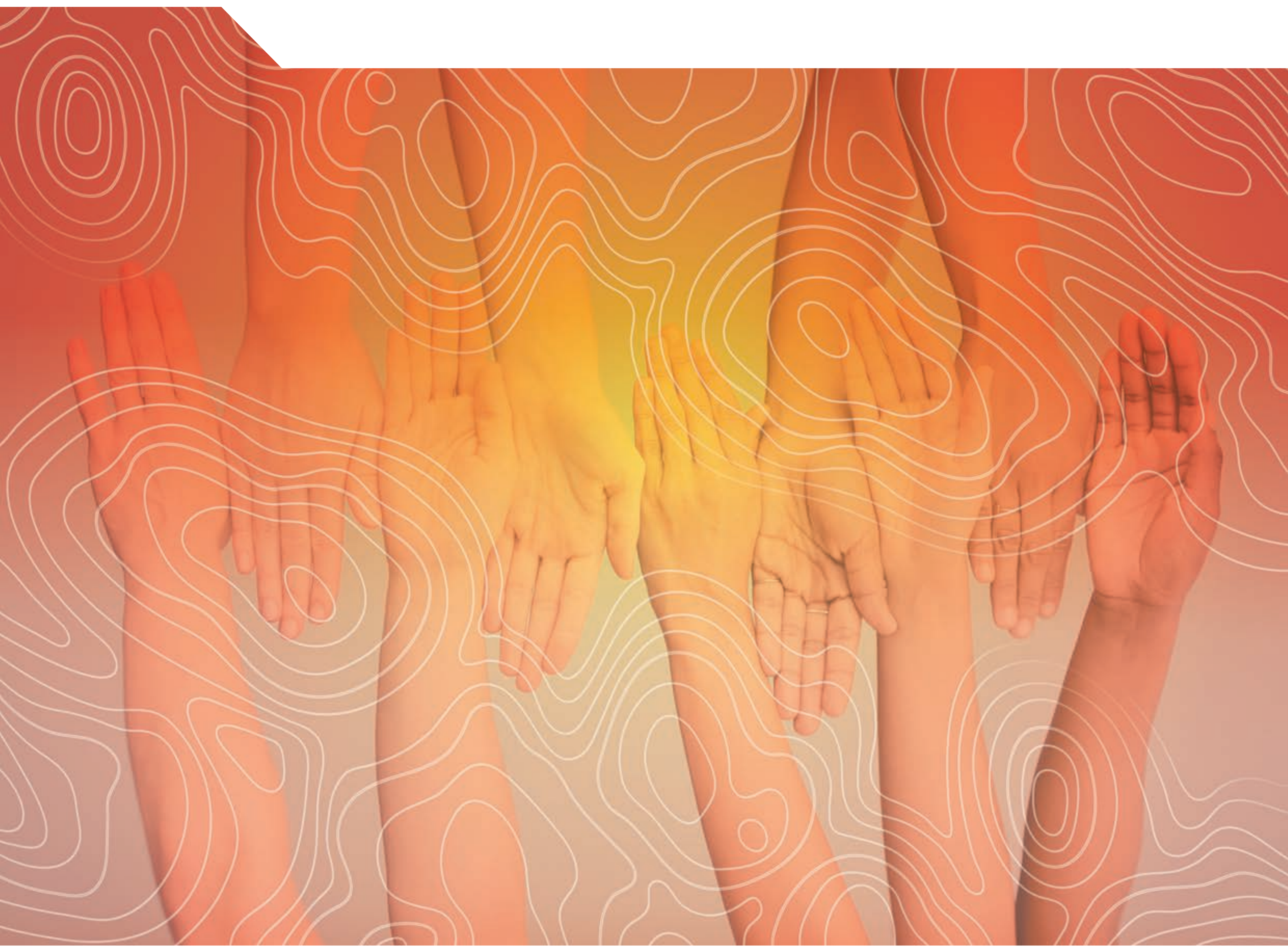
OECD Rural Studies

Access and Cost of Education and Health Services

PREPARING REGIONS FOR DEMOGRAPHIC CHANGE



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Preface

We are delighted to introduce the joint study "*Access and Cost of Education and Health Services"*, conducted by the OECD and the European Commission's Joint Research Centre. The estimates of the cost and access to education and health services in this report are the first of their kind and an essential evidence base to develop better policies in this area. This analysis can help policy makers identify at a very granular level present and future service supply shortages and respond accordingly. By illustrating the trade-offs between efficiency and equity faced by every community, the report can also support decision making at both the regional and local levels.

Education and health are the two social services in which national and subnational governments typically spend the most resources to ensure provisions keep pace with widespread and changing demand. As the COVID-19 pandemic has demonstrated, without adequate access to services, vulnerable citizens are more exposed to exclusions. For this reason, it is essential for policy responses to ensure an effective, fair and just recovery across European and OECD countries to shape a sustainable future for all citizens, regardless of where they live and work.

Particularly, governments are facing growing challenges in providing schooling and health services in regions and localities that are sparsely populated, scattered and difficult to access. Sustainable and effective policy responses, that aim to leave no-one behind and capitalise on the digital transition, will benefit from the report's analysis of the various costs and accessibility of services. As countries recover from the pandemic, this report represents a valuable tool to support policy makers' quest to develop sustainable recovery paths.

The report is also a good example of the importance of evidence to underpin key territorial policy perspectives. It is the fruit of the long-standing collaboration on territorial issues between the OECD and the Joint Research Centre. This report is combining the wealth of policy experience and knowledge within the OECD with frontier data and tools produced by the EC-JRC's LUISA Territorial Modelling Platform. It is an excellent guide and tool for policy makers and practitioners to navigate recent developments brought by demographic change and provide their constituencies with policies ready for current and emerging challenges and opportunities. We hope that policy makers from across the EU and OECD will benefit from its in-depth and well-researched analysis.

Mathias Cormann

OECD Secretary General

Mariya Gabriel

Commissioner for Innovation, Research, Culture, Education and Youth

Foreword

How can governments deliver on the mandate to provide public services across territories efficiently, especially in places with low density facing depopulation and ageing? This report is the second of the sub-series *Preparing Regions for Demographic Change*, that aims at supporting policy makers navigate the challenge of providing services with equity and efficiency. This report complements the first report of the sub-series focused on policies and good practices, *Delivering Quality Education and Health Care to All*.

This report makes use of novel methods to simulate the location of education and health services and estimate the differences in access and costs at very granular geographical levels. The chapters apply these methods to Europe and provide a thorough analysis of territorial differences in the cost of and access to education and health services arising from local differences in demand. The report also identifies the areas facing the most difficult future challenges in provision based on available population projection grids. As the previous report of the series, the findings highlight the value-added of considering a spatial lens in developing policies to mitigate inequalities across different geographies. These stem due to the unique trade-off between costs and physical access to local services in rural areas.

This report was carried out as part of the OECD’s Regional Development Policy Committee (RDPC) Programme of Work and Budget. The RDPC provides a unique forum for international exchange and debate on regional economies, policies and governance. It was discussed in the 24th and 25th meetings of the Working Party on Rural Policy and was approved by the RDPC [CFE/RDPC/RUR(2020)6/REV2] on May 4th 2021.

Acknowledgements

This report was produced in the OECD Centre for Entrepreneurship, SMEs, Regions and Cities (CFE), led by Lamia Kamal-Chaoui, Director, as part of the programme of work of the Regional Development Policy Committee (RDPC), and the European Commission's Joint Research Centre (EC-JRC). The report benefitted from the financial support of the European Commission Directorate-General for Regional and Urban Policy.

