch up in the speed performance in relation to urban areas. Whereas disparities between urban and rural digital access persist, the observed improvement in broadband access in rural areas is a promising signal of the efforts to bridge the digital gap across territories in many European countries.

Chapter 7 - Renewable Energy Potential

The EU's renewable energy production primarily occurs in rural areas. There remains a large untapped potential to produce more solar, wind, and hydropower. The EU could potentially produce up to 12,500 TWh/year of electricity from solar, wind, and hydropower sources, which is more than 5 times the electricity consumed in 2021 and exceeds the total energy consumption of the EU in the same year. Rural regions can play a crucial role in the EU's decarbonisation goals. Furthermore, the majority of untapped potential is located in less developed regions. Expansion of renewable energy capacity should consider and mitigate any impacts on local environmental conditions.

Chapter 8 - Tourism's COVID-19 Impact and Recovery

Tourism was among the industries most affected by the COVID-19 pandemic, underscoring this industry's vulnerability to international shocks. The pandemic's impact on tourism was uneven across EU regions, with urban destinations and areas reliant on foreign tourists hit the hardest. Tourism resilience is evident in its quick recovery post-COVID. This is good news for the many EU's countries and regions with a strong economic reliance on this sector. The digital and green transition of the tourism sector should contribute to make the European tourism industry also more sustainable and resilient going forward.

In conclusion, this report underscores the interplay between territorial cohesion and various socio-economic factors across the EU. By providing evidence-based insights into urbanisation, economic convergence, transport, digital accessibility, renewable energy, and tourism, it equips policymakers with knowledge on current challenges and leverage opportunities for further regional development. The continuous evolution of statistical and geospatial data will further refine our understanding and monitoring of these trends.

1 Introduction

The European Union's Cohesion Policy promotes economic, social, and territorial development and reduces disparities in development, wealth, and living standards across its Member States and regions. To this aim, the Cohesion Policy supports public and private investments in regions, to create enabling conditions for sustainable economic growth, innovation and job creation. In line with its goal of reducing disparities, Cohesion Policy focuses most of its funding on regions where economic development is below the EU average.

Cohesion Policy is planned in 7-year financing cycles. The current programming period (2021-2027) includes a total of EUR 392 billion investment. This represents about one third of the EU budget. This amount is delivered to regions via several financial instruments fulfilling different policy objectives. The current programming period's main objectives are to make Europe more competitive, greener, better connected, more social and closer to citizens . In the European Commission, Cohesion Policy is implemented by the Directorate-General for Regional and Urban Policy (DG REGIO) and the Directorate-General for Employment, Social Affairs and Inclusion (DG EMPL).

Monitoring territorial cohesion is necessary to evaluate whether the objectives of the policy are being accomplished. A Cohesion Report is produced every 2 to 4 years to follow-up on the various dimensions of the economic, social, and territorial cohesion. The Cohesion Reports, published by DG REGIO and DG EMPL with contributions from the Joint Research Centre, serve as a critical tool for monitoring the effectiveness of this policy and guiding its future direction.

The herein report assembles contributions from the Joint Research Centre – Territorial Development unit to the 9th Cohesion Report published in early 2024 . It includes seven short research papers addressing three broad topics: urbanisation and regional economic trends, transport and digital accessibility, and sectoral analyses focusing on renewable energy and tourism. These papers employ the latest data to offer updated background and evidence on issues with a strong territorial dimension to, ultimately, support the regional and urban policy decisions.

Each short research paper was prepared and delivered to DG REGIO during the drafting phase of the 9th Cohesion Report throughout the year of 2023. Each paper was then adapted to feature in this JRC Science for Policy report as a separate chapter. Although the chapters are relatively stand-alone, and covering a very diverse range of topics, overall, the contributions attempt at articulating both challenges and opportunities such for territorial cohesion in Europe going forward.

PART I – Urbanisation and regional economic trends

2 Long-term urbanisation and rural population decline in the EU[1]

Filipe Batista e Silva, Cristian Pigaiani, Lewis Dijkstra

2.1 Introduction

Cities are singular locations of spatial organization of humans and their activities and have always played an important role in socioeconomic, cultural and technological development [1]. Cities and, more broadly, urban areas are still gaining importance, with urbanisation rates expected to continue increasing globally [2,3]. Especially in Africa and some parts of Southeast of Asia, cities are attracting vast numbers of people from rural areas, while in highly urbanized world regions, such as Europe, cities are becoming actors of own right by new governance mechanisms and leading innovation and economic growth [3].

The concentration of population in urban areas is not a recent phenomenon, though. The urbanisation process in Europe, but also elsewhere globally, was fuelled by industrialisation already since the late 18th century, with a shift from agrarian-based to industrial-based economies and, more recently, to services. In addition, infrastructure development in urban areas and the flow of migrants from rural to urban areas seeking better employment and living conditions have boosted urbanisation.

The importance of cities can be explained by the competitive advantages offered by agglomeration effects such as i) increasing returns to scale and higher productivity (e.g., higher GDP per capita, higher rates of innovation) as well as ii) economies of scale, leading to more efficient resource use (e.g., land, energy, materials). Some scholars have observed that such agglomeration effects can be described as scaling laws, whereby the population size of cities has a superlinear effect on levels of socioeconomic activity and a sublinear effect on resource use [4]. Because large and dense urban agglomeration are major pools of labour, and offer many services and opportunities for social interaction and exchange, they drive innovation, resulting in higher productivity gains and growth [4-10]. Notwithstanding, recent findings suggest that the association between city size and growth is conditional to other contextual factors such as economic structure, urban infrastructure, governance and even the size of the country [11].

Clearly, urbanisation entails beneficial outcomes, but unfortunately not without some negative externalities too. For example, rapid and uncontrolled urbanization is often associated with high housing prices, congestion, social issues [12-13] and environmental degradation levels, namely the concentration of land, water and air pollution [14-15]. Such negative externalities, not only impact quality of life directly but may also hinder productivity and compromise sustainable growth in the long run [16]. Furthermore, when fast urban growth leads to lower densities, this may lead to lower energy efficiency of the urban system [17] and potentially less opportunities for sustainable transport modes [18]. Hence, it is important to monitor and manage urbanisation processes.

Recent developments in data, methods and definitions allow us to estimate urbanisation more accurately and consistently across time and space. In this study we apply the internationally agreed

[1] How to cite this chapter: Batista e Silva F, Pigaiani C, Dijkstra L (2024) Long-term urbanisation and rural population decline in the EU. *In*: Batista e Silva F and Dijkstra L (eds.) Challenges and opportunities for territorial cohesion in Europe - contributions to the 9th Cohesion report. Joint Research Centre Science for Policy report. Publications Office of the European Union, Luxembourg. doi:10.2760/466949

classification of the Degree of Urbanisation [19] at 1 km-cell level to a novel time series of population grids for the EU, spanning from 1961 until 2021 in 10-year time-steps. This unprecedented time series allowed us to assess where urbanisation levels stands today and how it have evolved since the early 1960's until today, per main EU macro-regions, per country, and even at more granular, local levels. Such data will also allow us to analyse the geography of population decline, a topic for upcoming research.

2.2 Results

Figure 1.1 shows the total and relative population per Degree of Urbanisation (cities, towns and suburbs, and rural areas), from 1961 to 2021, for the EU27 and per main geographical area (north-western, southern and eastern Europe). Between 1961 and 2021, the EU population increased from 359 to 456 million inhabitants. This overall demographic growth was accompanied by a steady urbanisation process, with population living in urban areas (cities, towns and suburbs) increasing from 59% to 71% at the expense of rural areas, which dropped to a share of 29% of the EU population in 2021. The increase in urban population was split between cities (+7pp) and towns and suburbs (+5pp).

However, current levels of urbanisation and the trends in this period spanning 60 years differ between macro European areas. Contrary to the population growth observed in the northwestern and southern EU, population in the eastern EU has been declining steadily since 1991. And even the population share in cities declined from 31% to 28% in the last three decades. In 2021, the eastern EU remained the least urbanised, with 61% of the population living in urban areas (cities plus towns and suburbs), compared to 71% in the northwestern and 78% in southern EU.

Despite the overall demographic growth, rural areas lost population in absolute terms in all 'corners' of the EU, from 145 to 130 million inhabitants. The decline in rural population as a share of the total population was particularly marked in the southern EU, decreasing from 36% to 22% since 1961. The increase in the city population share was highest in the southern EU (+12pp), followed by the eastern EU (+9pp), while it barely increased in the northwestern EU (+1pp). The population share in towns and suburbs grew most in the eastern (+6pp) and the northwestern EU, while it increased much less in the southern EU (+2pp).

As shown in Figure 1.2, urbanisation levels in 2021 vary substantially between Member States, ranging from more than 80% in Malta, The Netherlands and Spain to 55% or less in Slovakia and Slovenia. Member States can be further distinguished between those which experienced a strong urbanisation surge since the 1961, such as Cyprus, Bulgaria, Greece, Finland, Slovakia, Portugal, with 20 percentage points gain in urbanisation, and those which remained at similarly high levels such as The Netherlands, Germany or Malta, or similarly low levels such as Slovenia.

The map in Figure 1.3 shows the average population change per decade between 1961 and 2021 per regular grids cells of 5 x 5 km. The areas in yellow or red observed an average positive population growth, whereas the areas in dark or light blue observed population decline over this period. Areas in white either uninhabited or have experienced limited population fluctuation over the same period. The observed patterns depend on the country and are influenced by geography. Nevertheless, population growth and decline both tend to cluster in space. In addition, a marked urban-rural divide can be observed across the EU. Population has increased substantially in or around the main cities. Coastal areas and coastal cities observed important population growth too, especially in the southern EU. Rural areas lost population overall. But the rural decline has been more pronounced in the southern and eastern EU, with large swaths of inner/rural parts of, for example, Portugal, Spain, Croatia, Bulgaria, Romania and the Baltic countries experiencing a strong population decline in many areas.

This illustrates an increasing 'bipolar' EU, with an ever-higher concentration of population in fewer cities and large towns, and less population in most rural areas. There is no expectation that this trend will invert in the foreseeable future, although the speed of urbanisation is likely to decrease, especially in countries with already very high urbanisation levels.

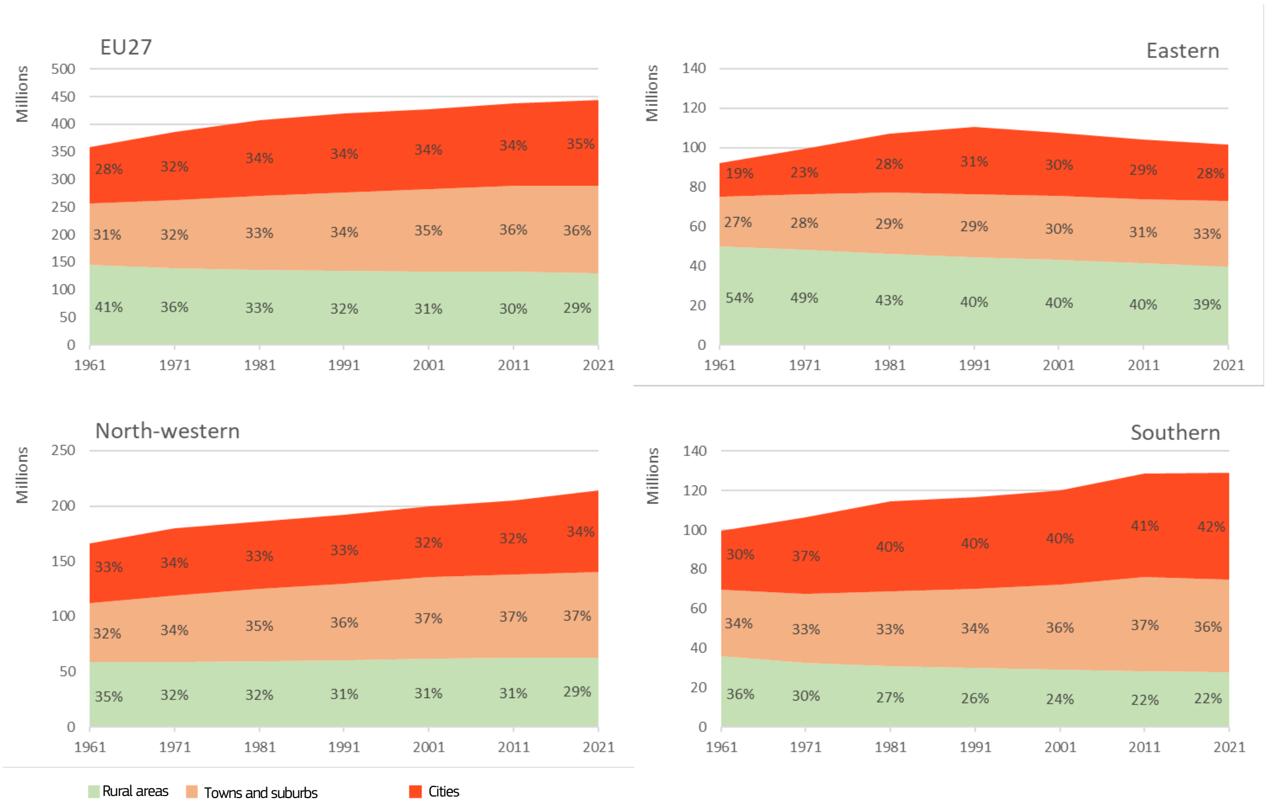

Figure 1.1. Total and relative population per degree of urbanisation (Cities, towns and suburbs, and rural areas), from 1961 to 2021, for the EU27 and per EU macro-regio (northwestern, southern and eastern EU).

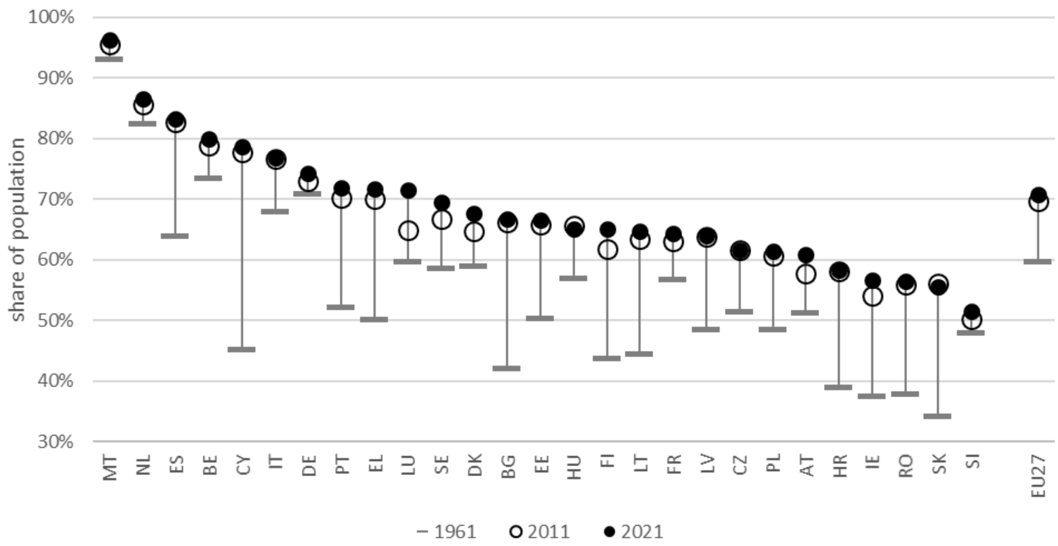

Figure 1.2. Share of urban population per EY Member State in 1961, 2011 and 2021.

2.3 Discussion and conclusions

The concentration of population in cities and urban areas is not a recent trend in Europe. However, new developments in data, methods and definitions allowed us to estimate urbanisation more accurately and consistently. According to our estimates, European urbanisation rate was already relatively high in 1961, with 59% of the population living in cities, towns and suburbs. Currently, the EU has an average urbanisation rate around 71%. There is no expectation that this trend will go into reverse, though on average the speed of urbanisation is likely to decline, especially in countries with already very high urbanisation levels.

Urbanisation is associated with innovation and increasing returns to scale, leading to higher productivity and socio-economic development. Because of the density of urban areas, they can also offer environmental advantages such as reduced land, energy and material consumption. On the other hand, the increasing population density and diversity in urban areas pose challenges related to local pollution, congestion, crime, and lack of social cohesion, potentially affecting well-being of residents. Conversely, the analysis herein allowed us to highlight the ongoing population decline in vast parts of the EU, in particular rural areas. To some extent, rural and remote areas are already lagging in terms of relevant territorial assets compared with more urbanised regions [20, 21]. Territories experiencing rapid and sustained population reductions may face a range of issues such as abandoned housing and difficulties to maintain infrastructure in increasingly thinly populated territories, leading to limited availability and access to both private and public services. The ageing and outmigration experienced in these areas further reduces investment decisions and growth prospects, potentially accentuating the declining trend.

In conclusion, the changing population distribution in space and across the urban-rural spectrum has implications for territorial, social, and economic cohesion. The analysis of past and recent trends can support decision makers anticipate future developments and propose place-based adaptations solutions for existing and emerging issues. Taking advantage of the increasing supply of statistical and geospatial data at high spatial and temporal granularity, future research will continue looking into demographic trends in Europe at different scales, including with a forward looking perspective of both urbanisation and spatial population dynamics.

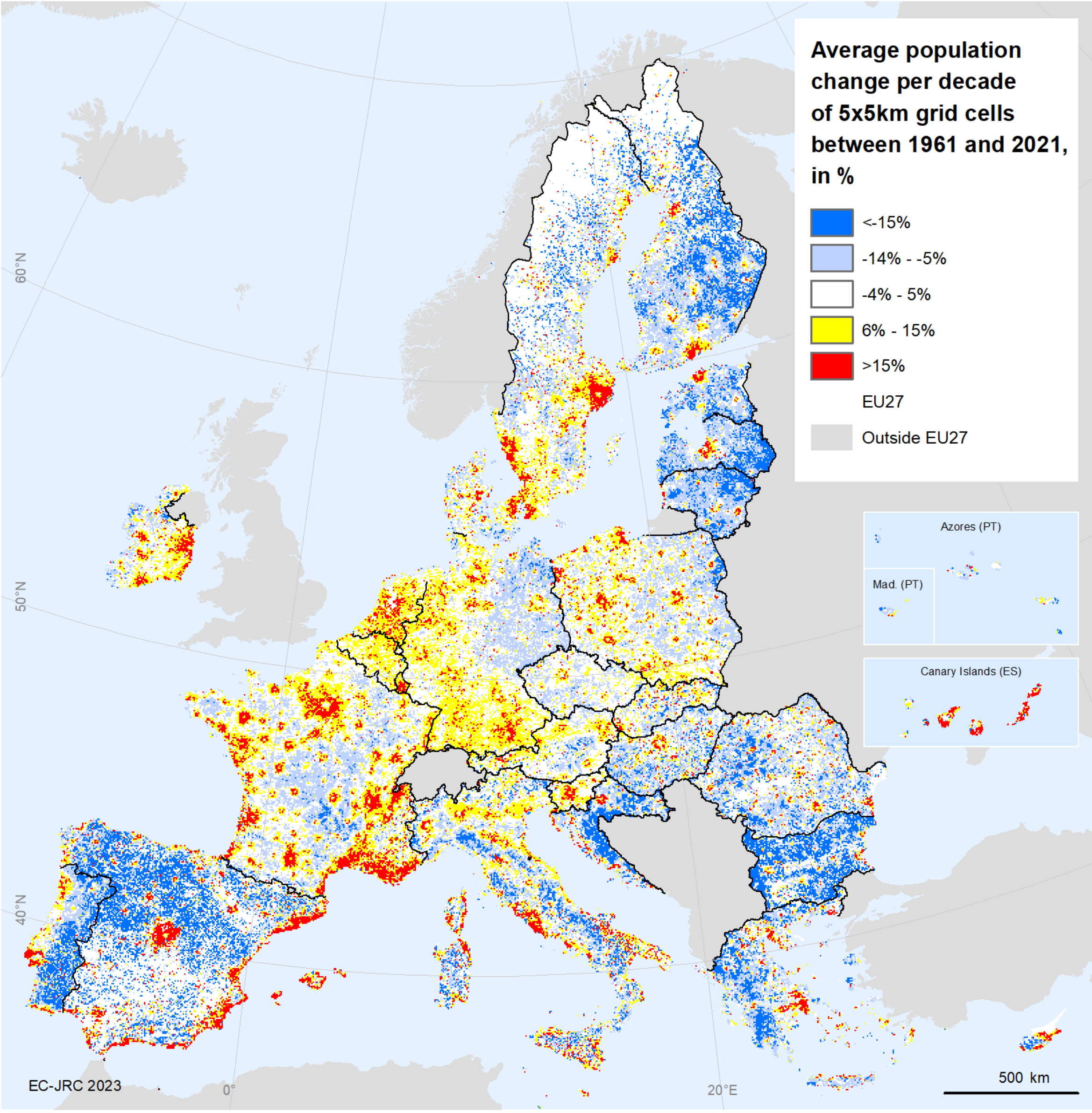

Figure 1.3. Average population growth per decade per areas of 5 x 5 km between 1961 and 2021.