From OECD side, the report was produced by Ana Isabel Moreno Monroy under the supervision of Jose Enrique Garcilazo, Head of the Regional and Rural Policy Unit in the Regional Development and Multi-level Governance Division, led by Dorothée Allain-Dupré. From EC-JRC side the report was produced by Chris Jacobs-Crisioni and Mert Kompil under the supervision of Carlo Lavalle, project manager of the LUISA Territorial Modelling Platform of the Urban and Territorial Development Unit led by Alessandro Rainoldi. The report was drafted by Chris Jacobs-Crisioni (EC-JRC), Mert Kompil (EC-JRC) and Ana Isabel Moreno Monroy (OECD) with contributions from Tamara Krawchenko (University of Victoria) (Chapter 1) and Daniel Howdon (University of Leeds) (Chapter 4). Marc Bournisien de Valmont (OECD) contributed valuable analysis to the report.

The OECD is grateful to Pedro Abrantes (Ministry of Education, Portugal), William Palmer (Nuffield Trust, United Kingdom) and Ulf Tynelius (Agency for Growth Policy Analysis, Sweden) for providing valuable inputs for the analysis. Special thanks to the following people at the OECD for their support and substantial comments at various stages of the report: Stefano Barbieri, Andrea Colombo and Andres Sanabria at CFE (OECD); Luka Boeskens and the OECD School Resources Review team led by Deborah Nusche (OECD); and Luca Lorenzoni and colleagues at the Health Division led by Francesca Colombo (OECD). The OECD is also grateful to delegates of the OECD RDPC and its Working Party on Rural Policy for comments and guidance throughout the project. EC-JRC is grateful to Carmelo Attardo and Glauco Prina for supporting the online data platform production, Maarten Hilferink (Object Vision) for providing technical support, and Patrizia Sulis (EC-JRC) for statistical support. This report relies on local demographic data produced by the LUISA Territorial Modelling Platform with contributions from Jean-Philippe Aurambout, Claudia Baranzelli, Filipe Batista e Silva, Anne Goujon, Andrius Kucas, Fabrizio Natale and Carolina Perpiña Castillo (all EC-JRC).

Pilar Phillip (OECD) co-ordinated the production process of the report. Meral Gedik provided editorial assistance and Jeanette Duboys (OECD) prepared the manuscript for publication.

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Executive summary

With population decline and ongoing concentration in metropolitan regions, the population base of many regions is becoming smaller, older and more dispersed. Within Europe, 35% of people live in a region that saw population decrease between 2011 and 2019. The population of regions covering about half of the European territory, most of them non-metropolitan, is projected to decline in 2011-35. In 2020 the average resident of a remote region in Europe was older than a resident of a metropolitan region, as remote regions continue to age faster than other types of regions. This situation is the result of low immigration and a dramatic decline in fertility rates from 2.8 children per woman of childbearing age in 1970 to 1.6 in 2018 on average across OECD countries.

Demographic change is a structural force that can widen territorial disparities in access to services. Population decline directly affects the provision of public services by shrinking the pool of potential users, leading to professional shortages and forcing facilities to close and consequently increasing distance to services for users in remote areas. While demography and geography have clear implications for service provision in rural areas, most countries do not quantify the effective difference in the costs resulting from these factors. In many cases too, the funding of public services in rural areas does not take into account the unavoidable costs of remoteness, smallness, and ageing.

This report advances toward this objective by considering two social services of general interest: (primary and secondary) education and health (cardiology, and maternity and obstetrics). It provides the first internationally comparable estimates of both cost and access (distance) to these services, as well as future projections based on demographic change at a very granular level.

Providing education with equity and efficiency in the future requires active policy interventions today

Today school networks in many OECD countries face constant pressure to adapt to decreasing demand in rural areas. In most OECD countries, on average only 1 in 5 children up to the age of 14 live in rural areas. Many rural communities do not have or will soon not have any children of school age. Smaller classes and fewer students per teacher in rural schools translate into higher costs per pupil. This report estimates that in Europe, the annual costs per student in sparse rural areas are 20% higher (EUR 720) compared to cities for primary schools and 11% (EUR 681) higher for secondary schools. This cost difference can be higher than 40% for primary schools in Estonia, Finland and Latvia and 16% for secondary schools in Greece and Spain.

To remain efficient and equitable, school networks have to find scale economies whenever possible while ensuring access to education of similar quality for all children. School consolidation, school clusters and networks can improve educational quality while saving resources. This report shows that because of the expected decrease in the number of students, satisfying demand in 2035 while maintaining similar distances to schools can be achieved with 8% and 20% less primary and secondary schools in sparse rural areas; 5% and 13% less in villages; 3% and 5% less in towns and suburbs; and

6% and 8% more in cities. Germany, Poland and Spain concentrate more than half of the expected reductions in the number of schools outside cities.

Even if supply adjusts to demand, long travel distances in rural areas pose a limit to school consolidation. This report estimates that students in sparse rural areas travel on average four to five times further compared to students in cities. This implies that some schools will need to continue to operate under capacity to ensure adequate access. Equity in provision, especially for children who cannot travel far independently dictates the need to provide solutions to students living in areas with difficult access.

Demographic change will tighten the trade-off between costs of and access to education in rural areas. For EU27+UK countries, this report shows that even after adjusting the school network to future demand, the costs per student in sparse rural areas are expected to increase by around 3% on average. Distance to schools is also expected to slightly increase everywhere outside cities, and proportionally more in villages. Policy simulations show that not adjusting the primary school network to demand changes in 2035 doubles the additional increase in costs per student in sparse rural areas and increases it by 60% in villages, while achieving only small accessibility gains. In countries expecting a sharp decrease in student numbers in sparse rural areas, the additional costs of not readjusting the school network to the future demand represents as much as EUR 1 243 per student in Lithuania (25% more) and EUR 741 in Latvia (14% more).

Expected changes in health services demand require continuous, substantial, and tailored policy interventions

Current population trends and the COVID-19 pandemic call for strategies addressing the efficiency of public service provision while ensuring access to services. Health spending as a share of GDP is projected to increase on average from 8.8% in 2015 to 10.2% by 2030 for OECD countries, with demographic changes accounting for about one-fourth of the overall projected change. As structural factors drive future increases in health expenditure, governments face pressure to increase efficiency while striving to achieve longer and healthier lives for everyone.

To provide services outside cities, policies need to strike a balance between accessibility and cost-efficiency. This report estimates that 1 in every 100 inhabitants use cardiology, and maternity and obstetrics services on average in Europe. In satisfying this demand, countries may have health service locations serving relatively large catchment areas that are either close to users or cost-efficient, but not both simultaneously. While in densely populated countries such as Belgium, Malta, the Netherlands, and the United Kingdom, less than 15% of the sparse rural population lives far from a health service location, in sparsely populated countries this percentage can be higher than 40%. This report highlights the importance of tailoring strategies for facilities serving relatively sparse rural hinterlands –including those located in towns and suburbs– as they face a more challenging balance between efficiency and access.

Policies face the challenge of responding to future changes in demand in an efficient and equitable manner. Adapting to demographic change requires concentrating the provision of some services such as maternity and obstetrics that will face decreased demand in many countries, and increasing and dispersing the provision of services such as cardiology related to ageing, especially in rural areas. By 2035, the number of cardiology service locations per user is expected to increase on average by 20%, with the highest expected increases in Slovenia (88%), Ireland (71%) and Denmark (64%). In turn, the number of maternity and obstetrics service locations is expected to decrease by 4%, with the highest decreases in Latvia (-67%), Slovak Republic (-56%) and Lithuania (-44%).

1 Service provision: Definition and trends

This chapter defines the scope of the report, discusses megatrends affecting the delivery of services, and summarises current discussions on planning for service provision. It starts with this report's definition of public services, the scope of the services considered and the territorial typologies used in the analysis. It then describes how depopulation, ageing and climate change are affecting the provision of services in OECD countries. Finally, the chapter discusses the relationship between costs and access to public services and outlines forward-looking strategies for service provision in the context of demographic change.

Main takeaways

- This report considers two social services of general interest, healthcare and (primary and secondary) education, as provided in facilities to which users travel.
- Health spending as a share of GDP is projected to increase on average from 8.8% in 2015 to 10.2% by 2030 for OECD countries, with demographic changes accounting for about one-fourth of the overall projected change. These trends stress the need for strategies addressing the efficiency of public service provision.
- Regions covering about half of the European territory are projected to have negative population growth in 2011-35, with a decline concentrated largely in non-metropolitan regions.
- Many rural communities that suffer from depopulation are at risk of a stagnating economy, lack of professional opportunities and increasing poverty and social exclusion. In fact, 31 million people (7% of the EU population) live in a region that faces the twin challenge of rapid population decline and low GDP per head.
- Lower density areas have fewer specialists, more difficulty in attracting the right skills, higher infrastructure costs and a smaller population to draw users to provide services at scale and a smaller local tax base to finance local services.
- Population decline directly affects the provision of public services by shrinking the pool of potential users, leading professional shortages and forcing facilities to close and consequently increasing distance to services for users in remote areas.
- The geography of population aging is uneven as non-metropolitan regions, especially remote ones, experience more rapid aging than others. This has implications for the current and future demand for health services such as cardiology.
- Accessibility, by measuring the ease of reaching opportunities, indicates both the availability of service and the ease with which the service can be reached by users. It is a useful measure of both evaluating the performance of transport and land use interactions and the need for new services based on equity grounds.
- Poor access to public services, low accessibility, lack of economic competitiveness and innovation are both causes and consequences of depopulation.

Introduction

Public service provision and delivery is one of the main mandates of regional and national governments in OECD and European countries. Education and health services, with their place-based characteristics and frequent use, respond to the widespread need of citizens and constitute the most important part of public service provision. Providing public services that are equitable, affordable, accessible and of high quality is challenging for governments in many ways. The capacity of the government to deliver on their service provision mandate has been put under further pressure by budgetary constraints and cuts following the 2008 financial crisis; demographic trends such as depopulation and ageing that affect the demand for services; and notably the current COVID-19 pandemic. More than ever, governments at all levels need to manage costs in order to allocate scarce and limited public resources into provision of services while ensuring adequate access to services of comparable quality to citizens everywhere.

Providing services in places with smaller and more dispersed populations is more difficult and possibly more costly than in denser places. This happens because lower density means higher transportation costs, loss of economies of scope and economies of scale, and greater difficulty in attracting and retaining professionals (e.g. health care professionals) (OECD, 2021[1]; OECD, 2018[2]; OECD, 2017[3]; OECD, 2017[4]; OECD, 2016[5]). The link between cost of service provision and density levels suggests the need for a differentiated policy strategy with a clear spatial approach. However, there are currently no internationally comparable data on public services cost and access.

Service provision has a place-based dimension requiring considering cost and access simultaneously. Cost efficiency increases with scale, and sometimes achieving scale comes at the cost of longer travel times for users. While a direct way to decrease the cost of service delivery is to increase the scale of provision, public investments must still recognise choices by citizenry about where to live. Ensuring minimum access as mandated by law must weigh the relative benefits of adding more service points versus improving road networks and encouraging less dispersed settlements.

In this context, population ageing and the increasing sparsity of some territories experiencing depopulation are likely to put additional strain on service delivery costs and quality in the near future. For some rural dwellers, particularly seniors, relocation is not always a viable option due to higher housing costs in urban locales and the loss of social networks that are critical to quality of life and wellbeing. Moreover, shrinking and ageing populations together with a lower tax base has further pressed governments to adapt to new conditions amidst growing demand and higher costs. For instance, while the economic future of rural communities depends on an educated and well-trained workforce, a shrinking population can decrease the minimum efficient scale for high-quality education.

A companion thematic report *Delivering Quality Education and Health Care to All* (OECD, 2021[1]) identified "good practices" in terms of rural public service provision, including innovations in service delivery (new approaches, partnerships and technologies) and conditions for success. The report aimed to help countries in their tasks to deliver public services in health and education, by establishing long-term strategies that can be sustainable according to population trends and innovative solutions.

This report aims to provide a better understanding of policies to address present and future public service provision by assessing the drivers of geographical differences in costs and access to education and health services. In particular, for primary and secondary schools; cardiology; and maternity and obstetrics services this report:

- offers new internationally comparable fine-grained estimates of service costs
- compares user travel distances based on simulated school and health service locations
- estimates changes in costs driven by future population changes
- sheds light on the present and future effect of demographic change on access to services in rural areas.

While this report offers estimations at different geographical levels for EU27 countries and the United Kingdom, the novel methods for estimating cost and access and using foresight to analyse policy scenarios can be reproduced in any context with available population grids.

This chapter sets the scene for the report, starting by outlining key definitions, continuing with a description of megatrends affecting the provision of services in OECD countries, and ending with a discussion on the relationship between accessibility and service provision and forward-looking planning strategies in the context of population decline and demographic change.

Definitions and typologies

Public services are an ample concept that englobes a range of services where governments have a role in ensuring provision which has nevertheless evolved in time. This section starts with outlining the definition of public services used in this report and continues with an outline of the territorial typologies used in the analysis.

What is understood by public services on this report

Public services are all those services that are rendered in the public interest. They are based on the notion that there is a social consensus that some services should be available to all and that—due to a lack of scale or significant externalities—it is the state that should be involved in the provision of those services in some way.[1] This broad definition conceals a great deal of choice in terms of what those services are, how they are delivered, and by whom. Table 1.1 outlines the main ways in which public services can be classified: according to function, provider (public/private), cost (free versus fee based), who benefits, and where the service is consumed geographically (see and Box 1.1 for an outline of previous classifications of public services).

Table 1.1. Classifying public services

Function	Services to guarantee basic physical conditions and to overcome locational disadvantages	Services to guarantee basic social conditions	Services supporting quality of life	Services to enterprises
Provision	Fully public	Association or non-profit	Private	Mixed public, private or non-profit
Cost	No fee open to access	Fee based (full or partial)		
Target population	Universal benefits	Targeted benefits		
Geography of consumption	Point-specific consumption of public service	Public services requiring continuous connection (line or network)	Digital consumption	

Box 1.1. Classifications of public services

Previous OECD work has classified public services according to their functions, along with four main types:

1. **Services to guarantee basic physical conditions** and to overcome locational disadvantages such as telecommunications infrastructure, electricity, waste supply and sewage, waste disposal, roads, and transport.
2. **Services to guarantee basic social conditions** such as social security, employment and training services, social housing, child care, long-term care, and social assistance services.
3. **Services supporting quality of life** such as sports and cultural facilities.
4. **Services to enterprises related to administration** (business registries) or direct or indirect aid such as export development services, business grants, etc. (OECD, 2010[6]).

Other classifications of public services have focussed on who benefits from them. Public services may be delivered with universal access or they may be targeted to certain populations – e.g. access may be determined by income thresholds. Others have made this distinction based on class dimension. For example, Lonsdale et al. distinguish between public services that disproportionally benefit middle- and higher-income groups (e.g. public universities, airports, art galleries) versus those that benefit lower-income ones (e.g. welfare programmes) regardless of whether they are universal or not (Lonsdale and Enyedi, 2019[7]).

While the public sector (national, regional, or local governments) is involved in the design, funding and delivery of public services, the line between what is public and what is private has become blurred with the adoption of new forms of service provision including contracting out and fee-based systems. Those services which are deemed ‘public’ in nature may be delivered by an entity that is fully or partially publicly-owned, private, mixed, an association, or a not-for-profit entity.[2] In this sense, public services are no longer synonymous with being free to all; they may involve fees. This report considers public services along with this definition without distinguishing private from public providers.

The European Commission distinguishes between public services (or “services of general interest”) based on whether they are fee-based or not, categorising three types (European Commission, 2019[8]):

- Services of general *economic* interest are those basic services that are carried out in return for payment such as postal services.
- *Non-economic* services are services for which there are no fees such as the police, justice and statutory social security schemes.
- *Social* services of general interest can be payment/fee based or not and include social security schemes, employment services, and social housing.

Under this definition, this report considers two social services of general interest: healthcare and (primary and secondary) education.