2.4 Methodological note

The degree of urbanisation from 1961 to 2021 was calculated using the Degree of Urbanisation Grid tool developed by the European Commission, Joint Research Centre [22]. This tool produces a grid-level classification of settlements based on population grids at 1 km^2 resolution, according to the definition of the Degree of Urbanisation [19]. For the analysis herein, we used the first classification tier of 1 km^2 grid cells, in three classes: urban centres, urban clusters and rural grid cells. For assessing urbanisation (Figures 1.1 and 1.2), we used the combination of urban centres and urban clusters, which are contiguous 1 km^2 cells with at least 300 inhabitants per km^2 and a minimum population of 5000 inhabitants.

As input to the tool, we used a novel, consistent time-series of population grids at 1 km^2 resolution for the period 1961-2021, with 10-year intervals, matching the census years. This time-series was constructed by the authors of this chapter combining two main types of grids and approaches, as follows:

— For the years 2021 and 2011 we used the population grids assembled and disseminated by Eurostat, based on address- or point-based, census population registers from National Statistical Institutes. These grids are often referred to 'bottom-up' grids, because address- or point-based population counts are aggregated to 1 km^2 grid cells, making them the closest available product to ground-truth.

— The population grids for 2001, 1991, 1981, 1971 and 1961 were estimated sequentially via a new, chain-linked, backcasting approach, starting from the year 2001. The approach combines the census grid for 2011[2], built-up data derived from Earth Observation [23], and known population per municipality for the covered years [24]. In a nutshell, population in 2001 is estimated by assuming a population change between 2011 and 2001 proportional to the observed change in residential built-up volume at the level of each individual 1 km^2 grid cell. The residential built-up volume is obtained from the GHS-BUILT-H dataset [23]. In a second step, the obtained population in the grid cells is rescaled so that their sum matches the known population in 2001 at municipality level[3]. The remainder grids are produced sequentially, and in a similar fashion, backcasting population from the previously estimated population grid.

In their production, all population grids in this time-series (including 2021 and 2011) are rescaled to match the NUTS3 population totals from the Annual Regional Database of the European Commission's Directorate General for Regional and Urban Policy (ARDECO) [25].

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3 Regional GDP growth projections: an uncertain outlook for economic convergence across the EU[4]

Filipe Batista e Silva, Riccardo Curtale, Matteo Schiavone, Lewis Dijkstra

3.1 Introduction

The European Union Cohesion Policy aims at fostering the economic, social, and territorial cohesion of the European Union. In practice, cohesion means fewer disparities in development, wealth, and living standards among different regions within the EU Member States. To this aim, the Cohesion Policy supports public and private investments in regions, to create enabling conditions for economic growth, innovation and job creation, based on the principle of solidarity, where the wealthier regions support the development of less developed ones.

Monitoring territorial cohesion is necessary to evaluate whether the objectives of the Cohesion Policy are being accomplished, and to review and improve the Cohesion Policy itself. One way the European Commission monitors territorial cohesion is by looking at convergence of EU regions in relation to economic indicators. Monfort (2008) [1] reviewed metrics and approaches frequently used to analyse convergence and dispersion among regions, including the so-called beta and sigma convergence. In an assessment published in 2020, Monfort [2] showed that, overall, disparities decreased sharply within the EU in the period 2000-2008, due to strong convergence by the less developed countries of the EU, especially in Eastern and Central Europe. However, since the 2008 financial and economic crisis, the convergence process stalled, with disparities remaining relatively stable around pre-2008 levels. Monfort [2] also shows that, over the period 2000-2017, within-country disparities actually increased for a large number of EU countries, notably Bulgaria, Romania, France and Greece.

In the herein analysis, we provide a forward-looking perspective of convergence trends with a temporal horizon of 2040. The analysis is based on past trends and the latest available projections of population and economic growth from the 2021 Ageing Report [3]. We use the novel Demography-Economy-Land use interaction (DELi) model to downscale GDP projections from the country level to the regional, NUTS3 level [4]. The regionalisation took into account regional growth factors observed in the period 2000-2019, including: beta-convergence (or the catching up factor), country fixed effects, population structure, human capital, urban agglomeration and quality of institutions. We then calculated regional convergence using the weighted coefficient of variation (wCV) of GDP per capita at the NUTS2 and NUTS3 levels for both the observed (2000-2021) and projected periods (2021-2040).

This analysis intends to contribute to the debate on the future of the Cohesion Policy, anticipating possible upcoming challenges to territorial cohesion. In a preview of the more detailed results presented in the remainder of this chapter, we estimate that, between 2023 and 2040, convergence of GDP per capita among NUTS2 regions within the EU is expected to decrease by 6%. However, the simulations show that it can decrease up to 30% under a scenario of lower convergence, with future GDP per capita growth being much stronger in already high-income regions, capital regions and

[4] How to cite this chapter: Batista e Silva F, Curtale R, Schiavone M, Dijkstra L (2024) Regional GDP growth projections: an uncertain outlook for economic convergence across the EU. *In*: Batista e Silva F and Dijkstra L (eds.) Challenges and opportunities for territorial cohesion in Europe - contributions to the 9th Cohesion report. Joint Research Centre Science for Policy report. Publications Office of the European Union, Luxembourg. doi:10.2760/466949

regions with large urban agglomerations. In both scenarios, the decrease in convergence happens despite the strong GDP growth projected for catching-up countries. These scenarios highlight a non-negligible risk of past convergence being undone, at least partially, compromising territorial cohesion. This emphasizes the future role of regional development policies to resume and sustain the convergence path within the EU.

3.2 Results

Figure 2.1 shows the weighted coefficient of variation of GDP per capita in Purchasing Power Standards (PPS) at NUTS2 level, between 2000 and 2040. Until 2021, the values are observed, as reported in ARDECO [6], and from 2021 to 2040 the values are simulated based on DELi. Regional convergence improved between 2000 and 2009 (wCV decreasing from 0.44 to 0.38) and then stayed relatively stable until 2021. The central scenario indicates a steady but moderate increase to levels slightly above 0.40 between 2021 and 2040. Using the upper and lower 90% confidence bound for the beta-convergence parameter in DELi yields a relatively wide uncertainty band around the central scenario, showing that regional convergence is possible, but real risks towards divergence cannot be discarded.

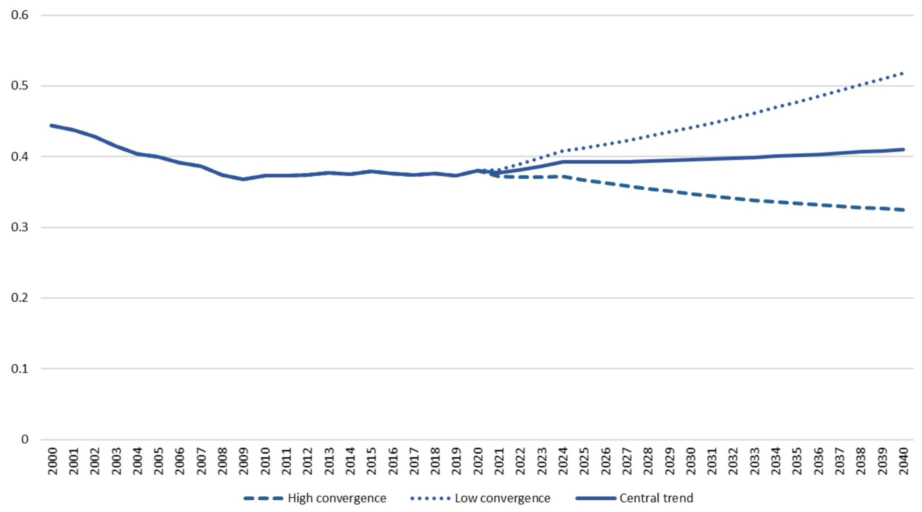

Figure 2.1. Weighted coefficient of variation of GDP per capita in PPS at NUTS2 level (y axis), 2000-2040.

In Figure 2.2 we show the coefficient of variation measured for the NUTS2 and NUTS3 levels and for the regional distribution of GDP per capita and total GDP. The disparities measured using the wCV are higher when using the NUTS3 level, owing to the higher regional heterogeneity for the smaller NUTS3 regions compared to NUTS2. In other words, the NUTS2 level analysis cancels out much of the regional variability.

Figure 2.3 shows the same information as in Figure 2.2, but indexed to the year 2021 (start of the projection). It indicates that future trends are aligned towards a slight increase of regional disparities, both at the NUTS2 and NUTS3 levels, and also for both GDP per capita and total GDP. However, total GDP shows a more marked trend towards higher regional divergence, likely due to population concentrating in fewer, more urban regions, as per the Eurostat demographic projection. Although convergence is often analysed for GDP per capita, the analysis of convergence for total GDP is complementary. A scenario in which there is substantial further divergence in total GDP, in other words, further concentration of total GDP in fewer regions, may pose a set of different issues for territorial cohesion. In fact, Figure 2.4 shows that, despite a higher convergence in GDPpc in PPS across urban-rural typologies, which has been going on for two decades and is expected to continue (see Figure 2.4a), GDP will be further concentrated in predominantly urban regions, as opposed to intermediate and predominantly rural regions (see Figure 2.4b), according to our central scenario.

Finally, the maps in Figure 2.5 show the estimated GDP per capita growth in the period 2021 – 2040 at NUTS2 level, for the three scenarios. The maps highlight substantial differences in simulated regional GDP per capita growth across regions and scenarios. Clearly the high convergence scenario results in much more similar GDP per capita growth rates across regions within each country, and often with capital and more developed regions growing at slower pace than national average growth.

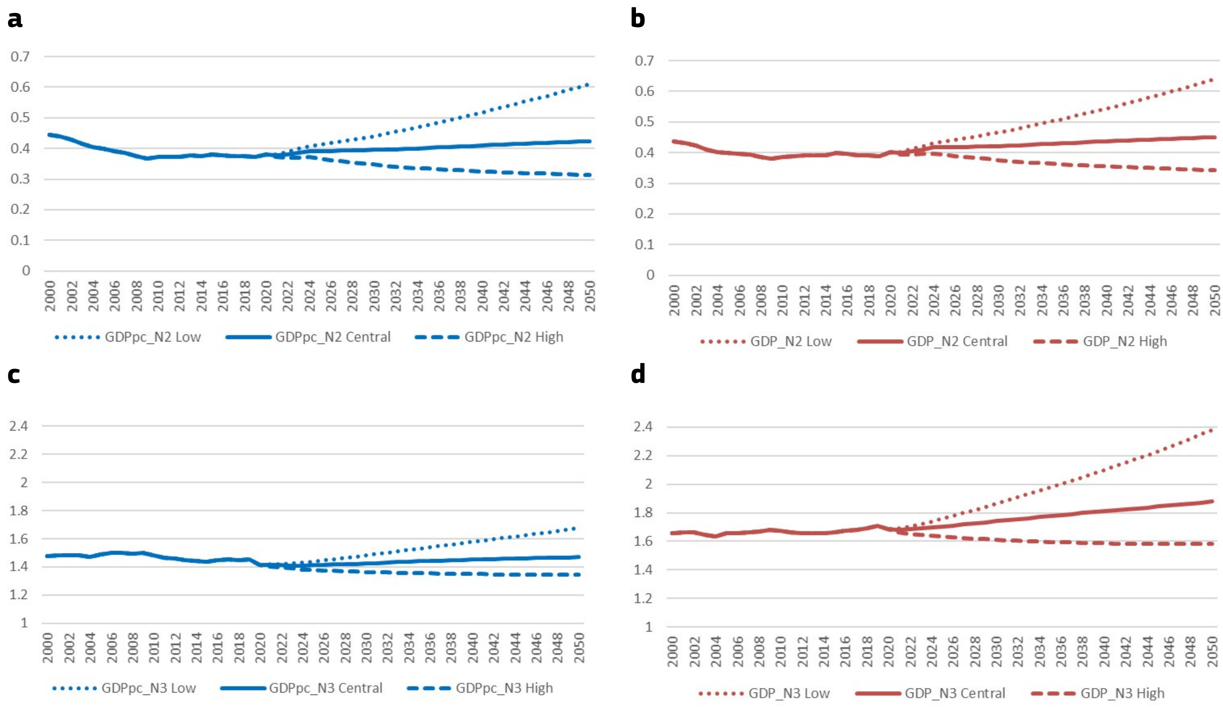

Figure 2.2. (a) Weighted coefficient of variation of GDP per capita in PPS for NUTS2 regions, (b) coefficient of variation of GDP in PPS for NUTS2 regions, (c) weighted coefficient of variation of GDP per capita in PPS for NUTS3 regions, (d) coefficient of variation of GDP in PPS for NUTS3 regions, between 2000 and 2040.

3.3 Discussion and conclusions

With the DELi model [4] we were able to regionalise the country-level projections from the 2021 Ageing Report, to assess possible scenarios (and uncertainty) of EU's regional economic convergence going forward. At NUTS2 level, regional convergence improved between 2000 and 2009 (wCV decreasing from 0.44 to 0.38) and then stayed relatively stable until 2021. The projections from 2021 to 2040 show a steady but moderate increase to levels above 0.40. However, we found a wide uncertainty band around the central scenario (wCV between 0.33-0.52 by 2040, with 90% confidence).

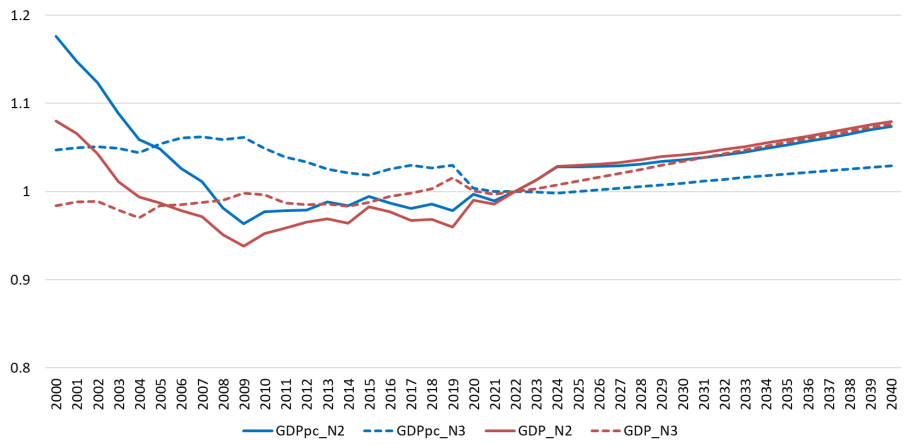

Figure 2.3. Weighted coefficient of variation for GDP per capita and coefficient of variation for GDP, in PPS, for the NUTS2 and NUTS3 levels, 2000-2040, indexed to levels in 2022 (y axis).

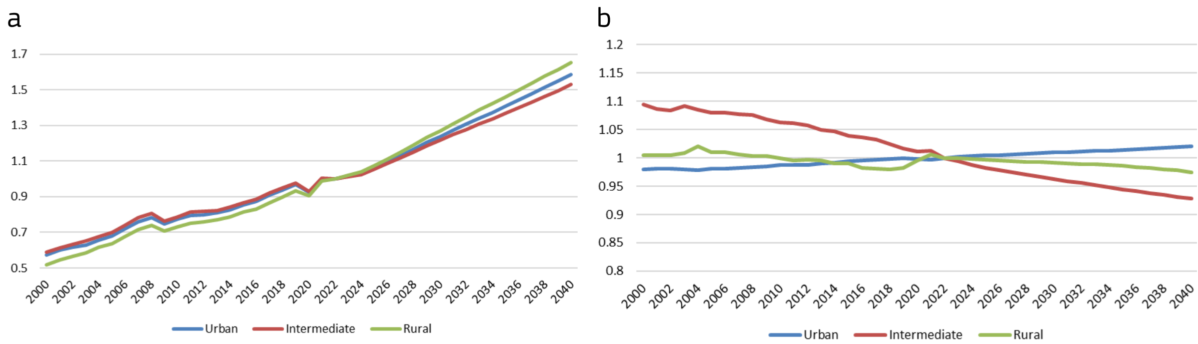

Figure 2.4. Trend of GDPpc in PPS (a) and of shares of total GDP in PPS (b) across the Urban-Rural typology, 2000 – 2040. Both variables are indexed to levels in 2022.

From 2021 onward, the disparities in total GDP regional distribution are likely to increase more than those for GDP per capita, owing to the effect of population concentrating in fewer, more urbanised regions, based on the Eurostat demographic projection. The analysis also showed that regional disparities are higher when measuring wCV per NUTS3 compared to NUTS2 (wCV of 1.41 and 0.38 by 2021, respectively), owing to spatial scale effects (higher regional heterogeneity for the smaller NUTS3 regions than for the larger NUTS2 regions).

According to these scenarios, further regional convergence in the future is in the spectrum of possibilities. However, the most likely business-as-usual scenario indicates a higher likelihood for slight divergence, undoing past convergence, at least partially. This emphasizes the future role of regional development policies to resume the convergence path.

The main limitations of the approach to generate this outlook are two-fold. First, we used an exogenous source of population at NUTS3 level. So, in the used model configuration, regional economic growth is a function of demography but not vice-versa. In reality, demographic trends are expected to be sensitive to economic trends too, particularly via migration flows. An econometric analysis showed that GDP per capita is a significant predictor of regional net migration for various age groups [4]. Future scenarios generated using the DELi model will have both endogenous GDP per capita and net migration, to better capture this bidirectionality. Second, total country GDP is constant between scenarios, reflecting a non-plausible zero-sum game situation, where the growth of one region comes at the expense of the growth of another region. In future simulations using DELi, we may relax the country constraints, to investigate whether high, central and low convergence scenarios may imply differences in aggregate country and EU GDP growth.