Classifications that consider public services according to how they are consumed geographically are also relevant for this report. For example, some services may require consumers to travel to the place of use (e.g. airports, libraries, recreation centres, schools, and medical facilities); others, may be accessed through continuous connections and space (e.g. roads, water mains, power lines). From this perspective, services can be seen as either points (the former) or lines and networks (the latter) (DeVerteuil, 2000[9]). Some services hold features of both points or lines/networks such as bus lines and the postal service. Digital services defy these categories – they are services delivered at point, requiring no travel on behalf of the consumer and no network beyond digital connectivity, however that be delivered.

This report considers point-specific health care and education services (provided at schools or service locations) to which users travel. It does not consider services that require continuous connections or services provided digitally.

Territorial typologies to evaluate service provision

Settlement patterns are one of the most important determinants of service provision. Dispersed populations and longer distances to services reduce access and increase inequalities, leading to such phenomena as 'medical deserts' (Pierron and Roca, 2017[10]; Sanz-Barbero, Otero García and Blasco Hernández, 2012[11]). Areas outside cities, especially those with lower density and more difficult access, have thinner labour markets and fewer specialists, and more difficulty in attracting the right skills. These areas may also have at the same time higher provision costs and a smaller population to draw financial resources from to finance local services (Table 1.2).

Table 1.2. Characteristics of higher and lower density areas

Higher density areas	Lower density areas
• Higher access to services • Thicker labour markets • More diversified labour market • Larger number of specialists • Lower infrastructure and transportation costs • Larger population for locally financed services	• Lower access to services • Thinner labour markets • Less diversified labour market • Fewer specialists • Higher infrastructure and transportation costs • Smaller population for locally financed services

To analyse the cost and access to services varies across places in Europe, this report uses two territorial classifications at two levels of geographical aggregation: the degree of urbanisation classification at the 1 km^2 grid-cell level, and the TL3 regional typology based on access to cities (see Box 1.2 and Box 1.3).

The two typologies are useful for describing the concentration of population and its geographical dispersion. According to the degree of urbanisation, more than half of the population in EU-27 countries and the United Kingdom concentrate in cities and towns and suburbs, while sparse rural areas concentrate little population but the majority of land (Table 1.3). On the other hand, according to the regional typology based on access to cities, around 60% of the EU27+UK population lives in metropolitan regions, and the largest share of the remaining 40% lives in regions close to cities (Table 1.4). The share of population in remote regions is particularly relevant to service provision because their sparsity is high and distances long. This share varies considerably across EU27+UK countries, being highest in large countries with difficult terrain and/or weather including Sweden, Finland, Greece, and in small Eastern European and Baltic countries including Latvia, Croatia, and Estonia (Figure 1.1).

Table 1.3. Share of land and population by degree of urbanisation, EU27+UK

2011

	Share of land EU27+UK	Share of population EU27+UK
Sparse rural areas	95%	18%
Villages	2%	12%
Towns and suburbs	3%	33%
Cities	1%	37%

Source: Authors' elaboration based on (Eurostat, 2021[12]) and (OECD, 2021[13]).

Table 1.4. Share of population by type of TL3 region, EU27+UK

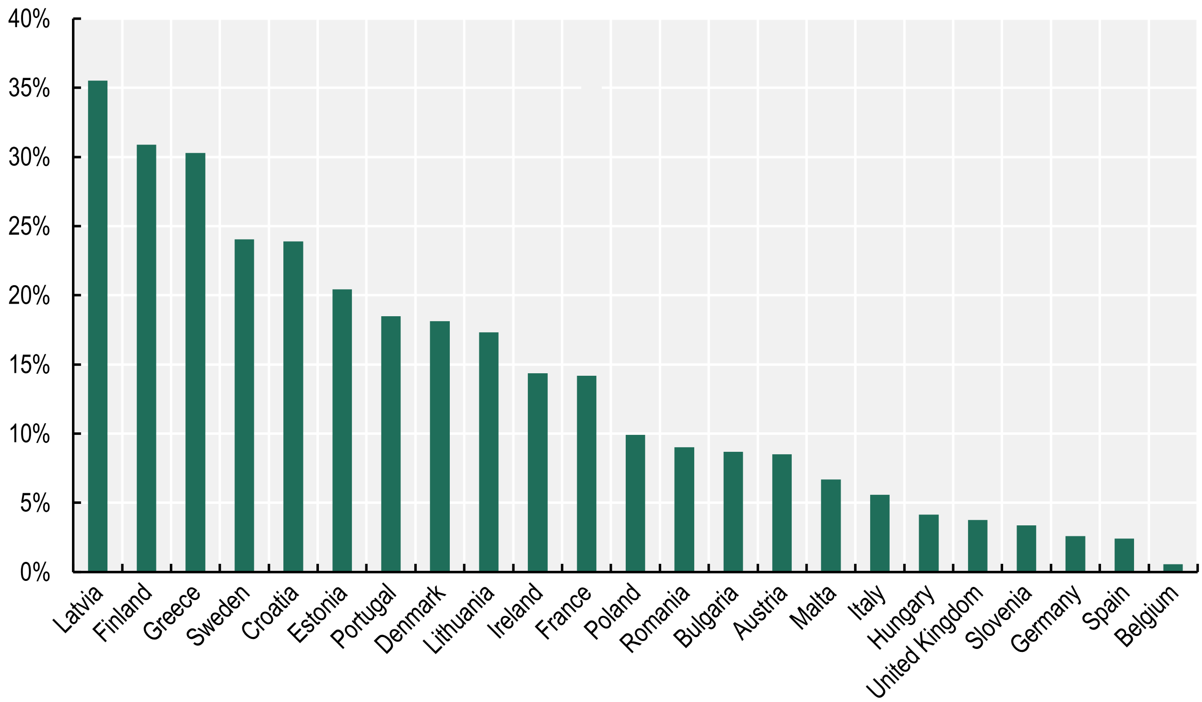
2020

Type	Share of population (%)	Projected population growth (%), 2011-35	Median age (years)
Metropolitan Regions	60.6	17.44	44.3
Non-metropolitan regions close to metropolitan areas	15.4	-8.91	46.4
Non-metropolitan regions close to small metropolitan areas	15.9	-25.75	45.4
Non-metropolitan remote regions	7.7	-31.15	46.8

Note: 2019 data for the United Kingdom. Population change is the average compounded annual growth in 2011-35.
Source: Authors' elaboration based on (Eurostat, 2021[12]; Goujon et al., 2021[14]; OECD, 2021[13]; Jacobs-Crisioni et al., n.d.[15]).

Figure 1.1. Share of population in remote TL3 regions, EU27+UK

2020



Note: 2019 population for the United Kingdom. Missing countries do not have any remote regions.
Source: Eurostat (2021[12]), "Population change - Demographic balance and crude rates at regional level", https://ec.europa.eu/eurostat/cache/metadata/en/demo_r_gind3_esms.htm; OECD (2021[13]), OECD Regional Statistics, www.oecd.org/regional/regional-statistics/.

StatLink https://doi.org/10.1787/888934245880

Box 1.2. Degree of urbanisation classification

Method to classify grid-cells by their Degree of Urbanisation, levels 1 and 2

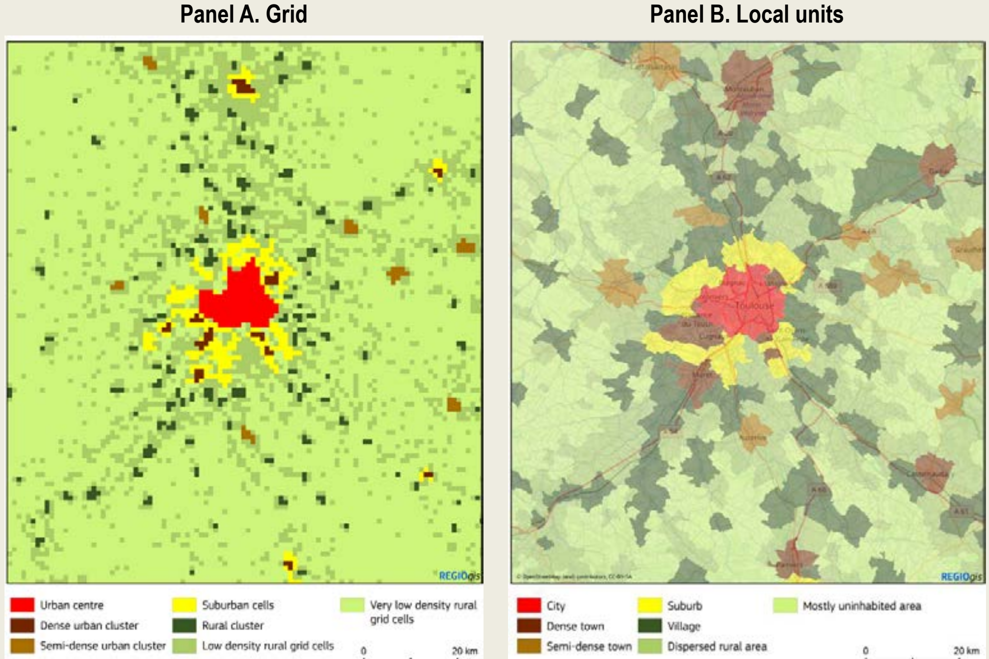
The Degree of Urbanisation was designed to create a simple and neutral method that could be applied in every country in the world. It relies primarily on population size and density thresholds applied to a population grid with cells of 1 by 1 km. The different types of grid cells are subsequently used to classify small spatial units, such as municipalities or census enumeration areas (see Figure 1.2 for an example). The Degree of Urbanisation was endorsed by the UN Statistical Commission in March 2020.

The Degree of Urbanisation level 1 classifies the entire territory into:

- Cities, with a population of at least 50 000 in contiguous grid cells with a density of at least 1 500 inhabitants per km^2.
- Dense towns, with a population between 5 000 and 50 000 in contiguous grid cells with a density of at least 1 500 inhabitants per km^2.
- Semi-dense towns, with a population of at least 5 000 in contiguous cells with a density of at least 300 inhabitants per km^2 and are at least 2 km away from the edge of a city or dense town.
- Suburbs, with most of their population in contiguous cells with a density of at least 300 inhabitants per km^2 that are part of a cluster with at least 5 000 inhabitants but are not part of a town.
- Villages, with between 500 and 5 000 inhabitants in contiguous cells with a density of at least 300 inhabitants per km^2.
- Dispersed rural areas, with most of their population in grid cells with a density between 50 and 300 inhabitants per km^2.
- Mostly uninhabited areas, with most of their population in grid cells with a density of less than 50 inhabitants per km^2.

Figure 1.2. Degree of urbanisation level 2 grid classification around Toulouse, France

Panel A. Grid | **Panel B. Local units**



In this report, these categories are collapsed into four categories: 1) **sparse rural areas** (composed of mostly uninhabited areas and dispersed rural areas); 2) **villages**; 3) **towns and suburbs**; and 4) **cities**.

Source: European Commission/ILO/FAO/OECD/UN-Habitat/World Bank (2020), "A recommendation on the method to delineate cities, urban and rural areas for international statistical comparisons", Statistical Commission background document, 51th session, 3-6 March 2020. Items for discussion and decision: demographic statistics. Available at https://unstats.un.org/unsd/statcom/51st-session/documents/BG-Item3j-Recommendation-E.pdf.

Box 1.3. Classifying European TL3 regions by their level of access to cities

The regional classification based on access takes into consideration the presence of and access to Functional Urban Areas (FUAs). Access is defined in terms of the time needed to reach the closest urban area; a measure that takes into account not only geographical features but also the status of physical road infrastructure.

The typology classifies TL3 regions into metropolitan and non-metropolitan according to the following criteria:

Metropolitan TL3 region (MR), if more than 50% of its population live in a FUA of at least 250 000 inhabitants.

Non-metropolitan TL3 region (NMR), if less than 50% of its population live in a FUA. NMRs are further classified according to their level of access to FUAs of different sizes into:

- ***Close to metropolitan (NMR-M)***, if more than 50% of its population lives within a 45 minute-drive from a metro (a FUA with more than 250 000 people).
- ***Close to small metropolitan (NMR-S)***, if the TL3 region does not have access to metro and 50% of its population has access to a small or medium city (a FUA of more than 50 000 and less than 250 000 inhabitants) within a 45 minute-drive.
- ***Remote (NMR-R)***, if the TL3 region is not classified as NMR-M or NMR-S, i.e. if 50% of its population does not have access to any FUA within a 45-minute drive.

Driving time by road to the nearest city depends on the definition of the cities, the road network used, the boundaries of the regions and the spatial distribution of the population within the region. In the implementation, cities are represented by their centroid point, defined as the population-weighted average location of the centroids of 1 km² grid cells covering the city. Around these centroid points, service areas of 45 minutes by major and secondary roads are calculated. The generic speed attribute provided with the road network data is used, so that it does not take into account possible traffic congestion issues.

All service areas are merged to create an accessibility surface characterised by its maximum driving time to at least one city. This surface is then overlaid with the centroid points of 1 km² population grid cells. All centroids falling within the accessibility surface are defined as "close to a city", the other cell centroids as "remote". From this, it is possible to determine which part of the TL3 population is located in areas close to a city by calculating the share of regional population living close to a city.

Source: European Commission (2021), Assessing remoteness of regions: An update. Internal document, DG Regional and Urban Policy; Eurostat (2019[16]), *Methodological manual on territorial typologies: 2018 Edition*, https://ec.europa.eu/eurostat/web/products-manuals-and-guidelines/-/KS-GQ-18-008; Dijkstra and Poelman (2008[17]), *Remote Rural Regions: How proximity to a city influences the performance of rural regions*, https://ec.europa.eu/regional_policy/en/information/publications/regional-focus/2008/remote-rural-regions-how-proximity-to-a-city-influences-the-performance-of-rural-regions; Fadic et al. (2019[18]), "Classifying small (TL3) regions based on metropolitan population, low density and remoteness", *OECD Regional Development Working Papers*, https://doi.org/10.1787/b902cc00-en; OECD (2020[19]), *Rural Well-being: Geography of Opportunities,* OECD Rural Studies, https://doi.org/10.1787/d25cef80-en.