3.4 Methodological note

We downscaled the projections of GDP from the 2021 Ageing Report [3] at country level to sub-regional level (NUTS3), using the DELi model. The model starts by estimating future growth of GDP per capita, using econometrically estimated regional growth factors, including beta-convergence, country fixed effects, population structure and factors of growth such as human capital, urban agglomeration and quality of institutions. Historical socioeconomic data at NUTS3 are taken from the ARDECO database [6]. Total regional GDP is obtained by multiplying the forecasted GDP per capita with the population retrieved from EUROPOP2019 demographic projection from Eurostat available NUTS3 level [7]. Validation of the model has shown that it is substantially superior at predicting future regional GDP shares than a null model that does not consider regional differences in GDP per capita growth rates [5]. The detailed methodology of the DELi model is described in a dedicate Technical Report [4].

DELi's GDP per capita growth equation includes an econometrically estimated beta-convergence parameter. The central estimate for this parameter is used to generate the central scenario. The upper and lower 90% confidence estimates for this parameter are used to derive the high and low convergence scenarios. We analysed the trends of the weighted coefficient of variation for GDP and GDPpc in Purchasing Power Standards (PPS), at the NUTS2 and NUTS3 levels for the whole of the EU, for the three scenarios. The weighted coefficient of variation (wCV) used herein is consistent with the metric proposed by Monfort (2020) [2]. It the disparities in the distribution of GDP per capita weighting for the different sizes of the regions (i.e., larger distances to the average EU27 GDP per capita in less populated regions count less than in more populated regions). The higher the wCV, the higher the disparities.

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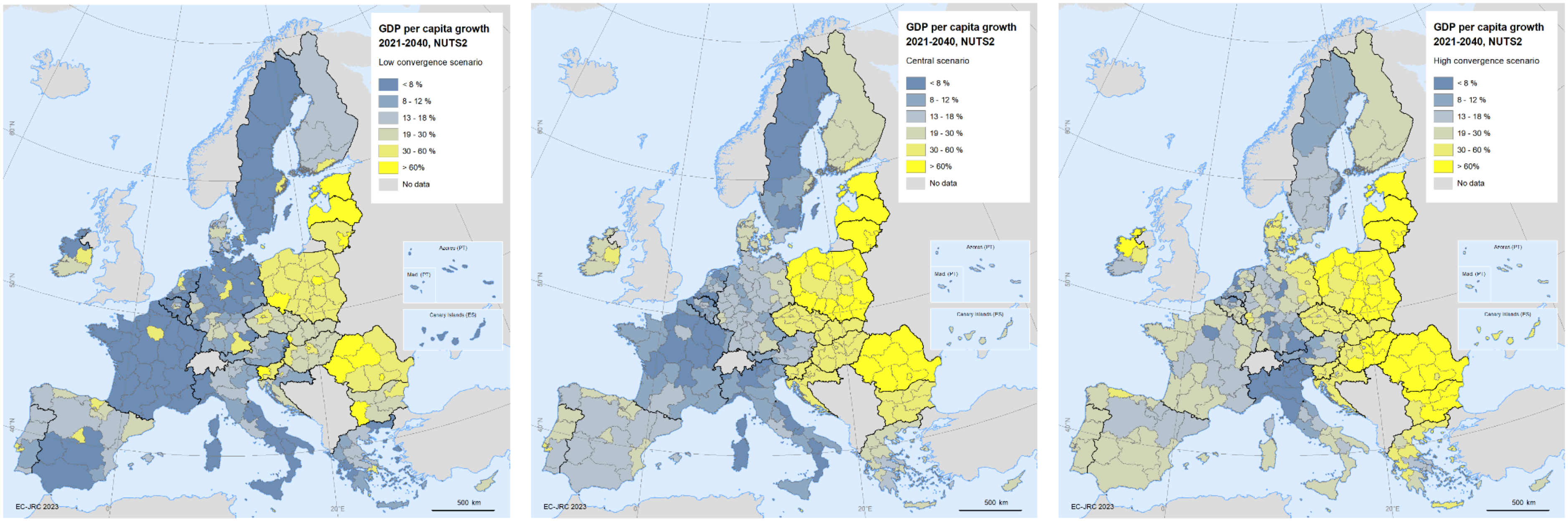

Figure 2.5. GDP per capita growth between 2021 and 2040 at NUTS2 level. From left to right: Low convergence scenario, central scenario, and high convergence scenario.

PART II – Transport and digital accessibility

4 Urban, suburban and rural car travel demand across the EU[5]

Chris Jacobs-Crisioni, Lewis Dijkstra, Mert Kompil

4.1 Introduction

Road transport is a sizeable contributor to Europe's greenhouse gas emissions [1]. Understandably, many EU member states have developed initiatives to decarbonise transportation, provide incentives for public and active transport, or tax the external costs of cars with internal combustion engines. However, these initiatives bring forward equity concerns, as the impacts of such initiatives may not be distributed fairly spatially or among the population. One reason is that the daily dependency of the EU population on personal cars varies considerably across the EU territory. The amount of travel by car is a key indicator of how dependent inhabitants are on passenger cars for their daily transport needs. Aggregate average kilometres travelled by passenger vehicles are already available as national statistics in many European countries. Unfortunately, these data are not available at a spatially more granular level, even though information on kilometres travelled is typically registered for all vehicles that are subject to mandatory recurring technical inspections.

This chapter reports on a project that was set up to fill the knowledge gap by estimating subnational travel demand through an informed disaggregation of national-level statistics. These estimates are useful inter alia to understand territorial variations in car dependency, and the potential socio-economic impacts of policies for sustainable transport. Travel demand is approximated by the amount of kilometres travelled per-capita by passenger cars registered in EU regions. A regression model has been trained on three member states for which regional car travel data is available, and subsequently used to predict local car travel across the EU. The results of this model are reported on in this chapter. Characteristics of the method are given succinctly in a methodological footnote.

4.2 Results

For the sake of example, grid-based model results have been aggregated to the NUTS3 level. The results of this exercise are shown in Figure 3.1. From this map follows that the most kilometres travelled per capita by passenger cars tend to be in rural and intermediate regions close to major cities; this is for instance shown clearly around Stockholm, Madrid, Prague, Sofia and Athens. However, some member states do stand out with diverging patterns. For example, the dynamic in France can be summarised as a contrast between its rural areas and Paris, Lyon and Marseille. Italy stands out as, instead of regions surrounding cities, its often remote communities in Italy's central mountainous areas have the highest kilometres travelled.

[5] How to cite this chapter: Jacobs-Crisioni C, Dijkstra L, Kompil M (2024) Urban, suburban and rural car travel demand across the EU. *In*: Batista e Silva F and Dijkstra L (eds.) Challenges and opportunities for territorial cohesion in Europe - contributions to the 9th Cohesion report. Joint Research Centre Science for Policy report. Publications Office of the European Union, Luxembourg. doi:10.2760/466949

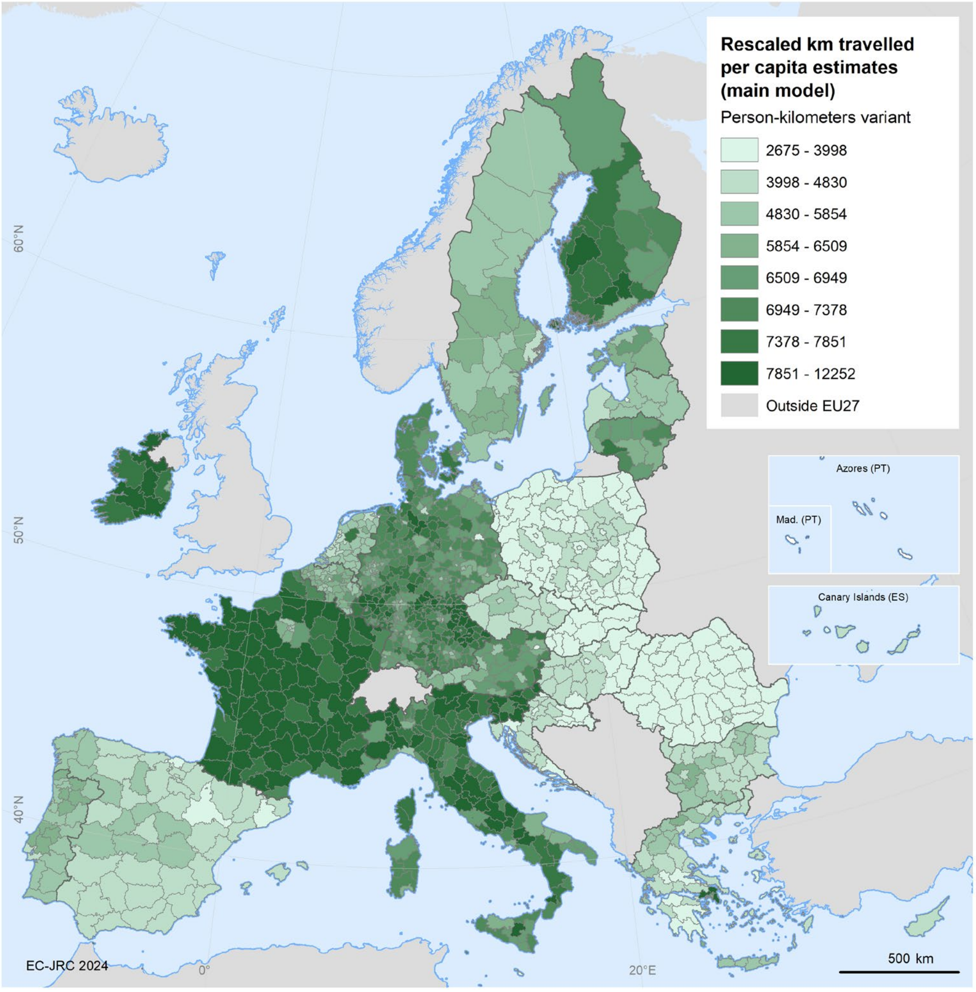

Figure 3.1. Results of downscaling national statistics on passenger car kilometres travelled to the NUTS3 level, using the outlined downscaling approach. The downscaled national vehicle kilometres travelled are based on person-kilometres.

To gain more insight in vehicle usage between rural and urban settings we've broken down our grid-based estimates by degrees of urbanisation (see Figure 3.2). Several conclusions can be drawn from this graph. First, there are sizeable differences in estimated car use between member states, with inhabitants of many new member states typically driving the least, and inhabitants of Ireland, France, Luxembourg and Slovenia driving cars the most. Inhabitants in rural locations tend to drive more on aggregate. Greece presents a single exception, as we estimate that urban inhabitants drive the most in Greece, and rural inhabitants the least. The gaps in estimated car usage differ substantially between member states. In Czech Republic, Romania and Slovakia, the gap is less than 1,000 kilometres annually; while in Austria and France the gap is around 3,000 kilometres. The estimated urban/rural gap in per-capita vehicle usage is the largest in France.

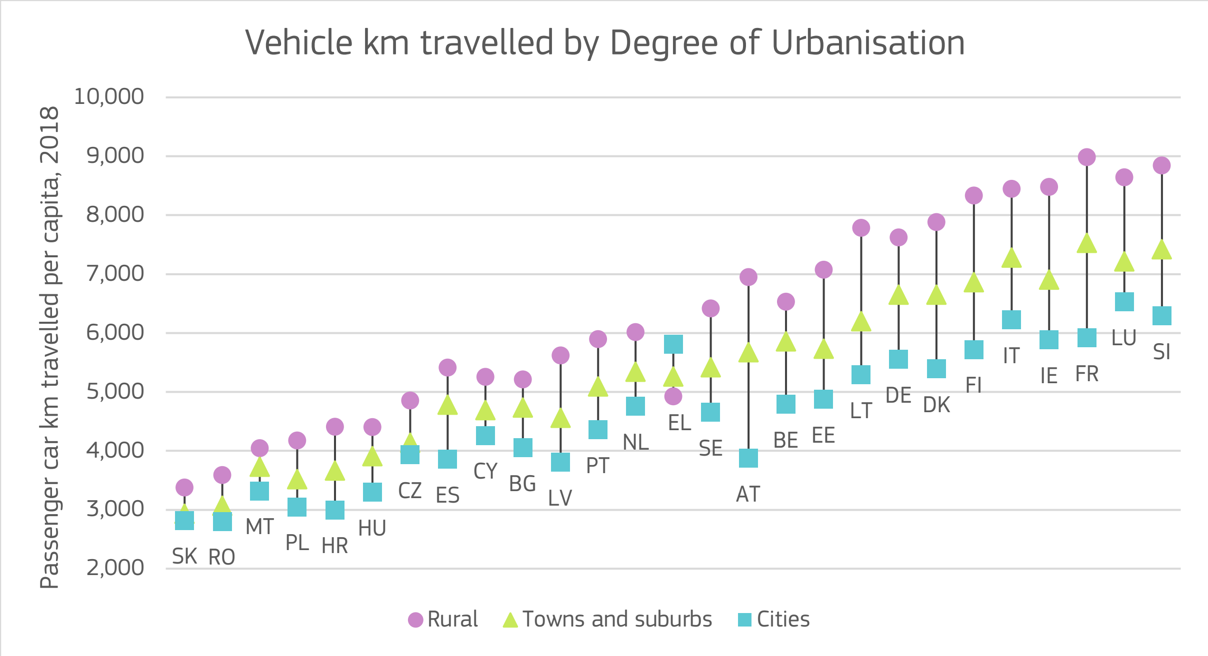

Figure 3.2. Estimated national passenger car kilometres travelled per capita by degree of urbanisation.

4.3 Discussion and conclusions

The presented exercise foremost highlights that car dependency is not distributed uniformly across Europe's territory, owing to geographical but also policy aspects that may directly or indirectly encourage car use. Taking this into account may be valuable for understanding the impacts and support of political endeavours to 'green' mobility across Europe. Given the sizeable gaps in car use between rural and urban territories in some member states, it seems likely that policies that increase the cost of passenger car usage will have particularly sizeable social impacts in the rural areas of member states including France, Germany, Ireland and Slovenia.

With a limited number of variables that describe spatial context, not preferences, it is possible to disaggregate regional variation in kilometres travelled with considerable accuracy. Thus, without taking into account the likely variation in EU citizen's stance towards passenger cars, spatial context matters for car dependency. Because EU citizens tend to sort themselves according to their preferences, it is plausible that inhabitants with a preference for car-based mobility tend to live in places with high car dependency. Thus, the impacts of increasing the costs of car usage may not only have more sizeable social impacts in rural areas; they may also be met with considerable resistance as rural citizens do not perceive or dislike viable alternative means of transport.

4.4 Methodological note

The results are based on a model that describes how four variables affect regional deviations of per-capita passenger car kilometres from the country average. The dependent variable was observed in 2019 and collected by respective national statistical offices from Ireland, The Netherlands and Sweden. The model takes this form $= e^{0.105} * pwd^{-0.044} * nd^{0.173} * cpc^{0.565} * (rp + 0.01)^{-0.015}$. This model implies that regions have comparatively less car kilometres travelled if population-weighted densities (*pwd*) are higher (from [2]); have more car kilometres travelled if estimated travel demand (*nd*) is higher (see [3]); have more car kilometres travelled if the amount of cars per capita (*cpc*) is higher; and have less car kilometres if railway transport performance (*rp*) is higher (see [4]). The model explains a considerable amount of the variation in the dependent variable (the adjusted R^2 is 0.86). Analysis of model errors show that it is fairly conservative, underestimating car use in regions with comparatively many kilometres travelled values, and overestimating car use in regions with comparatively low values. In order to verify the robustness of this model, many alternative specifications were tested with other variables and/or transformations of the variables. These confirm that the signs and quantitative impacts are robust.

The model is subsequently used to compute variation in car use at the 1 km^2 grid level. The variables describing approximated travelled road distances as well as population weighted densities could be produced at the 1 km^2 grid level across the EU. The cars per capita variable depends on official statistics from Eurostat that describe number of passenger vehicles registered in the territories of EU member states. For most member states, these statistics are available at the NUTS2 level. However, for France and Lithuania, these data are only available at the NUTS1 level, and for Portugal even only at the country level. By necessity, the number of cars has therefore been imposed to the 1 km^2 grid level from the most granular data provided by Eurostat, i.e., NUTS0, NUTS1 and NUTS2.

Unfortunately, only a limited number of member states report travelled car kilometres directly. Where data is missing on car kilometres travelled, total kilometres travelled by persons in passenger cars were used as an alternative. These are more widely available in the EU but not fully comparable with vehicle kilometres travelled. To convert kilometres travelled by persons in cars to estimates of vehicle kilometres travelled, total kilometres travelled by persons were divided by 1.7. This is the average vehicle occupation rate in the EU [5]. Doing so yields a rough estimate of total kilometres travelled by passenger cars. The aggregate number is subsequently divided by national populations to obtain a comparable estimate of vehicle kilometres travelled per capita, and used in the downscaling exercise through multiplication with the normalised model results.

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5 Time lost due to morning road peak conditions in the EU[6]

Chris Jacobs-Crisioni, Lewis Dijkstra, Mert Kompil

5.1 Introduction

Demand for road transport varies considerably throughout the day, with excessive demand leading to congestion during peak hours. This in turn leads to time loss for EU citizens while travelling. The accessibility consequences of traffic have been studied extensively using data from TomTom [1]. However, the extent and territorial distribution of time loss has long been unknown. Arguably, such time loss estimates are conceptually even more challenging as these require an assessment of how many people travel to which destination, and using which routes. Recent advances in transport modelling, and some coarse assumptions on travel behaviour, now enable a rough estimate of the territorial distribution of peak hour time loss.

This chapter reports on a modelling exercise in which speed and time loss intensities are shown for the EU territory. The modelling approach is described succinctly in a methodological footnote. Trips are modelled between all inhabited 1 km^2 grid cells in a country [2]. The modelling further hinges on the straightforward assumption that all citizens make an equal amount of trips, and their destination choices depend only the population at the destination, free-flow travel time to the destination, and a generic distance-decay function. Travel speeds and time loss are subsequently deduced by taking into account how much time they would spend to reach the same destinations, given road speed conditions at 8:30 AM, during peak hours. Results were averaged to functional areas [3,4], NUTS3 regions, degrees of urbanization and urban audit typologies for the purpose of this report. As the actual number of trips made by citizens, the time at which those trips are made, trip destinations, and routes chosen remain unknown, the results have an indicative character only.

5.2 Results

5.2.1 Speeds and speed loss

Time loss results need to be framed carefully. Congestion tends to lead to larger time losses if uncongested travel speeds are higher. Thus, time loss results are easily biased towards locations that enjoy higher free-flow travel speeds. To add necessary nuance to our results we therefore begin with showing that average free-flow travel speeds are not distributed uniformly across the EU. Figure 4.1 shows the distribution of average free-flow speeds in the EU’s functional areas. Average free-flow travel speeds range from 26 km/h to 75 km/h for passenger cars. The lowest average speeds are predominantly found in metropolitan areas in the Baltics, Spain, Poland and Romania. The highest overall average speeds can be found in Germany, owing to that country's extensive motorway network and the lack of speed limits on a part of that network. In some member states the differences in

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speeds between metropolitan and rural areas seem surprisingly marked, for instance in Spain and Latvia.