Public services under pressure

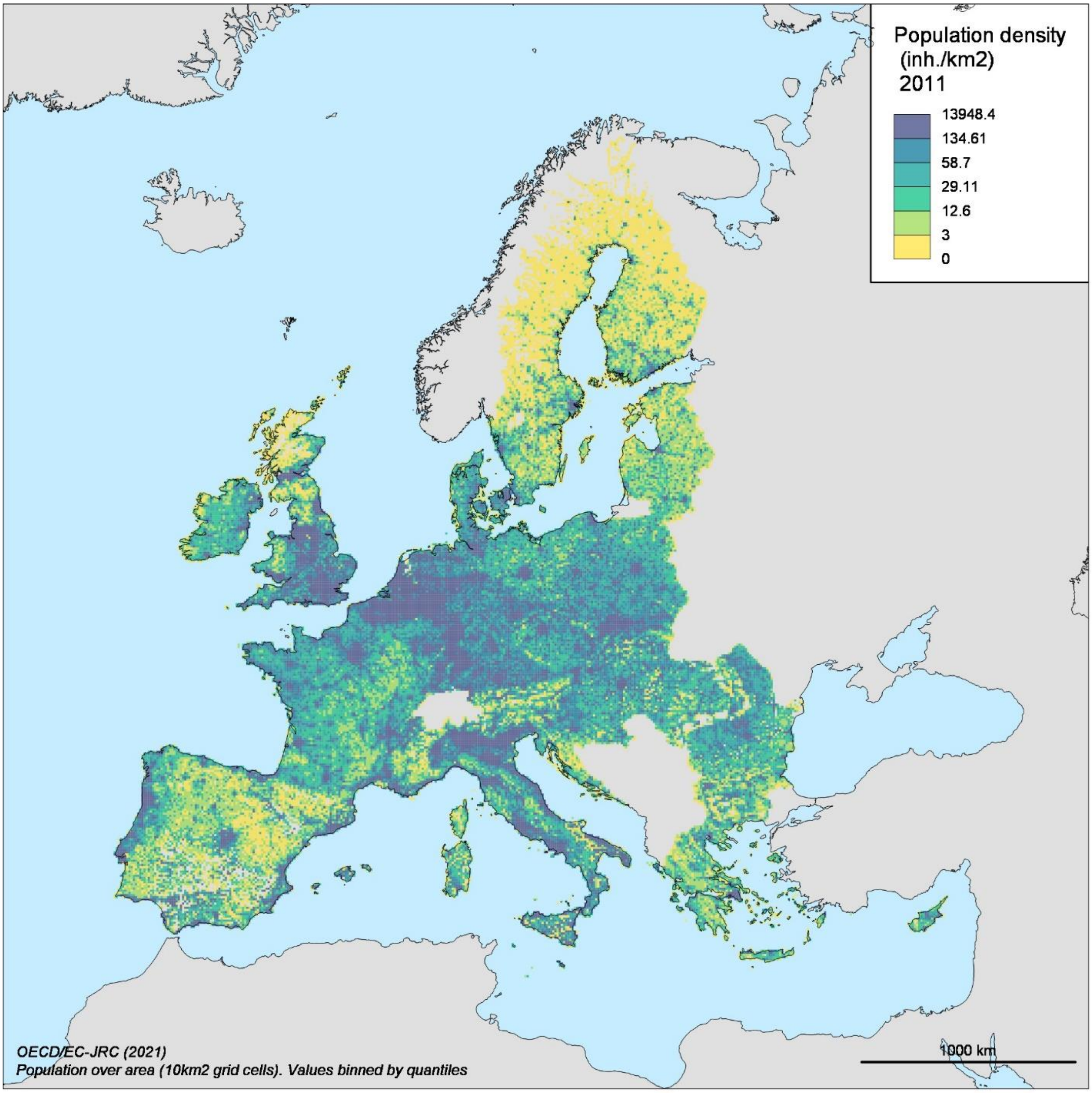
The rising costs of public services —particularly health care and social care—are present in media discourses across the OECD and are a source of growing concern for policy makers. Population aging is one of the main factors that is often pointed to as contributing to these costs, leading to what some have termed “apocalyptic demography”, a moral panic about the presumed rising health care costs (Walker, 2006[20]). However, as will be discussed, the picture is more complicated; on the one hand, demographic change is but one among several increasing health care costs (Gee, 2002[21]), on the other hand, the trend in healthy ageing in OECD countries acts as a counterforce to raising health care costs.

Depopulation and sparsity

Across Europe, variations in population density and remoteness already offer a picture of places facing access to services issues. While congestion in large cities can become an issue for access, the concentration of potential user services already facilitates providing services such as education and health care at scale. In vast sparsely populated areas of Europe, such as parts of the Iberian peninsula, northern Scandinavia or mountainous areas in the Balkans (Figure 1.3), services may be provided in facilities operating below their minimum viable scale. Achieving scale in many cases may not even be possible without stretching user travel times beyond reasonable limits.

Figure 1.3. Population density, EU27+UK

2011

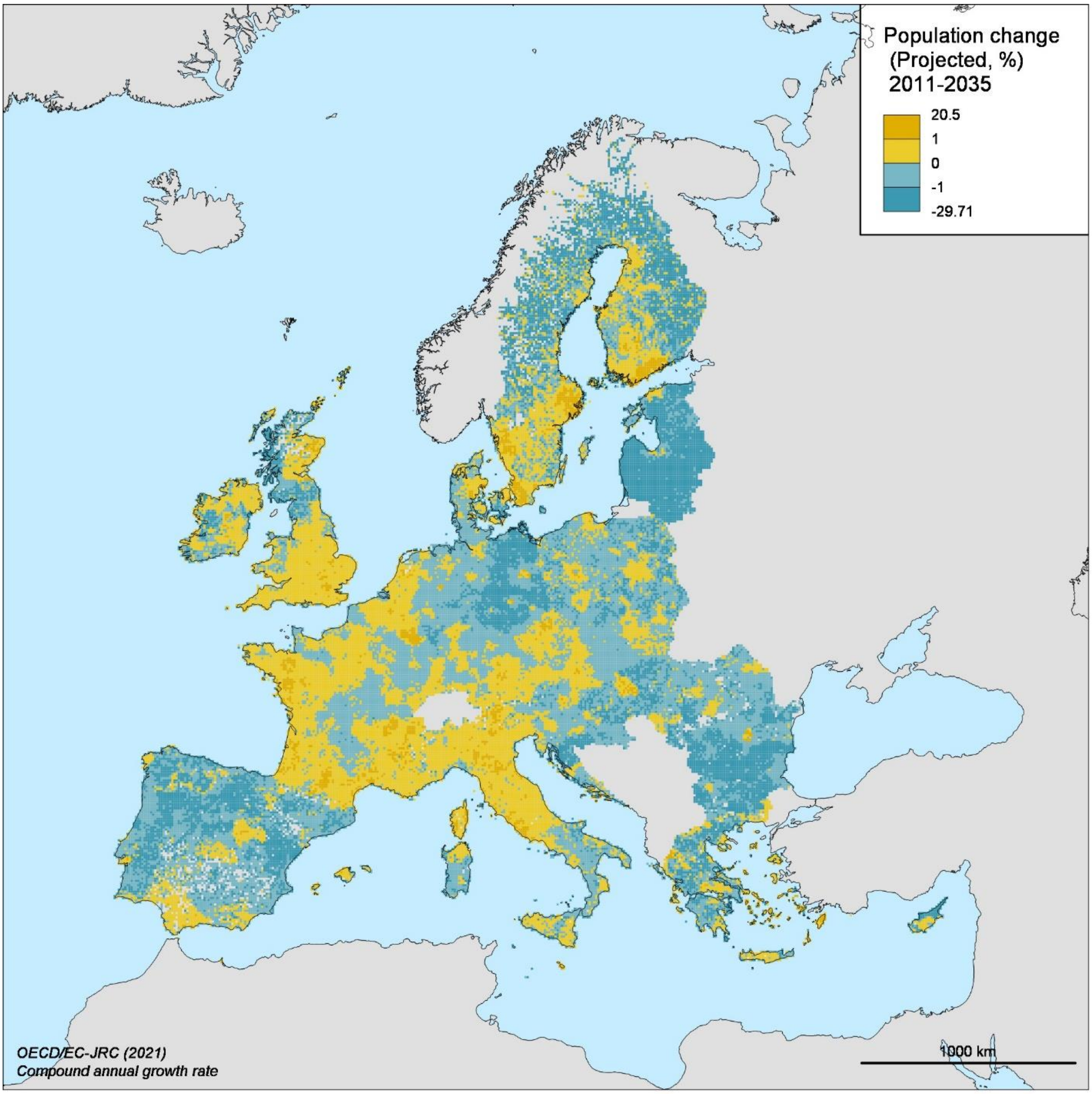


Source: Authors' elaboration based on (Goujon et al., 2021[14]) and (Jacobs-Crisioni et al., n.d.[15]).

Within the European Union, 65% of people live in a region that saw population increases between 2011 and 2019. For the remaining share, population decline has become a prolonged trend. In fact, regions covering about half of Europe's territory are projected to experience negative population growth in 2011-35 (Figure 1.4), with a decline concentrated largely in non-metropolitan regions (Table 1.1).

Figure 1.4. Projected population change, EU27+UK

2011-35



Note: Change is calculated as compound annual growth rate in 2011-35.
Source: Authors' elaboration based on (Goujon et al., 2021[14]) and (Jacobs-Crisioni et al., n.d.[15]).