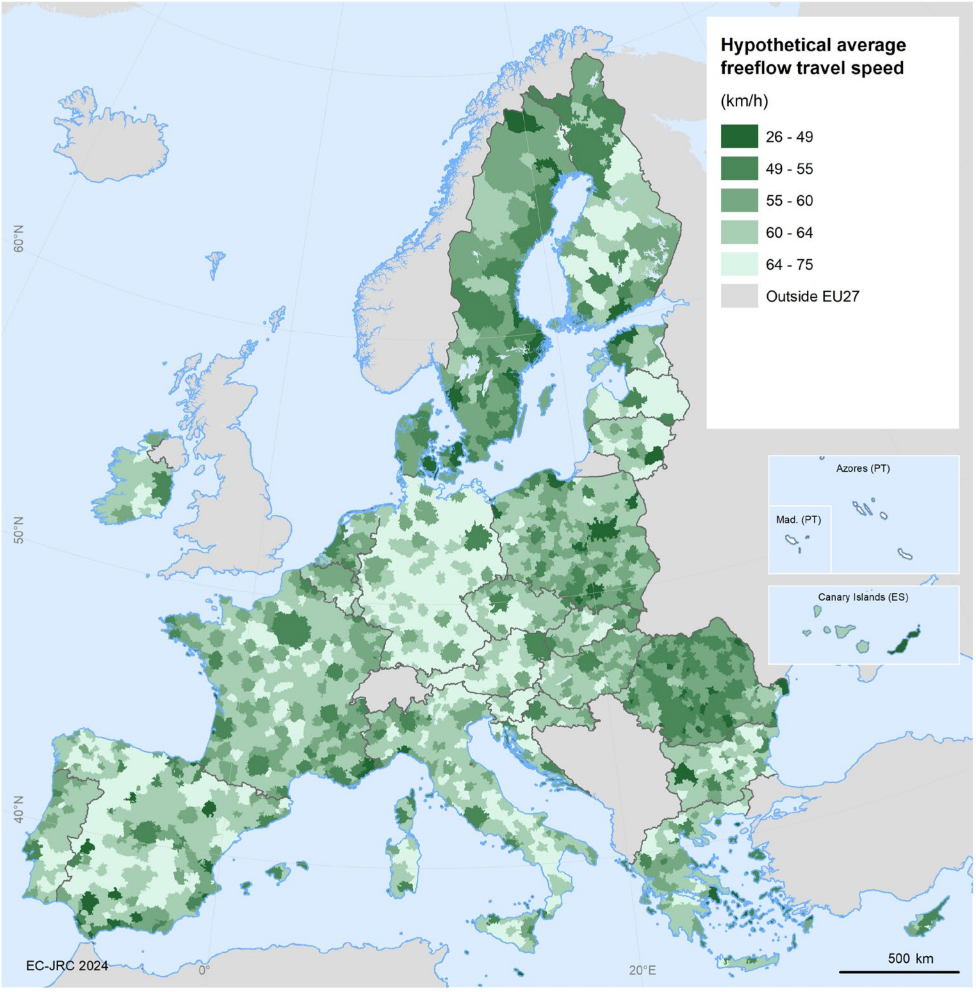

Figure 4.1. Hypothetical average free-flow travel speeds for passenger cars at the functional area level, indicating low speeds particularly in metropolitan areas.

Figure 4.2 shows the speed losses when all modelled trips would be done with the driving conditions at 8:30 AM. This map seems to be very correlated with Figure 4.1, with higher free-flow speeds typically leading to larger speed losses, for instance in Germany and rural areas in Spain. Overall, urban areas seem to have the lowest absolute losses in speed. Rural areas in central Romania seem to be a curious outlier, with low free-flow speeds and very limited speed losses. In Figure 4.3, average travel speeds are broken down by degree of urbanisation. These figures corroborate that speeds tend to be faster in rural areas, towns and suburbs. The differences between free-flow and morning peak condition travel speeds indeed seem somewhat larger for rural areas and towns and suburbs than for cities, although for some member states (for instance Luxembourg) the differences may be negligible.

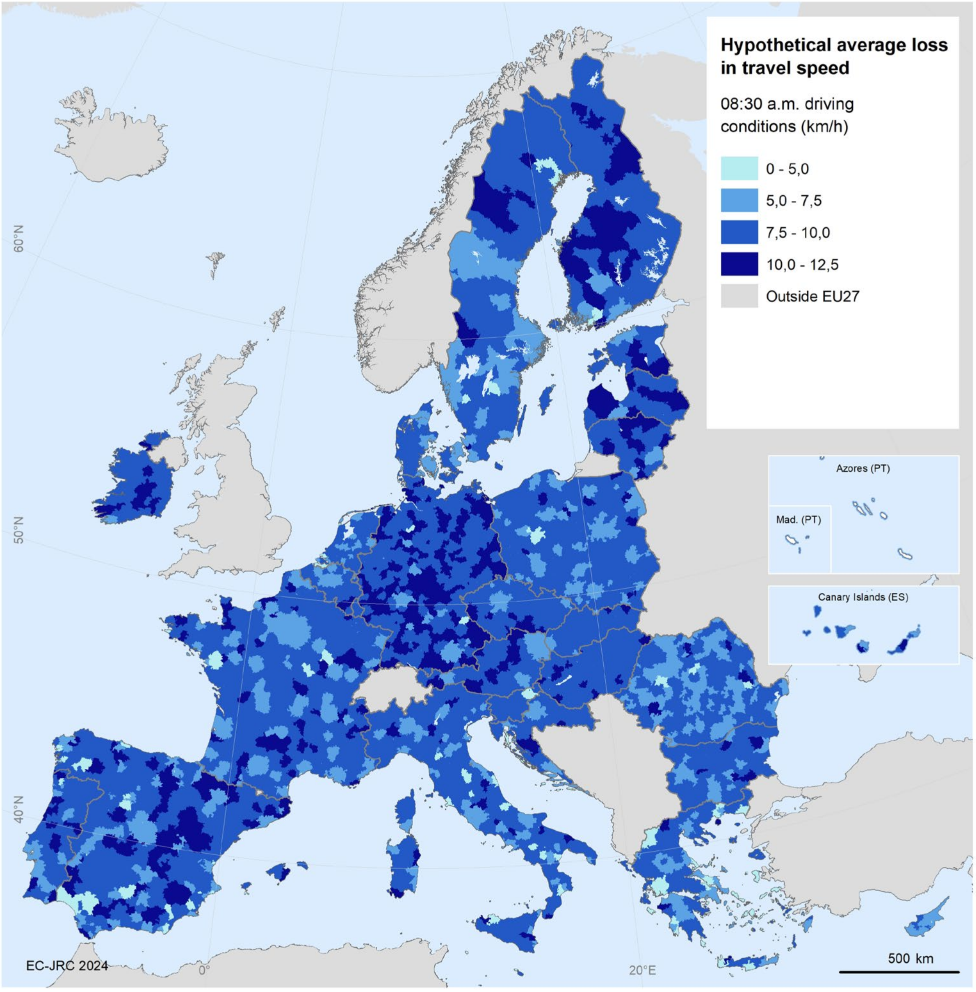

Figure 4.2. Hypothetical average loss in travel speeds due to morning peak hour traffic conditions, showing sizeable speed losses in many of the functional areas with high free-flow travel speeds.

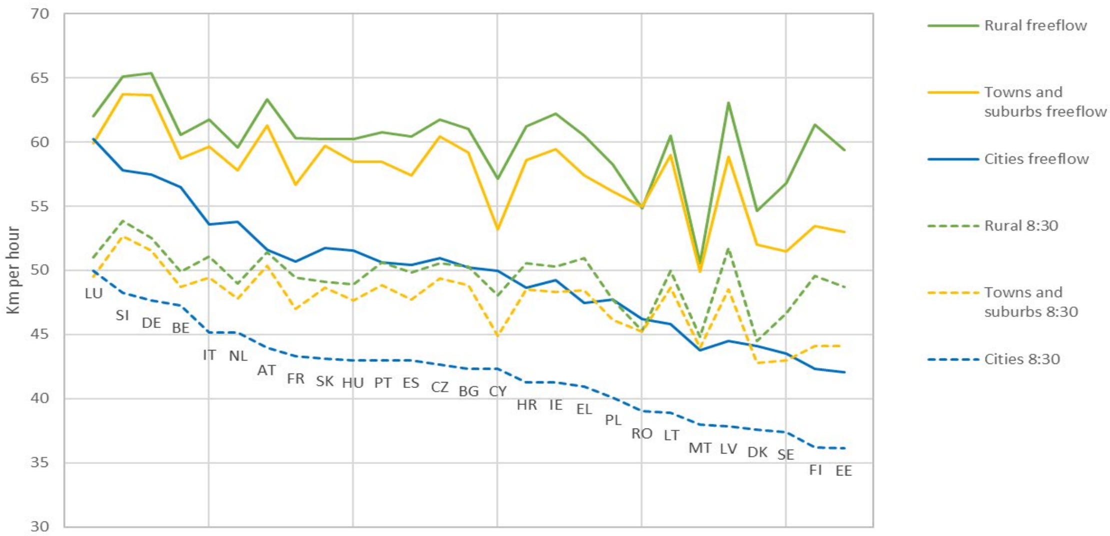

Figure 4.3. Free-flow and morning peak hour average travel speeds by degree of urbanisation.

5.2.2 Time loss intensity

Parts of the EU territory do not only vary in potential travel speed, but also in travel length (see Chapter 3), and in the amount of roads that are available for car travel. We therefore choose to indicate time loss intensities in order to emphasize that congestion affects only a limited part of the road supply. To indicate the territorial intensity of time loss we normalize hours lost by road lengths measured per urban audit zone. Time loss intensity by road length is also mapped by NUTS3 region in this section.

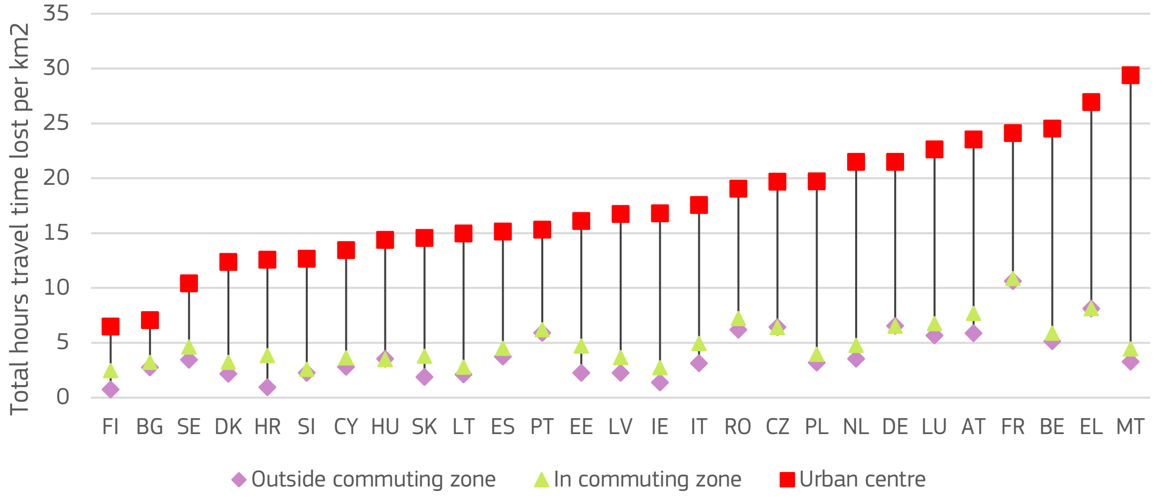

Figure 4.4. Time loss intensity by road length in urban audit typology in EU member states, highlighting the concentration of time loss on roads in urban areas.

Figure 4.4 shows, by EU Member State and urban audit typology, the intensity of time lost. This is computed as the total estimated amount of time residents would lose when travelling their modelled journeys with 8:30 AM travel speeds, versus the kilometres of road in a specific urban audit typology. From these results follows that, even though speed losses are relatively limited in urban centres, these still translate into a high intensity of time loss on the limited amount of roads present in urban centres. Surprisingly, time loss intensities are fairly comparable between commuting zones and the territory outside commuting zones, presumably because of the comparably large supply of roads outside of urban centres.

When time loss intensities are presented at the level of NUTS3 regional level as in Figure 4.5, the picture changes somewhat. Metropolitan regions clearly show high intensities of time loss per km of road. However, Romania, which does not present conspicuously high time loss intensities in urban audit typologies in Figure 4.4, shows high time loss intensities across most of its territory. On the other hand, France, which does show very high time loss intensities in Figure 4.4, does not show remarkably high time loss intensities in most of its territory. A likely explanation follows from the somewhat mixed definition of NUTS3 zones, which possibly emphasizes urban centre results in Romania, while providing more mixed results from France.

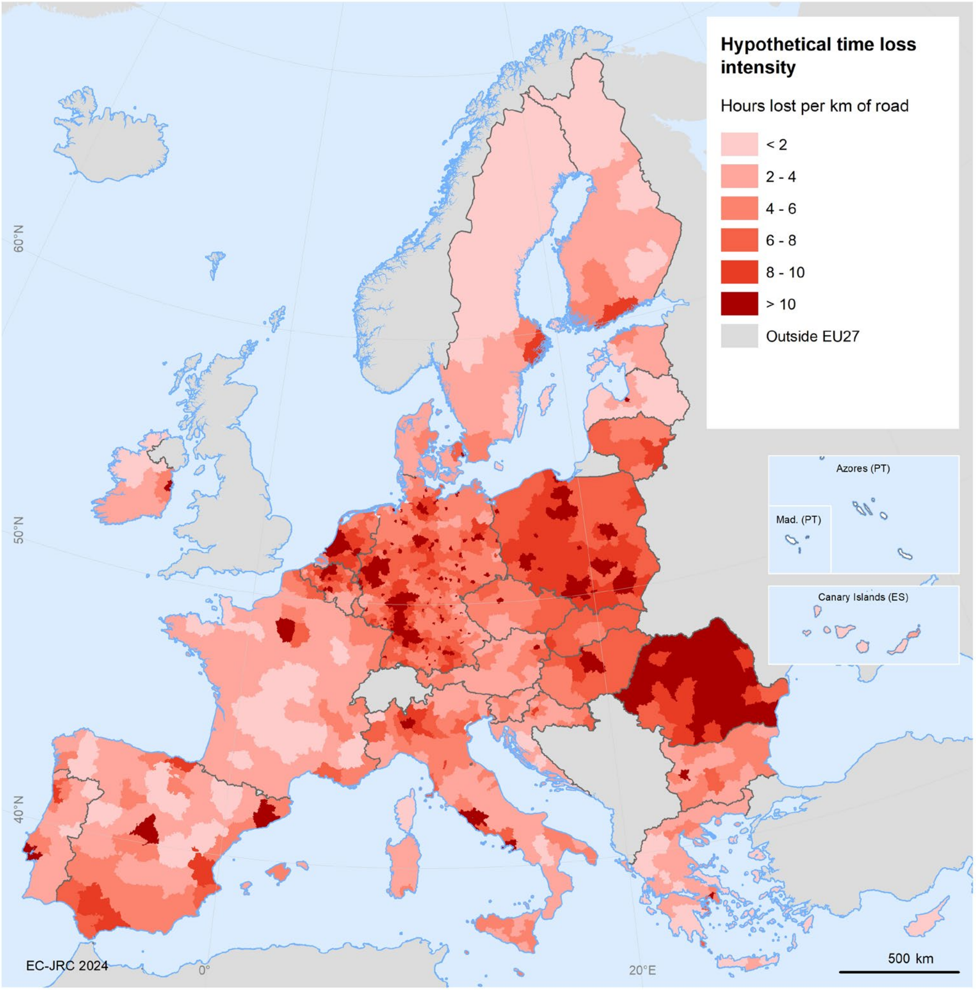

Figure 4.5. Regional time loss intensities in the EU, highlighting the high intensity of time loss per km of road predominantly in metropolitan regions and most of Romania.

5.3 Discussion and conclusions

Overall, this analysis indicates very clear spatial differences in travel speed, speed losses and time loss intensities throughout the EU territory. Travel speeds tend to be lower for the residents of urban areas. In absolute terms, urban residents tend to experience less speed loss as well in morning peak conditions. However, the limited speed loss affects a large part of the population and occurs on the limited road length in urban areas. Thus, throughout the EU, time loss intensities are predominantly concentrated in urban areas.

Closer study of the used data shows that substantial speed loss occurs most evidently on motorways and other main arteries (see Figure 4.6). The reason for such speed drops is not only due to congestion on the network. For example, in the Netherlands, speeds seem to drop considerably during weekday mornings not because of congestion, but because posted maximum speeds are much during daytime hours in order to restrict nitrogen emissions. Thus, caution needs to be exercised when interpreting the presented results as the consequence of congestion. Much more work may be needed on the interpretation of the used TomTom data to ensure that factors such as time-variant maximum speeds are not included in these estimates.

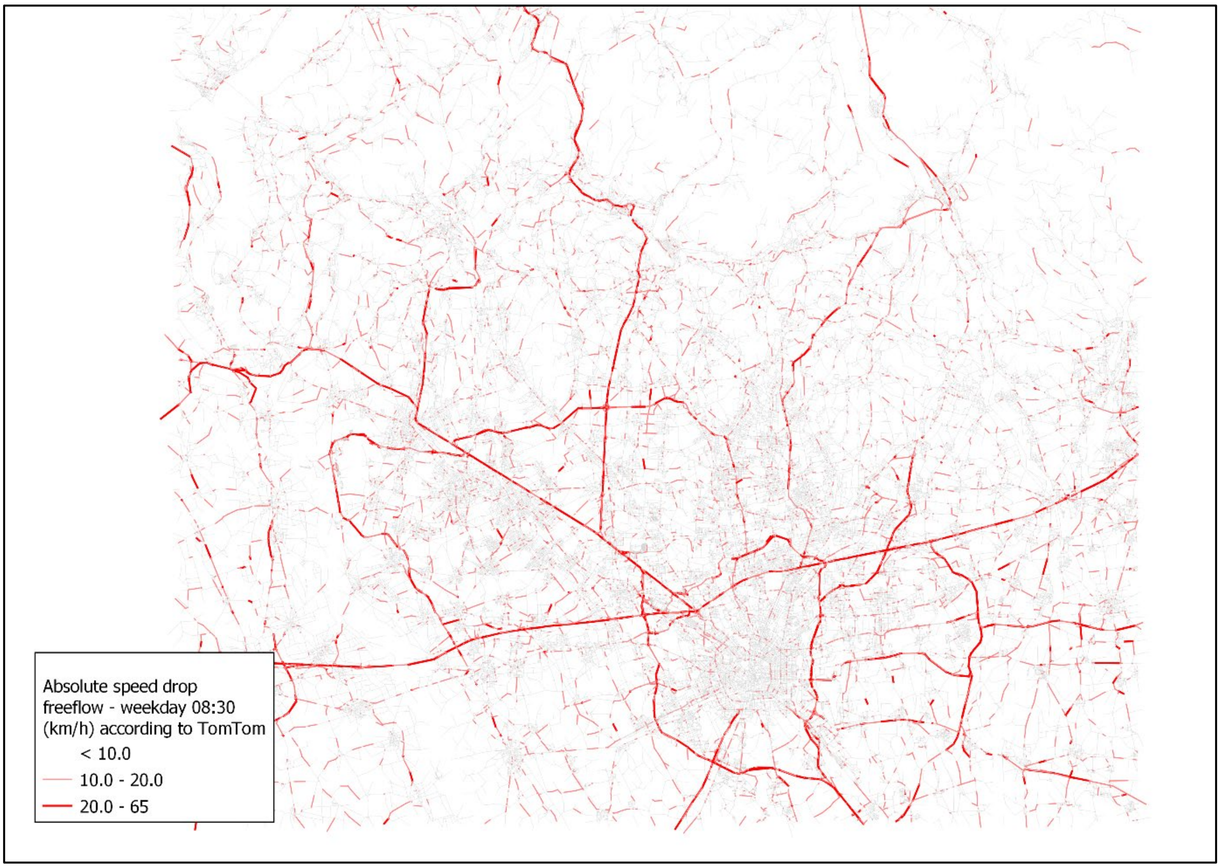

Figure 4.6. Absolute speed drops on an excerpt of the TomTom network around Milano, Italy, exemplary for the observation that speeds drop primarily on the motorway network during the morning peak.

5.4 Methodological note

To estimate time loss, we apply the approach outlined in section 2.1 of Jacobs-Crisioni *et al.* (2015) [2]. This approach entails an origin-constrained spatial interaction model between inhabited 1 km^2 grid cells in Europe in 2018 [5]. It yields a distribution of trips from every inhabited origin grid cell to all inhabited grid cells that are i) within member state boundaries and ii) within 60 minutes driving according to free flow conditions. Trip distribution is based on free-flow travel times according to the pan-European TomTom Multinet road network data[7]. Those travel times (in minutes) are subject to distance decay. Two log-logistic distance decay functions are applied that we label as "GVE general" and "steep decline"; we consider them indicative of general and steep travel cost elasticities, respectively (Figure 4.7). The first function has been fitted on observed travel behaviour in the Netherlands [6]; the second has an empirical validation of sorts, as travel demand estimates using the outlined approach fit best with observed regional deviations in passenger car use (see chapter 3). This chapter's results show the effects given the GVE general function; results from the 'steep decline' function are available upon request.

[7] https://www.tomtom.com

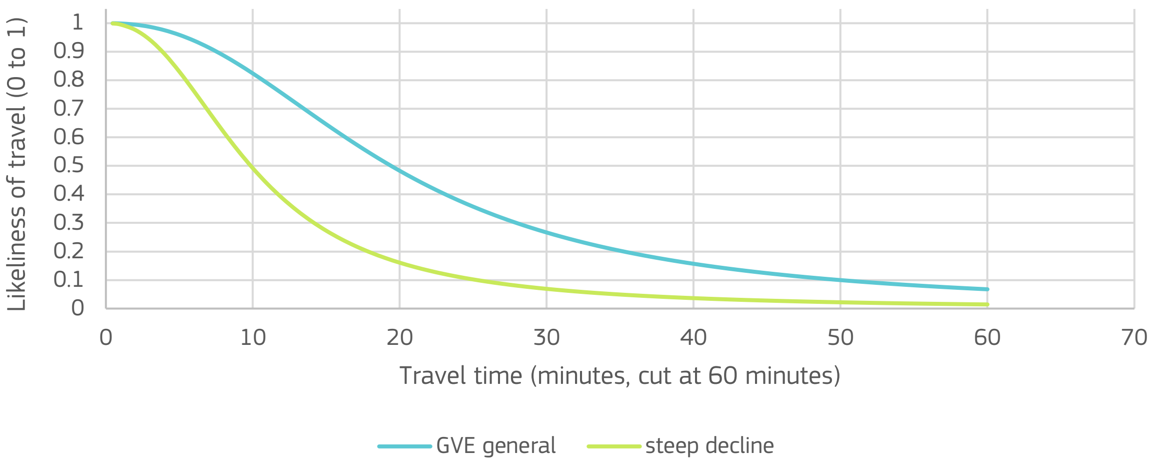

Figure 4.7. Likeliness of travel by trip travel time.

The trip distribution is computed using free-flow speed conditions on the quickest routes from an origin to all destinations. To attribute the time lost reasoned to places of origin, we need to track time loss in the morning commute. We therefore track the amount of time it would take to drive the same route, in case the speeds on the network reflect regular weekday speeds at 8:30 in the morning. Those speeds are obtained from speed profiles registered in the TomTom data. We choose 8:30 in the morning because, across Europe, the selected time is the peak morning moment in terms of time lost [1].

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6 Spatial trends in broadband connectivity and digital accessibility in the EU[8]

Patrizia Sulis

6.1 Introduction

Access to broadband network is increasingly an essential enabler to drive the economic and social development of territories, improving access to services and contributing to the number of workplaces [1-3]. However, its availability can significantly differ across regions, influencing the ability of people to seize opportunities in the knowledge economy [4]. Moreover, digitalisation and economic development are intertwined elements [5, 6], and access to a fast and reliable broadband also has implications in terms of integrated policies (i.e., social cohesion, regional development, and market effects) [7].

Therefore, uncovering spatial patterns of access to the broadband network across different areas in the EU27 is critical to understand the needs of different territories and places, also in terms of quality of the broadband connection (i.e., broadband speed). The objective of this analysis is to provide insights on the digital accessibility in the EU at multiple administrative and spatial scales, comparing broadband performance across different countries, regions, and municipalities in the Member States. Close attention is paid to identify spatial disparities between regions and places in the EU characterised by different Degree of Urbanisation (cities, towns, rural areas). Such disparities can lead to the exacerbation of the existing digital divide or the establishment of new digital inequalities among people and places in the EU.

The quantitative evidence provided by the analysis can inform policy of the current situation, highlighting the areas to target with the aim of leaving no places nor people behind. Access to broadband and data, and building digital skills are elements that might help to foster new business and economic activities, particularly in less advantaged areas.

6.2 Results

6.2.1 Broadband performance

The analysis of average speed at country and regional level is presented in Figure 5.1. One can observe how regions with the capital cities appear to show the highest measured speed even in countries with the lowest average speed (see Greece, Cyprus, Croatia), with noticeable exceptions in France, the Netherlands, Germany. Regarding country average, France, Denmark, Spain, and Romania show an average speed higher than 200 Mbps, although several regions in the same countries are below this average (this aspect is particularly evident for France).

[8] How to cite this chapter: Sulis P (2024) Spatial trends in broadband connectivity and digital accessibility in the EU. *In*: Batista e Silva F and Dijkstra L (eds.) Challenges and opportunities for territorial cohesion in Europe - contributions to the 9th Cohesion report. Joint Research Centre Science for Policy report. Publications Office of the European Union, Luxembourg. doi:10.2760/466949

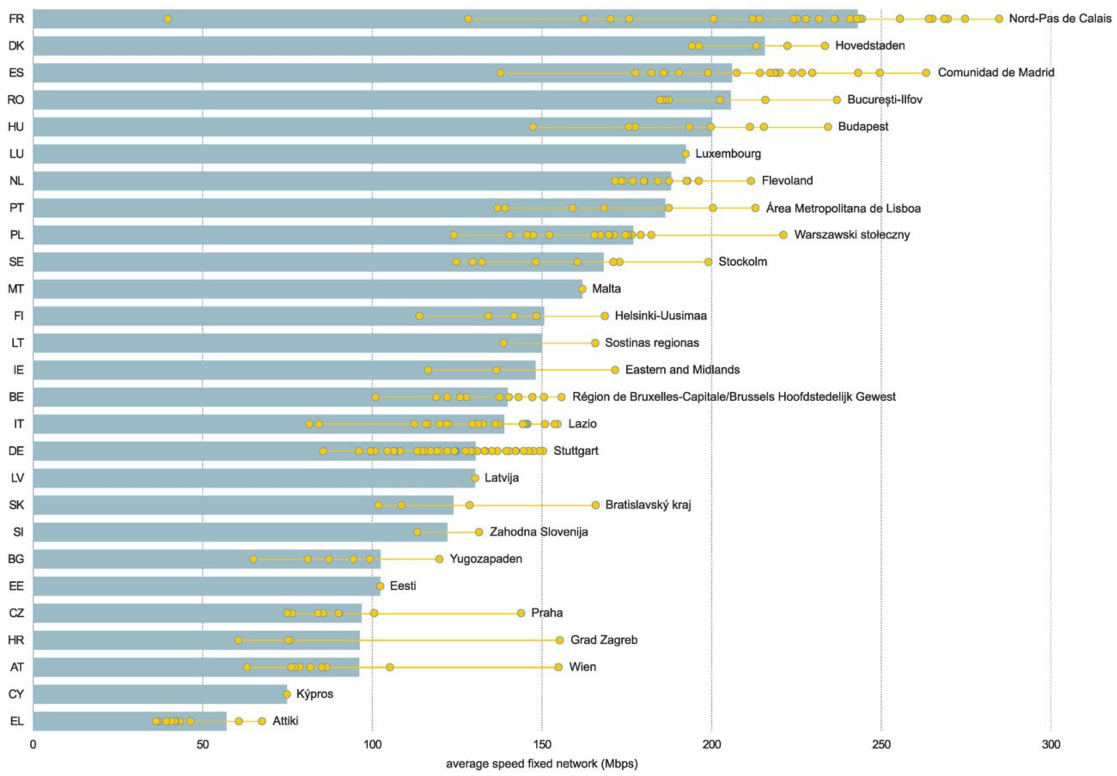

Figure 5.1. Average download speed per EU country (light blue) and NUTS2 region (yellow dot) calculated for the fixed network for the Q1 2023. *Source: Author's elaboration on Speedtest™ by Ookla data, Q1 2023.*

To observe the improvement of network performance across years, one can compare the variation in average speed that country residents can access between 2020 and 2023, as presented in Figure 5.2. Performance for fixed network appears to have undergone a generalised improvements across all Member States, possibly pushed by the Covid-19 pandemic that required several services and daily tasks performed by people, including education and work, to be moved online. Cyprus and Greece show rather impressive changes, moving from zero to more than 70% of the resident population accessing good network speed. Denmark, Spain, and France also show significant progress, with around 80% of population having potential access to network speed higher than 190 Mbps. Clearly, significant differences exist among different territories in each country, and can be observed looking at the comparison of average download speed between 2020 and 2023 across areas classified according to the Degree of Urbanisation (urban, towns, rural). Although a general improvement can be observed across all three classes of the Degree of Urbanisation in EU countries, cities appear to be the places where the highest performance improvements have been recorded since 2020. However, there are several countries that show the highest percent change in speed performance in rural areas (Estonia, France, Italy and Poland among others). This is a positive signal of the effort towards addressing and bridging the digital gap across territories and residents across Europe.

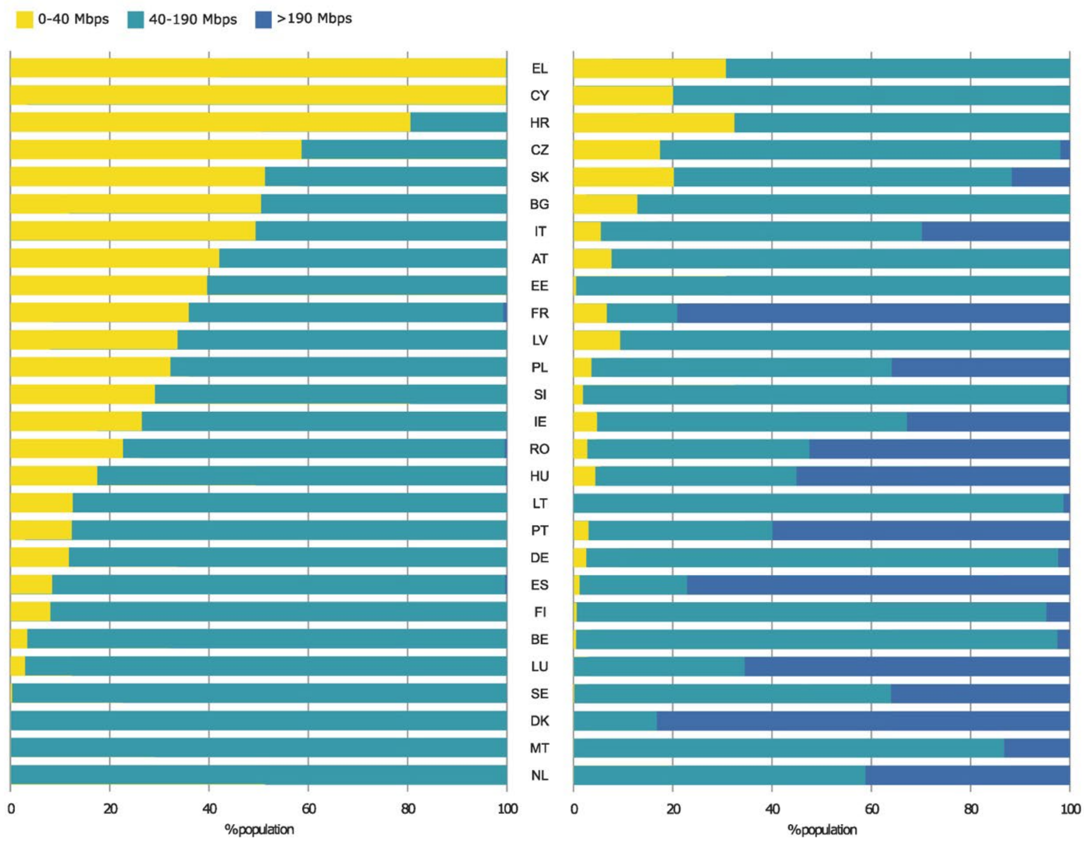

Figure 5.2. Share of population with access to fixed broadband network at different speeds (Mbps) at country level, for year 2020 (left figure) and 2023 (right figure). *Source: Author's elaboration on Speedtest™ by Ookla data, Q1 2020-2023.*

6.2.2 Urban-rural digital divide

An analysis of broadband performance at higher resolution makes possible to identify spatial disparities within different regions in the EU27. Figure 5.3 shows the average speed for fixed network calculated at municipality level (LAU). It can be observed how municipalities in Spain, France, Romania show a higher variety of speed values, ranging from very high speed in municipalities classified as cities and towns (brownish shades) to lower speed (light yellow). Other countries show a more homogeneous situation in speed value distribution, from Greece, Bulgaria and Austria (lowest speed class) to Denmark and the Netherlands (high speed over 200 Mbps). Finally, countries like Ireland, Poland, and Italy show a spatial patterns of speed values that highlights the distribution of urban areas in the country (see darkest spot in Poland and in Northern Italy). In Spain, France, Italy and Greece, information on speed is not available for some inner rural areas that are particularly remote. This aspect can be related to the very low population density of these areas or the lack of digital skills in the population living in these areas (for example, elderly residents), leading to no or very seldom testing of the network performance.

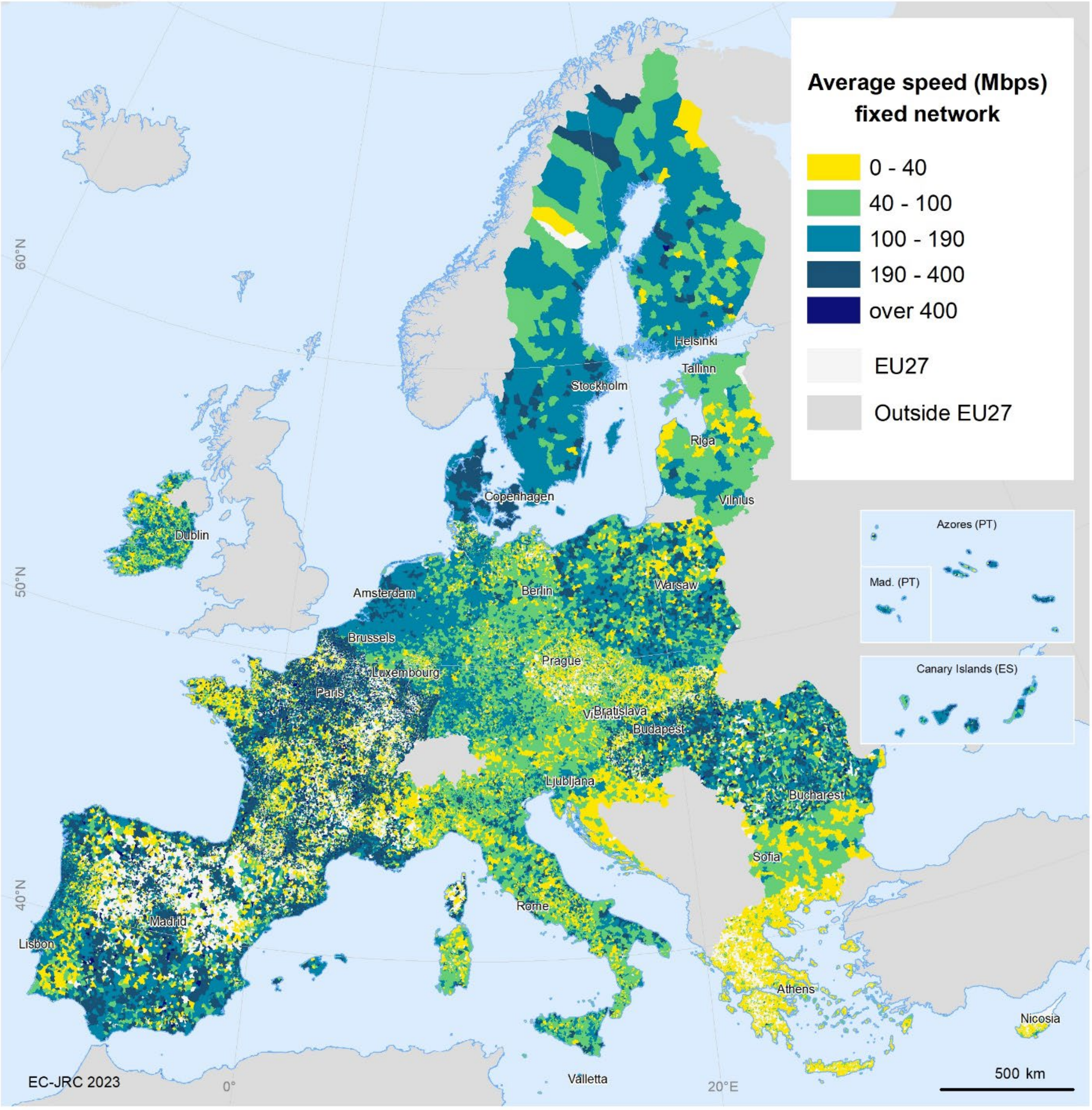

Figure 5.3. Average speed for fixed network at municipality level (LAU) in Mbps. Information on speed is not available for some inner rural areas in Spain, France, Greece. *Source: Author's elaboration on Speedtest™ by Ookla data, Q1 2023.*

The disparities between urban and rural territories are confirmed by the analysis of the average values for cities and rural areas in comparison to the country average for 2023. Urban areas show the highest deviation from country averages in all countries (except for Malta), highlighting the fact that they are the most connected places from the digital perspective. Rural areas are on the other side of the spectrum, showing an average speed up to 60% slower than the country average (as in Cyprus, Croatia, Italy). Towns show a mixed performance: in countries like Denmark and Portugal, the value is above the average and close to cities, whereas in other countries like Bulgaria and Italy, the pattern is comparable to the situation in rural areas.

Such disparities are reflected on the share of residents in urban and rural areas that have access to fastest, more reliable network connection. For fixed network, Figure 5.4 shows that in all countries the population residing in areas classified as cities according to the Degree of Urbanisation (left panel of Figure 5.4) have access to fast and very fast network connections, with Denmark, Spain, and France showing very good performances. On the other hand (right panel of Figure 5.4), only a small percentage of residents in rural areas have access to the fastest speed connection, and some countries, including Cyprus, Greece, Croatia, show that more than half of the population residing in rural areas only have access to the slowest class of speed connection.