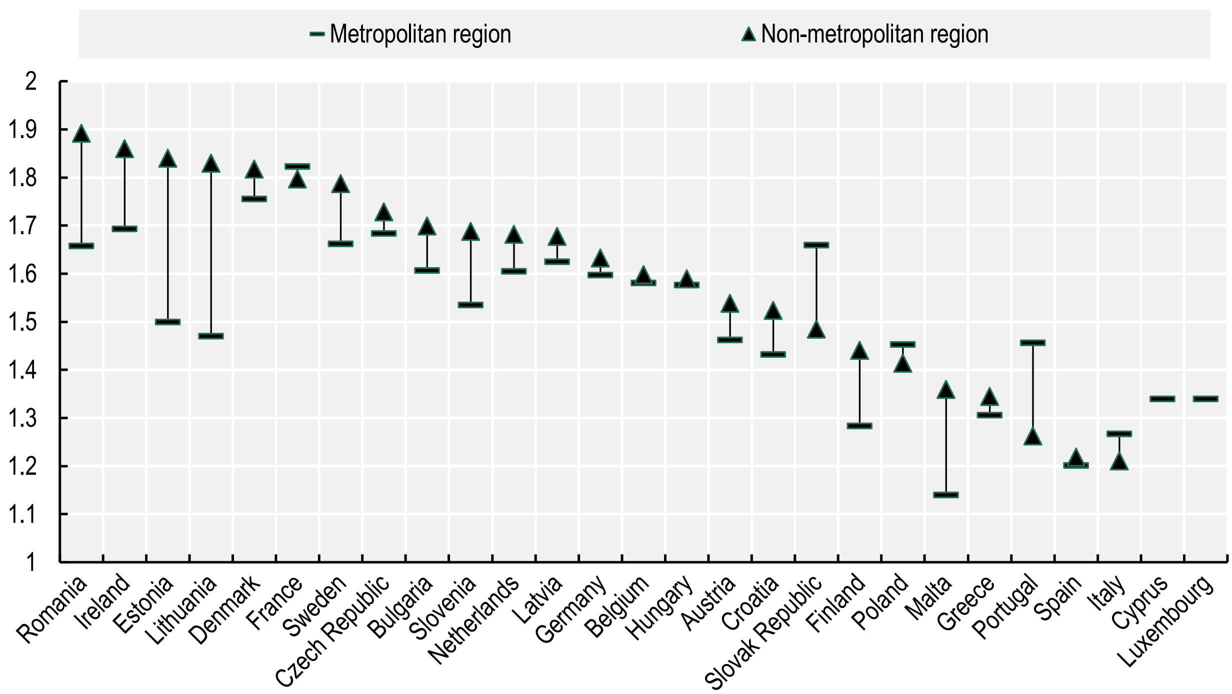
Around 30% of the OECD population lived in non-metropolitan regions in 2019 (OECD, 2020[19]), compared to 45% almost seventy years earlier. The reason for this population change is a steady and significant decline in fertility rates across the board in OECD countries, together with increasing population concentration in metropolitan regions.

Fertility rates declined dramatically across OECD countries, falling on average from 2.8 children per woman of childbearing age in 1970 to 1.6 in 2018 (OECD, 2019[22]) (OECD, 2021[23]), below the replacement levels needed to maintain the population in the long term in the absence of migration. Across

European countries, fertility rates are all below replacement levels and are considerably lower in Spain, Italy, and Greece. The rates are also higher in non-metropolitan regions than in metropolitan regions in all countries with available data except in the Slovak Republic, Portugal and to a lower extent Italy and France (Figure 1.5). The gap in fertility rate between types of regions is largest in Estonia and Lithuania.

Figure 1.5. Fertility rates by metropolitan and non-metropolitan regions, EU27

2019



Note: Total fertility rate computed by adding the age-specific fertility rates for women in a given year. It can be interpreted as the mean number of children that would be born alive to a woman during her lifetime if she were to pass through her childbearing years conforming to the fertility rates by age of a given year, and surviving.
Source: Eurostat (2021[12]), "Population change - Demographic balance and crude rates at regional level", https://ec.europa.eu/eurostat/cache/metadata/en/demo_r_gind3_esms.htm.

StatLink https://doi.org/10.1787/888934245899

Net migration, in turn, was positive in both metropolitan regions and regions near metropolitan areas, and negative other OECD regions in 2015. This suggests larger cities and their surrounding areas are attractive hubs for newcomers, whereas regions with or near a small/medium city and remote regions do not have the same level of attractiveness (OECD, 2020[19]).

The past decades have evidenced increasing concentration in or close to cities and away from remote and lower density areas across OECD countries. Metropolitan regions had twice as large population growth rates (0.70%) compared to non-metropolitan regions (0.33%) (OECD, 2020[19]). While peripheral rural areas tend to be more at risk of depopulation, lagging towns, cities and conurbations in OECD regions, for instance, those with industrial areas in decline, tend to lose population too. On the other hand, rural areas close to dynamic urban centres, as well as those with good connectivity to cities, have experienced population growth.

Projected population change has a direct link with current regional income levels. In Europe, most regions that experience rapid population growth have GDP per capita levels above the EU average, while regions with rapid population decline tend to have a comparatively low GDP per capita. In fact, 31 million people, or 7% of the EU population, live in a region that faces the twin challenge of rapid population decline and low GDP per head. Many of these regions are in the Baltic States, Bulgaria, Croatia, Hungary, Portugal, and Romania. Apart from this, many rural communities that suffer from depopulation are at risk of a stagnating economy, lack of professional opportunities and increasing poverty and social exclusion. Demographic developments may thus further exacerbate economic decline and thereby widen the gap between wealthy and poor regions (European Commission, 2020[24]; EPRS, 2020[25]; EPRS, 2019[26]).

Population decline directly affects the provision of public services by shrinking the pool of potential users, leading professional shortages and forcing facilities to close. As communities shrink and demand for services diminishes, some services may be either regionalised, reducing their accessibility, or withdrawn all together. A prime example of this is the closure of rural schools, which is a matter of intense debate, as such closures can initiate or accelerate a rapid decline in the social and economic well-being of rural communities (Lehtonen, 2021[27]; Johnson and Howley, 2015[28]). The OECD report *Delivering Education and Health Care to All* (OECD, 2021[1]) discusses policy options to address these issues, while this report focuses on estimating the effect of declining user bases on the cost of providing schooling and health care services.

Hospital or specific health service closure is another challenge brought by population decline. The closure of smaller hospitals, especially those in rural and remote areas, has major impacts on local communities (Vaughan and Edwards, 2020[29]; Kaufman et al., 2015[30]). OSU Center for Health Sciences (2021[31]) evaluated 173 closed hospitals in the US rural areas and found that the average distance between closed rural hospitals and the next nearest open facility is almost 18 miles, which creates an additional travel burden placed on patients. In the United States, more than 50 rural countries have lost all local hospital-based obstetric services since at least 2004, and mothers are reported to be more likely to give birth in an emergency room, or to give birth prematurely because of these closures (Kozhimannil et al., 2020[32]; Hung et al., 2017[33]).