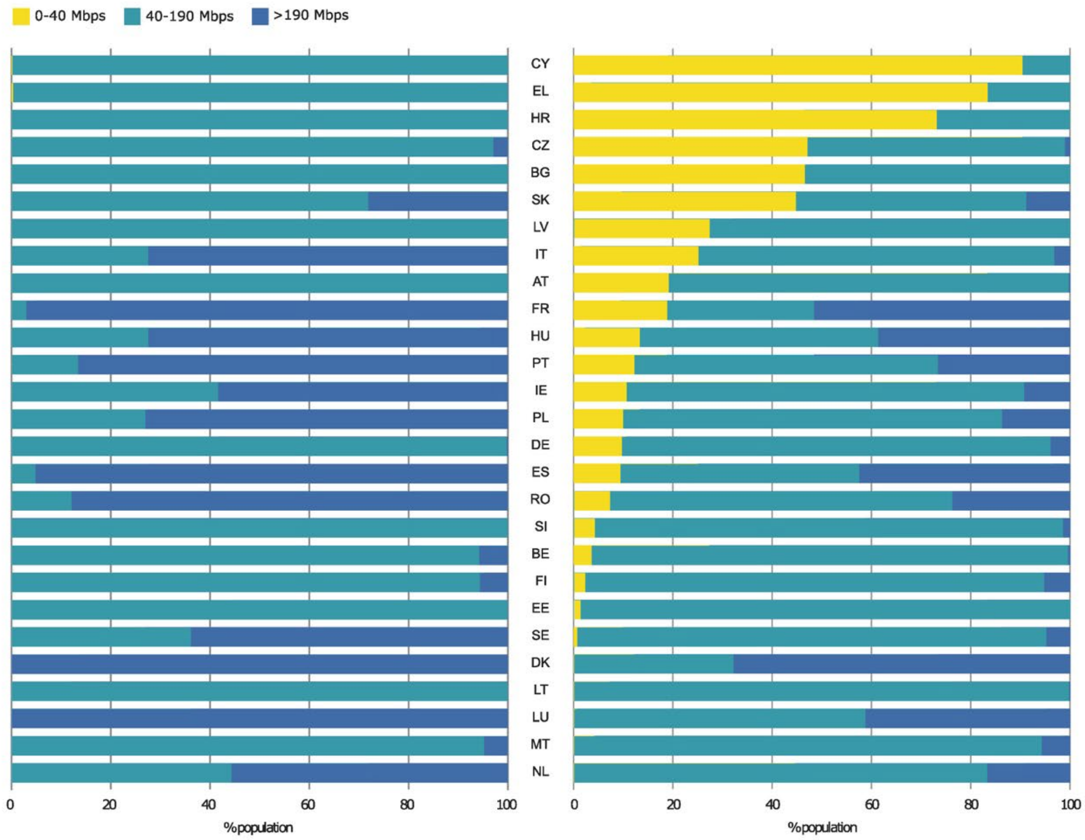

Figure 5.4. Share of population with access to fixed broadband network at different speeds (Mbps) in 2023 at country level for areas classified as cities (left panel) or rural (right panel). Source: Author's elaboration on Speedtest^{TM} by Ookla data, Q1 2023.

6.3 Discussion and conclusions

Digitalisation and development of territories are intertwined elements, therefore understanding access to broadband with good performance can inform policy to identify marginalised areas and resident to target for improving current conditions. In this analysis, spatial information on broadband network performance is employed to analyse patterns of digital accessibility and territorial disparities across regions in the EU27.

Results show that over the last years there has been a generalised improvement in broadband performance across all EU Member States, with regions including capital cities showing the highest broadband speed in the country. Whereas performance differences between cities and rural areas is still significant, results show that in the last years the highest percent change in speed performance occurred in rural areas for several countries. This is a promising signal of the current effort to bridge the digital gap across territories in many European countries.

Some limitations in the analysis are related to the representativeness of the data source employed, due to how the records on broadband performance are produced through voluntary testing by users via the Speedtest® app. For example, fewer records are available for areas characterised as remote and scarcely populated in some countries (inner areas in Spain, France). However, previous work performed with this data source, also from other research bodies (OECD, World Bank) show that spatial coverage and representativeness of this dataset European countries are high.

6.4 Methodological note

Data on broadband performance are provided by Ookla®[9] and contain spatial information regarding broadband network performance at the grid level, collected through an online application and averaged for each tile. For this analysis, data refer to the first quarter (January to March) of the years 2020 and 2023, to compare performance improvements over the years. The information used are 1) the average download speed of all tests performed in the tile, in kilobits per second, and 2) the number of tests taken by users in the tile, both for the fixed network.

To perform this analysis, tiles have been spatially joined to the geographical boundaries of EU27 countries, NUTS2 regions, and LAU municipalities, to calculate average download speed (Mbps) for different territorial scales and investigate trends and differences across regions. Averaged speed is weighted by the number of tests performed in each spatial unit of analysis to consider the uneven geographic distribution of measurements in some regions. Considering the high values in most of the Member states, the speed class has been defined into three groups according to the percentile classes for download speed (0-25% - 25-75%, over 75%)[10] to highlight significant differences across years.

Broadband speed is calculated for Q1 2020 and Q1 2023 to perform a comparative analysis between areas belonging to different classes of the Degree of Urbanisation (cities, towns, rural areas). This is to highlight the share of population that can access fixed broadband with specific performance parameters and the existing digital divide and the performance improvements occurred in the latest years.

[9] Speedtest® by Ookla® Global Fixed and Mobile Network Performance Maps. Based on analysis by Ookla of Speedtest Intelligence® data for Q1 2023. Provided by Ookla® (https://registry.opendata.aws/speedtest-global-performance accessed 10.07.2023). Ookla® trademarks used under license and reprinted with permission.

[10] In previous work [1, 8], classes have been designed differently: from 0 to 30 Mbps; from 30 to 100 Mbps; and over 100 Mbps.

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PART III – Sectoral analyses

7 Renewable energy in the EU, where is the untapped potential?[11]

Carolina Perpiña Castillo, Clara Hormigos Feliu,
Chiara Dorati, Lewis Dijkstra, Davide Auteri

7.1 Introduction

The EU has set ambitious targets to help mitigating the impact of climate change, aiming to reduce net greenhouse gas emissions by at least 55% by 2030 compared to 1990 levels, and become the first climate-neutral continent by 2050. Renewable energy (RE) is a pillar of the clean energy transition, and the EU's 2030 energy target has been recently strengthened to reach 42.5% of renewables in the energy mix, a share which stood at 22% in 2021 [1, 2].

To ensure these goals are met, a huge increase in green electricity generation will be required over the coming years, transforming the energy sector that is currently responsible for over 75% of the total GHG emissions in the EU [3]. In terms of power generation, wind, hydropower, and solar photovoltaics (PV) are currently the most prominent RE technologies, accounting respectively for 37%, 32% and 15% of the total electricity generated from RE in 2022. Furthermore, electricity generated between 2021 and 2022 increased substantially for solar (29%) and wind (9%) [2, 4]. To reach its 2030 energy and climate targets, the EU needs to build 30 GW a year of new wind power, and approximately 45 GW of PV generation capacity, more than doubling installed capacities of 2021 [5, 6].

To ensure a fair and just energy transition, new RE installations should be developed without conflicting with agri-food and ecological systems. This chapter provides an overview of the territorial assessment of current and potential renewable energy production in the EU, based on the results of a recent study [7]. The assessment covers the three most prominent energy sources, namely solar photovoltaics (both rooftop and ground-mounted PV systems), onshore wind and hydropower. Using high spatial resolution data, results are obtained at municipality level, allowing for an analysis by degree of urbanisation (i.e., cities, towns and suburbs and rural areas). Aggregations at the regional level are computed as well, and results are shown by level of development (NUTS2) and by border regions (NUTS3) with Russia and Belarus.

7.2 Results

7.2.1 EU electricity production from solar, onshore wind and hydropower

The assessment shows that the EU produced almost 1 000 TWh/year from solar, onshore wind and hydropower, with 72% of the production stemming from rural areas (Figure 6.1). From the existing renewable energy installations in operation in 2023, the EU was producing 375 TWh/year of electricity from hydropower, 350 TWh/year from onshore wind and 250 TWh/year from solar PV.

[11] How to cite this chapter: Perpiña Castillo C, Hormigos Feliu C, Dorati C, Dijkstra L, Auteri D (2024) Renewable energy in the EU, where is the untapped potential? *In*: Batista e Silva F and Dijkstra L (eds.) Challenges and opportunities for territorial cohesion in Europe - contributions to the 9th Cohesion report. Joint Research Centre Science for Policy report. Publications Office of the European Union, Luxembourg. doi:10.2760/466949

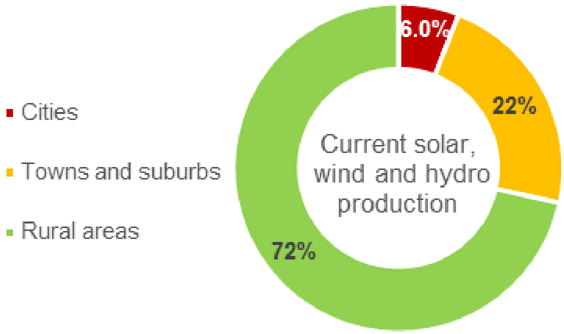

Figure 6.1. Renewable energy (solar, wind and hydro) production per Degree of Urbanisation.

At the Member State level, the highest annual production from the three sources at hand is found in Germany (184 TWh), Spain (142 TWh), France (133 TWh), Italy (104 TWh) and Sweden (99 TWh), which together account for 68% of the electricity produced in the EU from these three RE technologies (Figure 6.2). The share of each source in each Member State (MS) varies widely: for instance, hydropower is especially important in Austria, Latvia, Slovakia, Luxembourg and Slovenia, where it accounts for more than 70 % of the electricity generated by the three sources. Solar PV is key in Malta, where there is no onshore wind or hydro production, and in Hungary, where it accounts for 85 % of the electricity generated from these sources. Onshore wind is most prominent in Denmark (77 %) and Ireland (72%).

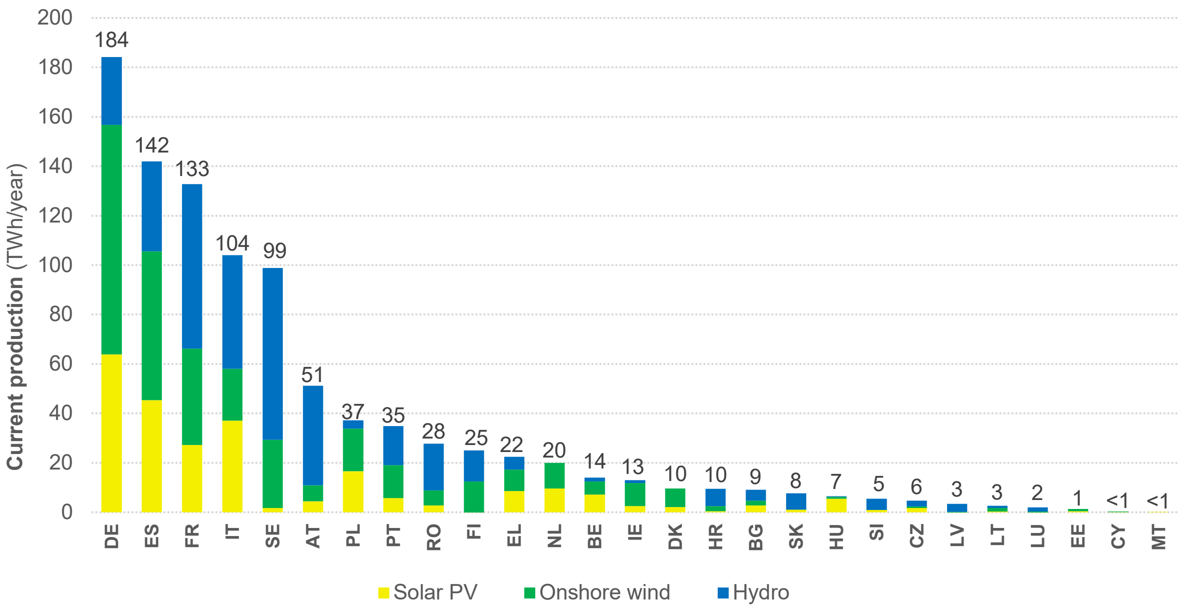

Figure 6.2. Estimate of the current production of electricity from solar PV, onshore wind and hydropower in the EU, 2023.

7.2.2 EU potential electricity production from solar, onshore wind and hydropower

The EU's untapped technical potential (i.e., the difference between the technical potential and the current 2023 production) to produce electricity from new solar and onshore wind installations, as well as through the modernisation of existing hydropower plants, could provide an additional production of up to 12 500 TWh/year. This figure represents the EU's maximum sustainable potential, defined using strong land-use and environmental constraints (see Table 6.1) to ensure that agri-food production is not undermined and that natural resources are preserved during the rollout of new installations. Under these conditions, potential solar PV installations could produce annually up to 11 000 TWh, followed by onshore wind farms (1 400 TWh) and hydropower strategies (130 TWh). The MSs with the highest annual untapped potential are Spain (2 300 TWh), Romania (2 400 TWh) and France (1 600 TWh), which together account for 56% of the EU's solar PV, onshore wind and hydropower potential.

By energy type, in all degrees of urbanisation solar PV is the largest source of untapped potential, followed by onshore wind and hydro power, as shown in 6.3. In rural areas, ground-mounted PV systems account for 85% of the untapped potential, followed by onshore wind (12%), rooftop PV (2.6%) and hydro power (0.69%). In towns and suburbs, as well as in cities, rooftop PV shows more untapped potential than onshore wind, as built-up areas are larger.

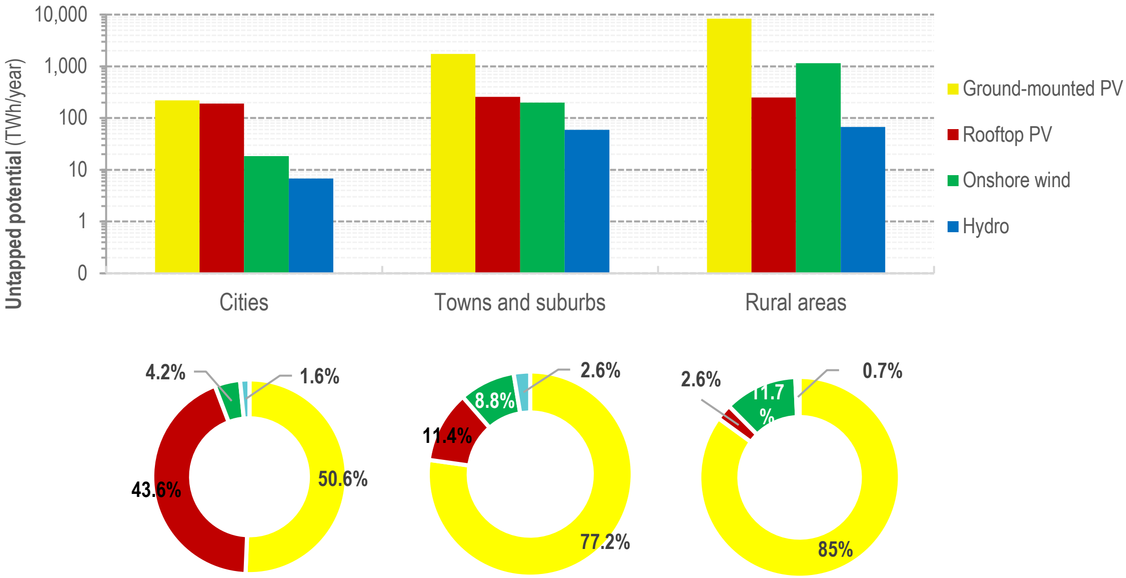

Figure 6.3. Untapped technical potential production of electricity with solar PV (rooftop and ground-mounted systems), onshore wind and hydro power (hydropower modernisation and small barriers, floating-PV) in the EU by degree of urbanisation.

Ground-mounted PV systems are the technology with the highest untapped potential in the EU. Using around 2.2% of its total land (maximum suitable area) for new installations, the EU could additionally produce 10 000 TWh/year of electricity with ground-mounted PV, of which rural areas would contribute 80%. Spain and Romania, together, hold 48% of the EU's total untapped ground-mounted PV potential. Rooftop PV systems are particularly relevant in highly urbanised areas, as well as in municipalities where land-competition is high and suitable land for new installations is scarce. Using 26% of the EU's built-up areas (0.17% of its total surface), rooftop PV systems could produce an additional 700 TWh/year of electricity, distributed similarly among rural areas (36%), towns and suburbs (37%) and cities (27%).

Using 2.8% of the EU's total land, new onshore wind farms could provide an additional 1 400 TWh/year. Rural areas hold 85% of the untapped potential for onshore wind and 83% of the suitable land available for new installations, which places them in a unique position to profit from this technology. In particular, onshore wind can be notably relevant in northern Europe, especially in Finland, Sweden and Ireland. Large areas of Estonia, Latvia, Lithuania, Denmark and Poland hold an untapped wind potential which is similar in magnitude to their ground-mounted PV potential, and would thus benefit from a development of renewables combining both technologies.

In the EU, the capacity to generate electricity with its hydrological resources is assumed to be almost fully exhausted. However, we estimate that current hydropower production could increase by 130 TWh/year by incorporating alternative technologies and revamping the existing plants. The largest share (61%) of this untapped potential stem from covering 10% of hydropower reservoirs with floating PV systems, while the modernisation of the existing fleet accounts for 35% of the potential. Additionally, the exploitation and (re)powering of historical water mills, water distribution networks and waste-water treatment plants accounts for 4% of the potential (5 TWh/year). Hydropower is the leading source of renewable potential in areas located predominantly in mountainous and remote locations, especially in the Alps, the Pyrenees and the Carpathian mountains.

Of the 12 500 TWh/year of the EU's combined untapped potential, rural areas hold 78% potential of solar PV, onshore wind and hydropower (9 800 TWh/year), followed by towns and suburbs (2 300 TWh/year, or 18% of the untapped potential) and cities (440 TWh/year, or 3.5%). At the Member State level, the countries with the highest combined untapped potential per unit area are Romania, Portugal, Latvia and Spain, where the potential production could reach more than 5 000 MWh/km^2 per year (Figure 6.4). The highest total untapped potential per unit area is found in rural areas of Portugal, as well as rural areas and towns and suburbs of Romania. At the municipal level, the distribution of the technical potential for each renewable energy source in the EU can be observed in Figure 6.5, where the potential energy production per unit area is shown by degree of urbanisation. On average, total potential production per unit area is highest in the EU's rural areas, where it could reach 3 100 MWh/km^2 per year, followed by towns and suburbs (2 700 MWh/km^2) and cities (2 600 MWh/km^2).

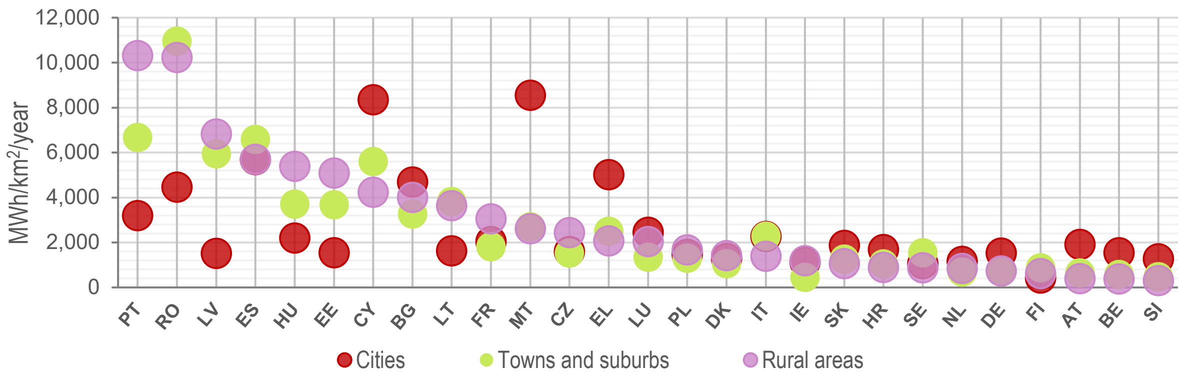

Figure 6.4. Untapped potential of solar, onshore wind and hydropower by degree of urbanisation in the EU Member States. Yearly production in MWh is shown per unit area (i.e., country area by degree of urbanisation).

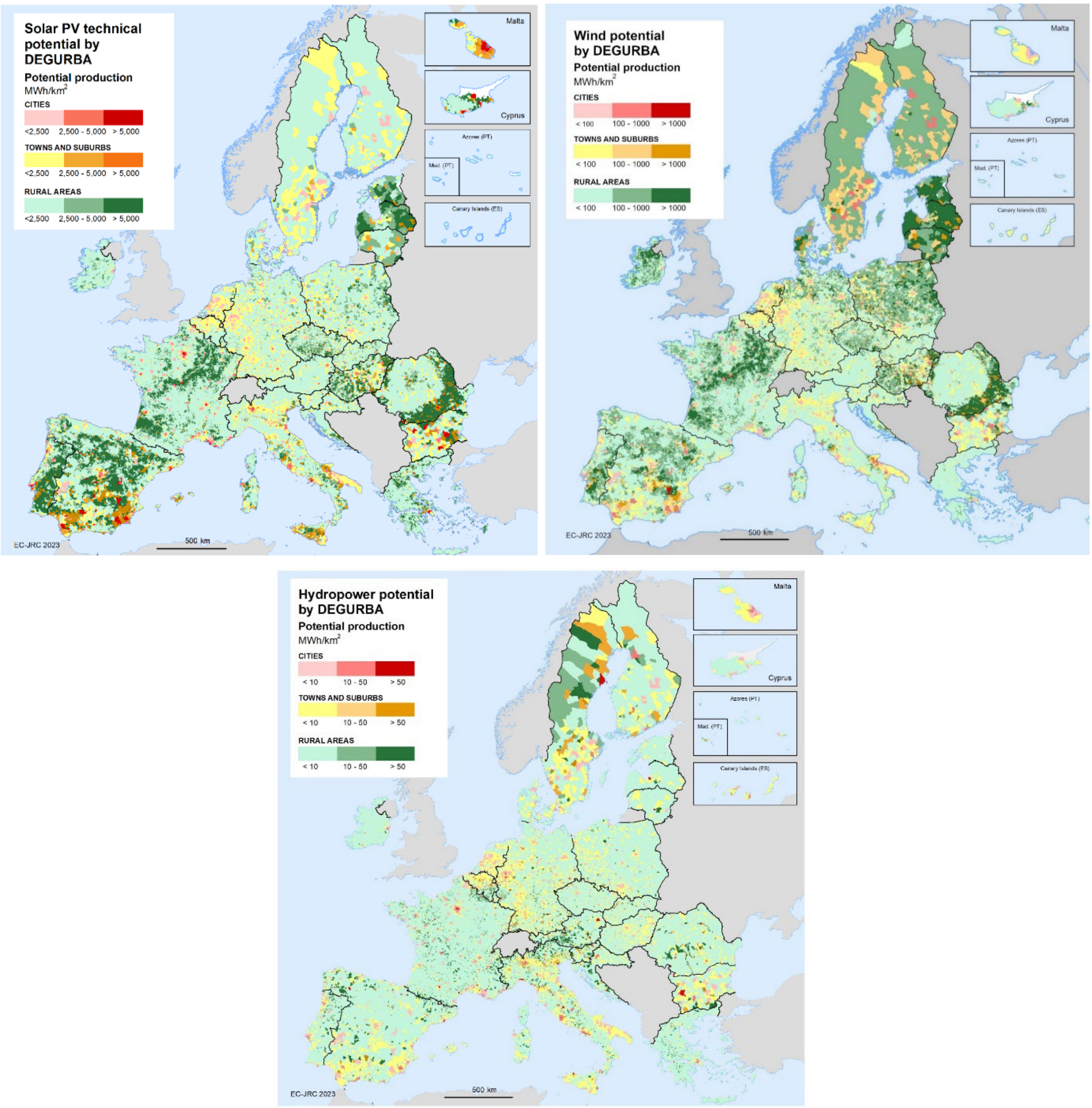

Figure 6.5. Technical potential for solar, onshore wind and hydropower in the EU's municipalities by degree of urbanisation. Annual potential production is depicted per unit municipality area. Note: areas with no data are shown in white.

7.2.3 EU untapped potential of renewables by regional development level

The combined untapped potential for solar PV, onshore wind and hydropower in the EU's NUTS2 regions is shown in Figure 6.6. The highest potential can be found in the Spanish regions of Castille-

La Mancha, Castille-Leon and Andalucia, as well as in the Sud-Muntenia and Sud-Est regions in Romania, where potential annual production could be above 500 TWh in absolute terms. Other regions with significant potential are Alentejo (PT), Latvia, Sud-Vest Oltenia (RO) and Aragon (ES), which could exceed 200 TWh/year.

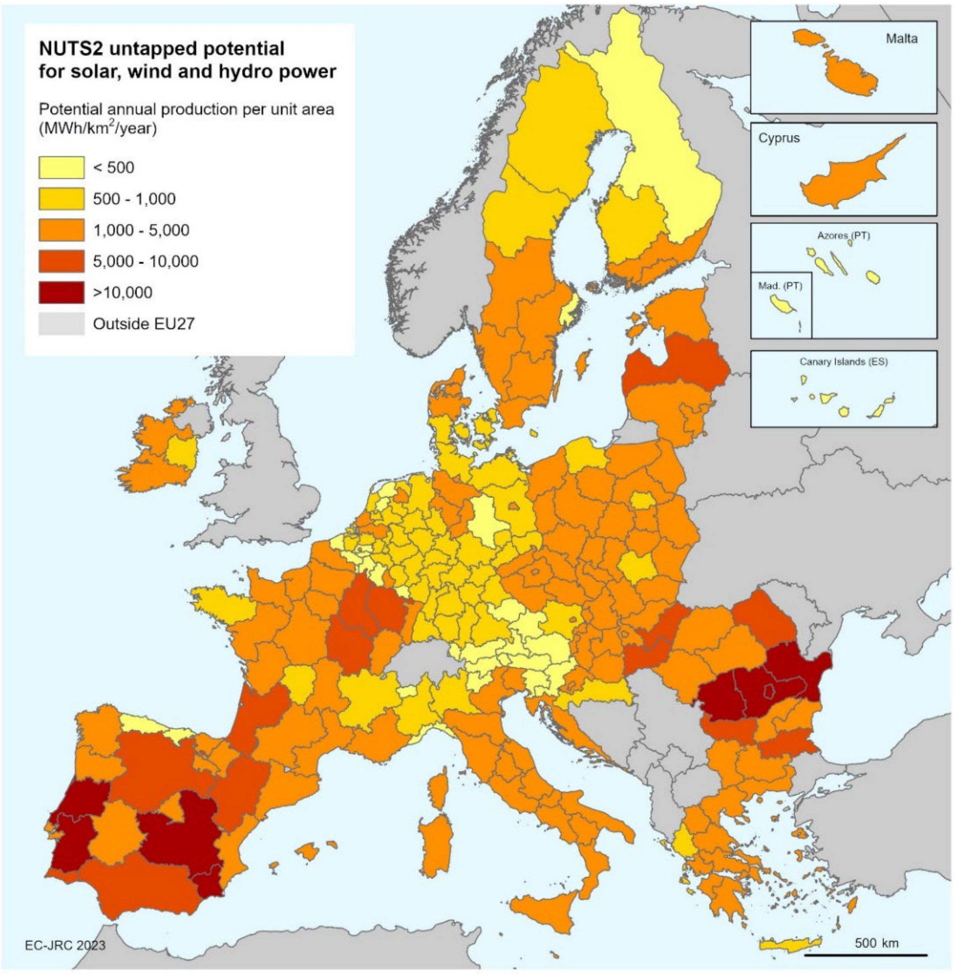

Figure 6.6. Untapped potential for solar, onshore wind and hydro power in the NUTS2 regions of the EU. The potential production is shown per year and region unit area.

Looking at development classes, we find that more than half of the untapped potential (59%) is located in less developed regions, followed by transition regions (28%) and more developed regions (13%). In Figure 6.7, total untapped potential per unit area is shown by degree of urbanisation and development classes. We observe that the highest untapped potential per unit area is found in rural areas of less developed regions, followed by towns and suburbs and cities of less developed regions.

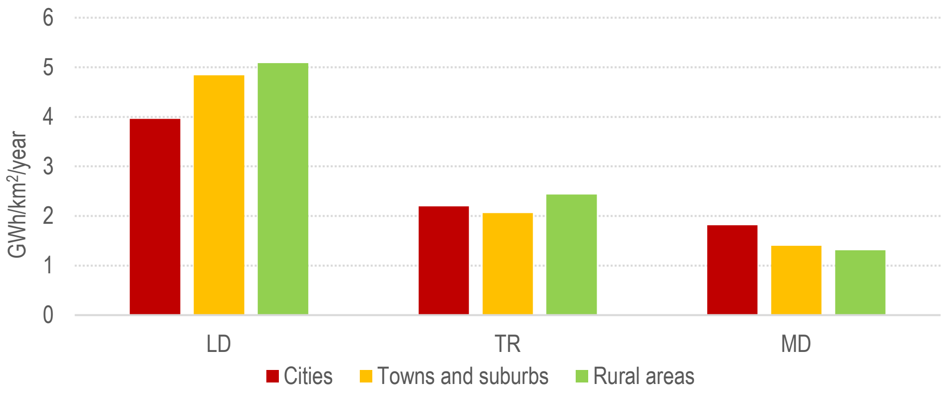

Figure 6.7. Untapped potential for solar, onshore wind and hydropower in the EU in less developed (LD), transition (TR) and more developed (MD) regions by degree of urbanisation. The potential production is shown per year and region unit area.

7.2.4 EU untapped potential of renewables in regions bordering Russia and Belarus

Due to security concerns, development of new RE installations in the vicinity of the EU's eastern borders might be considered less attractive, especially in regions bordering Russia and Belarus[12]. We find that eastern border regions (at the NUTS3 level) hold 21% of the EU's technical potential for onshore wind, 9% of its solar potential and 1% of its hydropower potential, as shown in Figure 6.8.

Border regions can contain a significant share of the country's technical potential. In Latvia and Lithuania, more than half of the onshore wind and solar potential is in regions bordering Russia and/or Belarus. In Finland, regions bordering Russia hold 85% of the hydropower technical potential, 61% of the onshore wind potential and 32% of the solar potential, while in Estonia more than 40% of the technical potential of all three RE sources is in border regions. In Poland, Slovakia, Hungary and Romania, regions bordering Belarus, Ukraine and Moldova hold less than 40% of each country's technical RE potential. Figure 6.9 depicts the technical potential of onshore wind per unit area, highlighting the NUTS3 border regions

[12] For these reasons, the potential of renewable sources in certain regions of Finland, Estonia, Latvia, Lithuania, Poland, Slovakia, Hungary and Romania might not be currently considered.

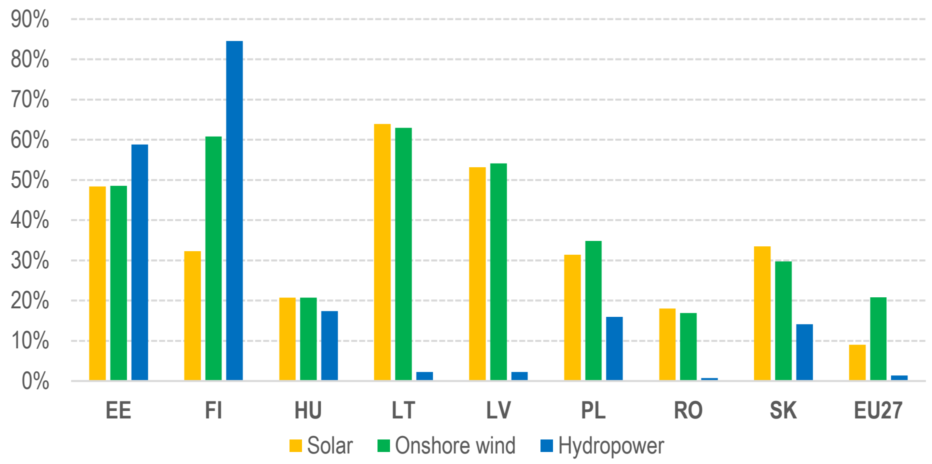

Figure 6.8. Share of technical potential (over the total country and EU potential) in regions bordering Russia and Belarus.

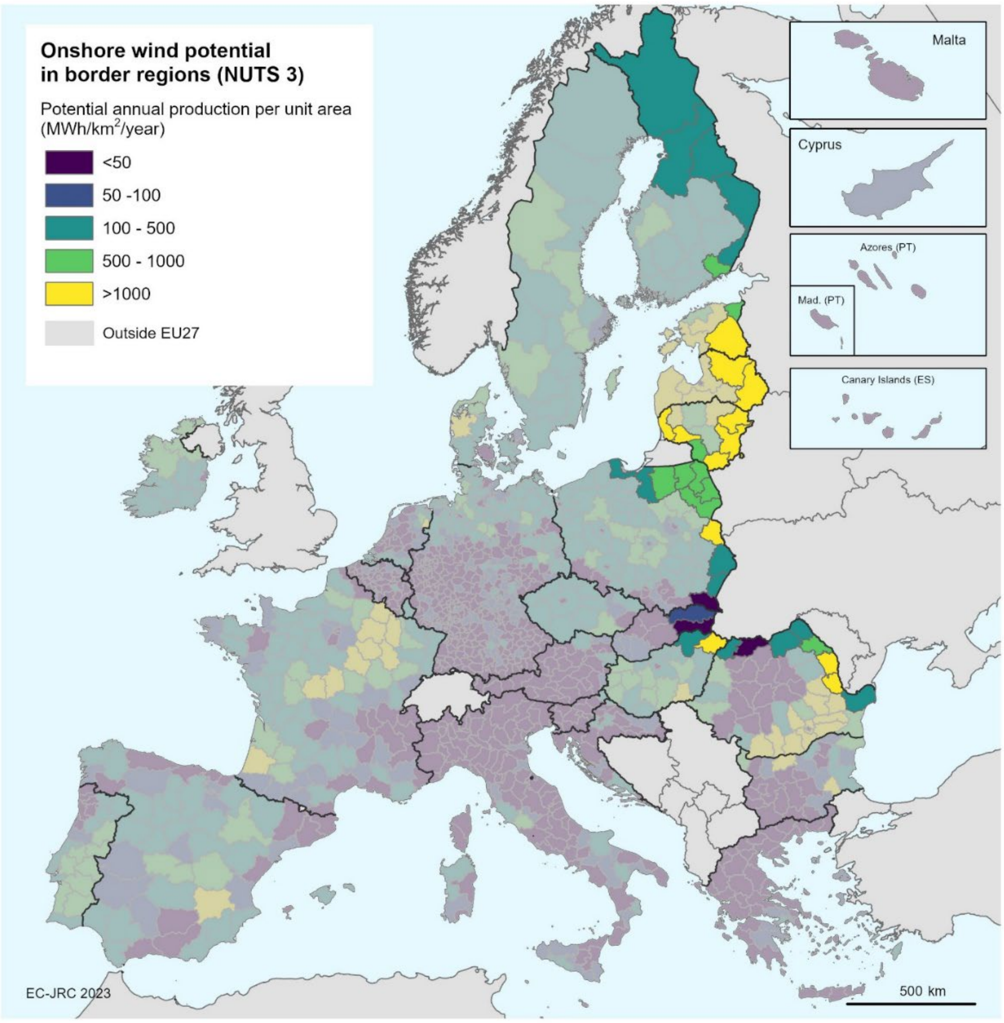

Figure 6.9 Technical potential of onshore wind in eastern border regions (NUTS3) of the EU. The potential production is shown per year and region unit area.

7.3 Discussion and conclusions

A massive and rapid rollout of renewable energy production is needed to reach the EU 2030 and 2050 energy and climate targets. To assess the current production of renewable energy and their possible future paths from a territorial perspective, this analysis evaluates current and potential production of the three leading RE sources, i.e., solar, wind and hydropower, at a high spatial resolution across the EU. A wide range of datasets including plant locations, land use, environmental factors and terrain features were used.

In 2023, the estimated EU's electricity production from the three analysed renewable sources reaches 975 TWh, where 375 TWh/year of electricity stems from hydropower, 350 TWh/year from onshore wind and 250 TWh/year from solar PV. This estimated production was found to take place mainly in rural areas (72% of the generated power, or around 700 TWh/year), with towns and suburbs contributing 22% (220 TWh/year) and city municipalities 6% (60 TWh/year).

The untapped technical potential production of electricity from the three analysed sources could reach cumulatively up to 12 500 TWh/year. This is more than 5 times the electricity consumed in 2021 and exceeds the total energy consumption of the EU in the same year [8, 9]. This production could be achieved without compromising environmental and agricultural resources. Solar photovoltaics is the technology with the largest renewable untapped potential (11 000 TWh/year), followed by onshore wind (1 400 TWh/year) and hydropower (130 TWh/year). Most of the EU's untapped potential (78%) is located in rural areas, which can play a vital role in the process of advancing towards decarbonisation goals. Solar photovoltaic systems in rural areas currently generate 136 TWh/year, but have the potential to generate 60 times more (8 600 TWh/year). Onshore wind production in rural areas yields 280 TWh/year but could potentially be four times higher (1 200 TWh/year), while hydropower production in rural areas yields 280 TWh/year a year and could potentially be 25% higher (350 TWh/year).

More than half (59%) of the EU's untapped potential for solar, onshore wind and hydropower is located in less developed NUTS2 regions, followed by transition regions (28%) and more developed regions (13%). The highest untapped potential per unit area is found in rural areas of less developed regions. On the other hand, EU NUTS3 regions bordering Russia and Belarus may be less attractive for additional solar, wind and hydropower investments due to the geopolitical instability of the area. This is particularly relevant for onshore wind, with 21% of the EU's technical potential located in border regions, and to a lesser extent for solar (9%) and hydropower (1%).

7.4 Methodological note

An extensive collection of spatial and statistical datasets was leveraged to quantify current and potential electricity production from solar, onshore wind, and hydropower at municipality (LAU) level in the 27 EU Member States for 2023. Specifically, the Wiki-Solar [10], the Worldwide wind farms [11], and the JRC-hydropower [12] databases, respectively, provided the core spatial information on the existing plants in operation and their installed capacity. For solar and wind sources, high-spatial resolution capacity factors[13] from PVGIS [13] and from the Global Wind Atlas [14], respectively, were used to estimate 2023 electricity production. Hydropower average capacity factors were derived from

[13] The capacity factor is the ratio between what a generation unit is capable of generating at maximum output versus the unit's actual generation output over a period of time, normally a year.

the JRC database attributes and from Eurostat data [4] to compute the energy generation at plant level.

In order to assess the technical potential production for solar and onshore wind, a land suitability analysis was performed using geo-spatial tools to assess the maximum suitable area available for new installations, considering a wide range of land-use, environmental and orographic criteria [15, 16, 17] (see Table 6.1). The combination of these criteria resulted in a land suitability map for each source at 100m resolution for the EU27. For both solar and wind, the untapped technical potential was computed as the difference between the overall technical potential and the current 2023 production. For hydropower, as most of the potential is already exploited in EU, the analysis focused on strategies for additional energy generation from plant modernisation, hidden small-scale hydropower solutions (i.e., powering water distribution networks, water treatment plants, and water mills [18, 19, 20]) and hybridisation with floating PV systems [21].

Table 6.1. Factors used in the land suitability assessment for potential ground-mounted PV and onshore wind installations. These factors are grouped as: excluded areas, thresholds on distances and geographic factors and conditions for inclusion of certain areas.

Excluded areas	Thresholds and restrictions	Included areas
Artificial land	Distance from settlements	Abandoned lands
Agricultural land	Distance from industrial areas and infrastructure	Eroded lands
Forests and water bodies	Distance to roads	Low-productivity agricultural lands
Protected and key biodiversity areas	Solar irradiation	
High nature value farmland	Wind capacity factors	
	Slope and aspect	

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8 Tourism in EU regions: from the COVID-19 shock to recovery[14]

Riccardo Curtale, Filipe Batista e Silva, Ricardo Barranco

8.1 Introduction

The tourism industry contributes substantially to the EU's GDP. Its direct and indirect contribution varies from nearly 5% to 15% in selected EU countries. Tourism was one of the sectors mostly impacted by the COVID-19 pandemic, putting at risk the jobs and income of millions of families in Europe. In response to the COVID-19 pandemic, the European Commission included the tourism industry among the 14 strategic industries to build a stronger single market in the European Union. To highlight the importance of tourism in the EU economy, the Transition Pathway for Tourism [1] was published as the first report in a series of foreseen transition pathways for EU industrial ecosystems. Along a set of guidelines to make the tourism ecosystem more green, digital and resilient, the Transition Pathway highlighted the need for further tools, data and evidence for policy support. The JRC Territorial Development unit provides specific support to the goals of the Transition Pathway for Tourism through: 1) the development of the EU Tourism Dashboard[15], the EU Commission tool for monitoring a set of indicators related to the green, digital and socio-economic aspects of tourism, and 2) research on tourism issues.

In a recent scientific article [2], we investigated the impact of COVID-19 on tourism demand and showed that the drop in nights spent due to the pandemic was heterogeneous in the NUTS2 regions of the EU. We identified the factors systematically affecting the vulnerability of tourism demand to the pandemic crisis. We found higher losses of tourism demand in urban destinations and in destinations highly dependent on foreign tourism, lower losses in domestic destinations, in proximity, or that have natural assets.

In this short follow-up study, we analyse not only the shock, but also the recovery of tourism demand after COVID-19 in the NUTS2 regions of EU27 countries, using data of guest nights in the 2019-2022 period. We investigate the factors and regions' characteristics explaining heterogeneity in drop and recovery of guest nights. In particular, we analyse: 1) the trend of tourism demand at NUTS0 and NUTS2 level in response to the COVID-19 pandemic; 2) the results of econometric models identifying the factors systematically mitigating or enhancing the tourism demand drop.

8.2 Results

In 2020, the initial year of the pandemic, tourism demand in the EU dropped by about 49% in relation to 2019 levels (Figure 7.1a). In 2022, the tourism demand reached 96% of the pre-pandemic level (2019), indicating a strong recovery, with some countries recording even higher values compared to pre-pandemic, such as Belgium, Ireland, France, Denmark and the Netherlands. At the NUTS2 level, in 2022 33% of regions fully recovered pre-pandemic levels (Figure 7.1b). We found a strong positive

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relationship between the shock and rebound. Regions with higher shock levels were also the ones with a higher rebound, which seems to indicate a resilient tourism sector overall at the regional level.

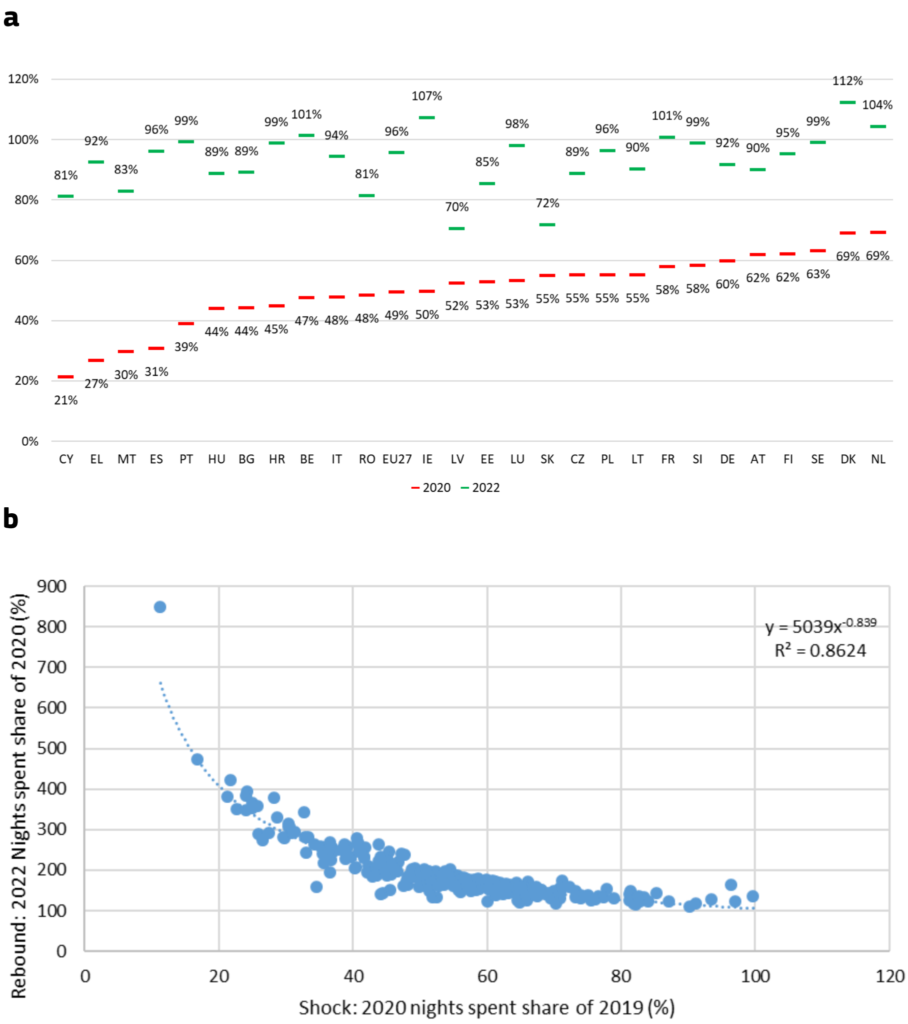

Figure 7.1. Tourism demand in 2020 and 2022 in relation to pre-pandemic levels (2019).

We analysed the trends of tourism demand in macro-areas[16] and show that the Southern EU countries registered a stronger shock in 2020, followed by Eastern, Western and Northern EU countries (Figure 7.2a). In 2022, all macro areas recovered more than 90% of the pre-pandemic level, with the Eastern countries recording the slowest recovery, which should be attributable also to the impact of the Russia-Ukraine conflict. The analysis of trend of different typologies of regions, whose definition is based on an updated and expanded version of Batista e Silva *et al.* (2021) [3] shows that urban regions were the most affected in 2020 and their recovery path is the slowest (Figure 7.2b). The

16 Macro areas defined according to EuroVoc classifications (https://eur-lex.europa.eu/browse/eurovoc.html?params=72,7206#arrow_7206): Northern countries (Sweden, Finland, Denmark, Estonia, Latvia, and Lithuania), Southern countries (Italy, Spain, Portugal, Malta, Cyprus, and Greece), Eastern countries (Poland, Romania, Slovenia, Slovakia, Czech Republic, Bulgaria, Croatia and Hungary) and Western countries (Austria, France, Germany, Netherlands, Belgium, Luxembourg and Ireland)

Snow-Mountain regions had a delayed impact given that the ski season in 2020 was partially unaffected by the pandemic.

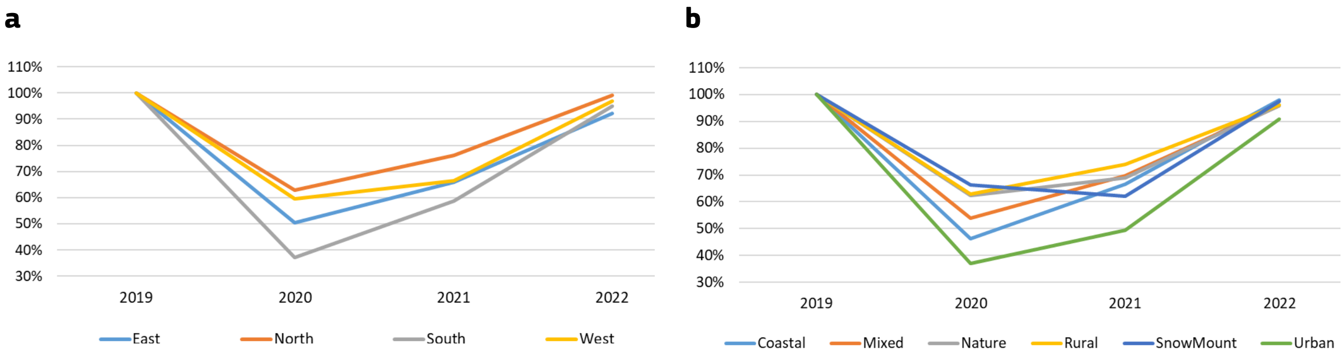

Figure 7.2. Trends of guest nights in 2019-2022, by macro areas (a) and regional tourism destination typologies (b).

Regarding tourism demand at the regional level, the map of the loss in guest nights in 2020 per NUTS2 regions shows a marked spatial dependence, with the highest relative losses being recorded on islands (e.g., Cyprus, Azores and Balearic islands), capital city regions (e.g., Madrid, Lisbon, Dublin and Rome) and regions in southern countries (e.g., Campania and Veneto in Italy, Cataluña in Spain, Macedonia and Western Thrace in Greece) (Figure 7.3a). In 2022, a third of NUTS2 regions recorded more guest nights than pre-pandemic levels, with a higher frequency for the coastal regions on the Atlantic Ocean (e.g., Southern region in Ireland, Jutland in Denmark, and Galicia in Spain). Capital city regions still recorded lower guest nights compared to pre-pandemic (Figure 7.3b). The effect could be given also by the reduction of business trips, due to the increase of online meetings, but this is a factor which cannot be disentangled from the data.

Finally, an econometric analysis revealed factors explaining heterogeneity in the shock (first column in Table 7.1), rebound (second column) and recovery (third column). The analysis of the shock confirms those described by Curtale *et al.* (2023) [2]. Regions characterized by urban tourism, with a high dependence on foreign arrivals, or with a combination of high tourism intensity and high seasonality had more severe losses in tourism demand. Conversely, regions with large tourism demand catchments (i.e., with higher population in the vicinity of the region, reachable via terrestrial transport), with low density and natural assets (e.g., coast, mountain, nature) had comparatively low reduction in guest nights.

The analysis of the rebound shows opposite and significant signs for several indicators that explained the differences in shock (e.g., tourism demand catchment, seasonality, share of foreign tourists, intensity X seasonality). This indicates a stronger rebound for regions hit stronger in 2020 and highlights a generalized resilient tourism sector, with tourism demand returning to spatial-patterns and preferences similar to those of 2019.

The analysis of the recovery shows that urban destinations, destinations in Eastern countries and destinations with a higher share of foreign tourists are associated with a slower recovery compared to pre-pandemic level, indicating persistent effects of the pandemic crisis on the tourism demand in regions with such characteristics. For Eastern countries, any inference on the recovery after COVID-19 should consider that the Russian-Ukraine war may have hampered the recovery.

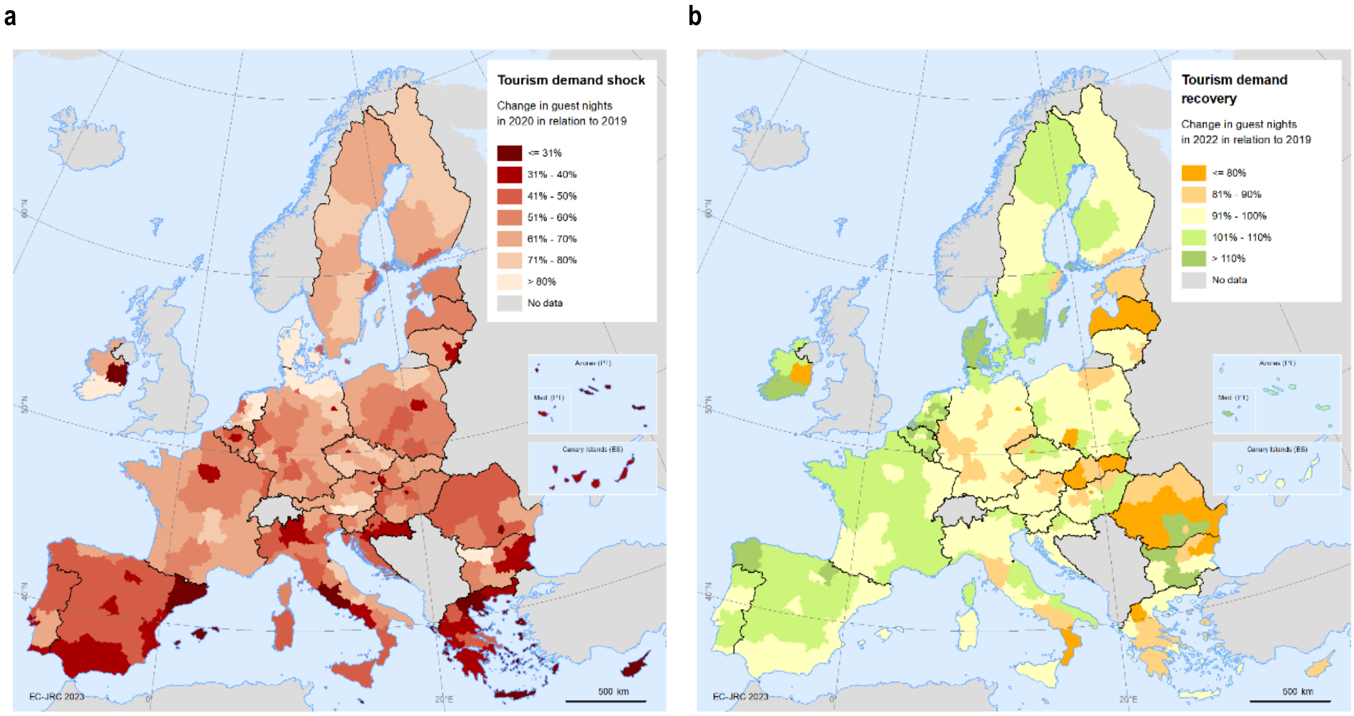

Figure 7.3. Guest nights in 2020 (a) and 2022 (b) compared to 2019, by NUTS2.

Table 7.1. Factors influencing shock, rebound and recovery of tourism demand at regional level following the COVID-19 crisis– econometric results. Highlights in grey the factors which had similar influence in the shock and recovery phases.

	shock 2020 vs 2019	***rebound*** 2022 vs 2020	***recovery*** 2022 vs 2019
Type (Reference = Coastal)			
Mixed	-0.027	-0.113	**-0.054***
Nature	-0.019	-0.094	**-0.051.**
Rural	0.011	-0.206	-0.051
Snow Mountain	0.045	**-0.675*****	-0.032
Urban	**-0.107*****	0.120	**-0.086****
Tourism indicators			
Tourism demand catchment	**0.006*****	**-0.037*****	0.001
Intensity	**0.005****	-0.008	-0.001
Seasonality	**0.001*****	**-0.006****	<0.001
Share of foreign tourists	**-0.003*****	**0.013*****	**-0.001***
Diversity	0.001	-0.002	<0.001
Intensity X Seasonality	**-0.005****	**0.017.**	0.001

Geographic controls (Ref. = West)			
East	**-0.041.**	-0.092	**-0.047.**
South	**-0.06.**	**0.285***	-0.007
North	**0.062***	**-0.444****	0.012

Notes: * = p.value<0.10, ** = p <0.05, *** = p<0.01. In grey the factors with a persistent significant impact in 2020 and 2022.

8.3 Discussion and conclusions

The analysis of shock and recovery of the guest nights in the EU shows that the pandemic had a strong but heterogeneous impact across regions. Guest nights dropped by 50% in 2020 in relation to 2019 and travel restriction represented the main factor for the loss in guest nights in 2020. Urban destinations, destinations with a high share of foreign tourists, and those in the Southern and Eastern Europe suffered relatively more, while regions with natural assets were relatively less impacted. The stronger the shock in 2020, the stronger the rebound in the following years, indicating a resilient tourism sector overall. However, some factors are associated with a persistent lower demand: share of foreign tourists, urban destinations and regions in Eastern countries.

The results of this study provide insight for policy support. As first lesson, given their tremendous socio-economic impacts, travel and mobility restrictions like the ones enacted in 2020 and 2021 should be carefully equated in the case of future crises, weighing the known negative social and economic consequences against eventual benefits. Secondly, while policymakers cannot change the structural or fixed geographical characteristics that make some destinations inherently more vulnerable to shocks, they could provide specific support instruments designed to mitigate the economic effects of shocks. Particular attention should be dedicated to urban regions and regions with high share of foreign tourists, given that the loss in tourism demand in those regions might have a negative effect on employment in the tourism sector.

The study presents some limitations due to data constraints. The spatial scale of analysis is restricted to the NUTS2 level, and some relevant variables such as the dynamics of the epidemiological context at tourism destination level could not be tested in the model due to inconsistent data at the EU level. However, the findings are supported by earlier country-specific studies, analysed in Curtale *et al.* (2023) [2], indicating that the main sources of heterogeneity in the results have been identified. Future research should focus on: 1) the investigation of the demand trend after 2022, possibly at a finer data resolution, and on 2) the economic impact of the tourism demand drop and rebound, as an indicator of the recovery of the tourism sector.

8.4 Methodological note

We assessed the reduction and recovery of tourism demand through the analysis of guest nights in accommodation services. We conducted a generalized linear model regression to identify the factors explaining differences in the shock (guest nights in 2020 vs 2019), the rebound (guest nights in 2022 vs 2020) and the recovery (guest nights in 2022 vs 2019) of tourism demand. We analysed the impact on guest nights of a series of region-specific variables. We included socio-economic controls, travel restrictions, territorial typology, tourism characteristics and geographic controls. The full list of variables included in this analysis is provided in Curtale *et al.* (2023) [2].

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9 Conclusion

The EU Cohesion Policy aims at promoting economic, social and territorial development, and reducing disparities across EU countries and regions. In the period 2021-27, Cohesion Policy is devoting EUR 392 billion to make Europe more competitive, greener, better connected, more social and closer to citizens. An efficient and effective Cohesion Policy can help lay the foundations of a European Union with opportunities for all.

In this report, we have analysed territorial data on a variety of socio-economic topics, also paying attention to the urban-rural divide: urbanisation and regional economic trends; transport and digital accessibility; renewable energy and tourism.

The interplay between territorial cohesion and various socio-economic factors across the EU is evident in the challenges and opportunities discussed in this report. For example, over the last 60 years, urban areas have become more populated, currently hosting around 70% of the EU's inhabitants. By contrast, population in rural areas has declined, along with the availability of services and infrastructure. Rural residents use cars more and risk being disproportionately affected by policies that increase car usage costs. On the other hand, the time lost to road traffic emphasizes the need to continue improving urban mobility. Promising trends for the future of EU rural areas include improved broadband access and speed, and the remarkable potential of these territories to become the EU's renewable energy powerhouse.

As the EU continues to evolve, so too will its statistical and geospatial data, further refining our understanding and monitoring of ongoing trends. Such "territorial intelligence" is necessary to support decision makers take informed decisions and targeted, place-based investments that consider the diverse challenges and opportunities faced by regions and territories, and ensuring that Cohesion Policy remains relevant.

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