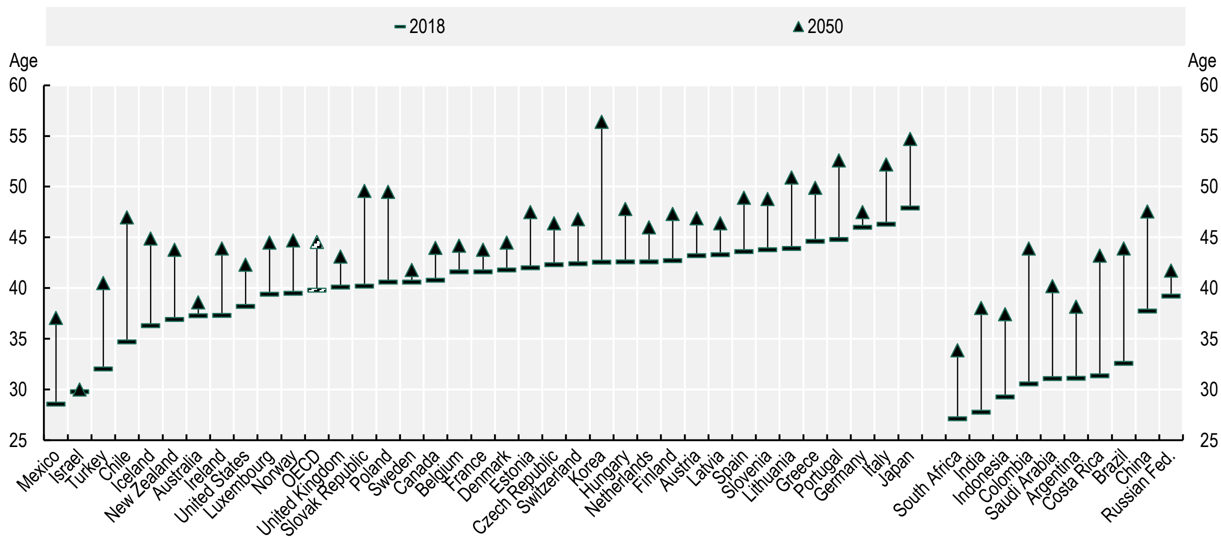
The consequences of population decline are self-reinforcing when population loss leads to a deterioration of the quality of life which in turn results in more population decline (Elshof, van Wissen and Mulder, 2014[34]). Poor access to public services, low accessibility, lack of economic competitiveness and innovation are both causes and consequences of depopulation. While insufficient access to public services may cause a deterioration in the quality and diversity of services available, a weak local market results in underutilisation, poor maintenance and ultimately withdrawal or clustering of services (ESPON, 2018[35]). Fewer local education or job opportunities and choices, inaccessibility to public and transport services, lack of adequate infrastructure – such as broadband services – and inadequate health coverage accelerates migration out of depopulating areas (EPRS, 2019[26]).

Ageing

Across OECD countries, people have been generally living longer and in better health today than in past decades. Before the COVID-19 pandemic, life expectancy exceeded 80.5 years across the OECD and was highest in Japan, at 83.9 years (OECD, 2019[36]). In Europe, life expectancy at birth increased by about 10 years over the last five decades, although in many countries this trend stagnated and even reversed in 2020 due to the COVID-19 pandemic.[3] Gains in life expectancy over time reflect increased health spending, healthier lifestyles and improving socio-economic conditions. In 2018, the median age of the population across the OECD stood at 39.8 years of age and it is anticipated that this will increase to 44.5 years of age by the year 2050 (Figure 1.6) (OECD, 2019[37]). Japan has by far the oldest population among OECD countries, with a median age of 47.9 in 2018 (estimated to increase to 54.7 by 2050); and is followed by Italy Germany, and Portugal. Mexico, Israel, Turkey, and Chile have the youngest populations among the OECD.

Figure 1.6. Median age of the total population (in years), OECD countries

2018 and 2050



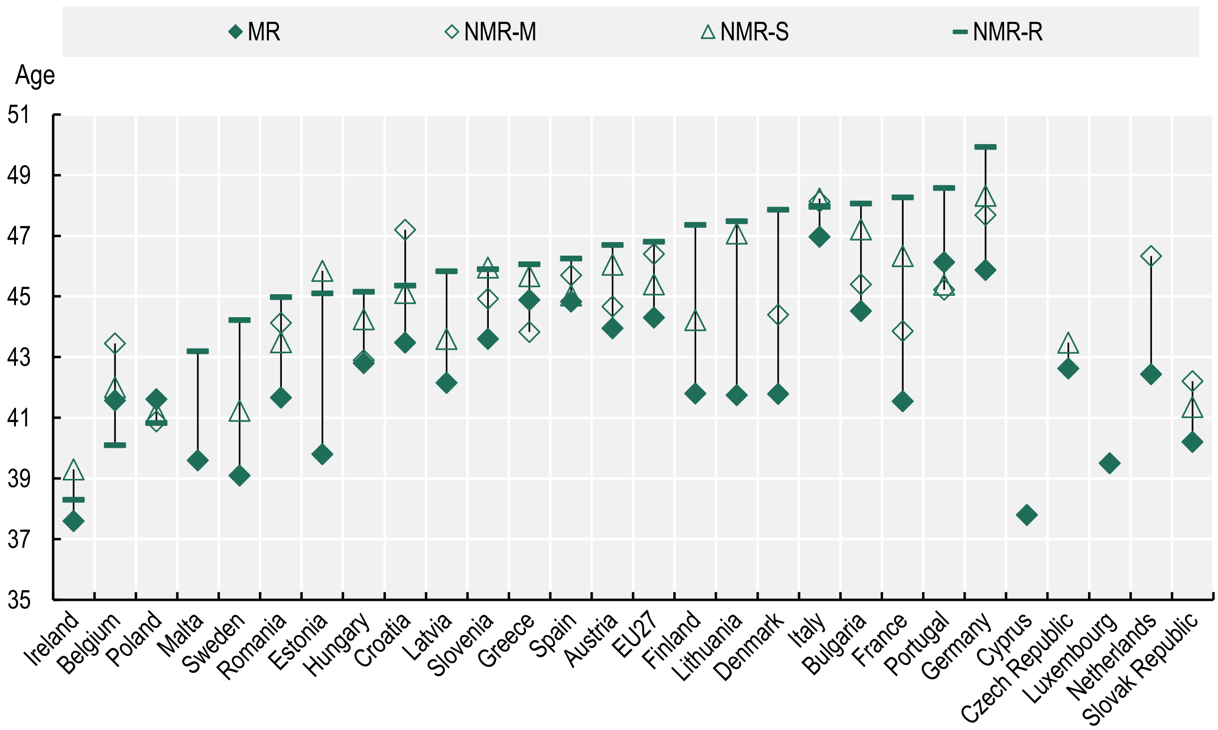
Source: OECD (2019[37]), "Rapid population ageing is widespread: Median age of the total population (in years), 2018 and 2050", in Working Better with Age, Ageing and Employment Policies, OECD Publishing, Paris, https://doi.org/10.1787/f67b8330-en.

In Europe, the median age of the population has been increasing for years and is projected to increase even more, from 44 years today to 49 years in 2070. The number and share of people in the older age groups is increasing as the median age increases: by 2070, 30% of people in Europe are estimated to be aged 65 and above, up from about 20% today. In the same period, the share of people aged 80 or over is projected to more than double to 13%. Similarly, Eurostat has estimated there will be more than half a million centenarians by 2050 (Eurostat, 2019[38]).

The geography of population aging is uneven. Some regions, particularly remote ones, experience more rapid population aging than others. In all 22 EU27 countries with remote regions except for Belgium and Poland, the average age of residents in remote regions is higher than that of metropolitan regions (Figure 1.7). This difference is the greatest in France, Denmark, Lithuania, and Finland, with remote regions having an average age over five years higher than metropolitan regions in 2020.

Figure 1.7. Median age by country and type of TL3 region, EU27

2020



Note: MR = Metropolitan regions, NMR-M = Non-metropolitan regions close to metropolitan, NMR-S = Non-metropolitan regions close to small metropolitan; NMR-R = Non-metropolitan remote regions.
Source: Eurostat (2021[12]), "Population change - Demographic balance and crude rates at regional level", https://ec.europa.eu/eurostat/cache/metadata/en/demo_r_gind3_esms.htm.

StatLink https://doi.org/10.1787/888934245918

The elderly dependency ratio—i.e. the ratio of the working-age population to that of seniors (ages 65 plus), is also higher in non-metropolitan regions in almost all OECD countries. The gap with metropolitan regions reaches 9 percentage points in seven OECD countries. Amongst non-metropolitan regions, the ones near a large city have the highest elderly dependency ratios (33%), followed by remote regions (31%) and regions close to a small/medium city (31%). Remote regions experienced, on average, the largest increases in elderly dependency between 2003 and 2019 (a 0.9 percentage point increase). Currently, the OECD-average elderly dependency ratios stand at 28.6%, and it is expected to increase to 35% by 2025 and to 53% by 2050. Greece, Italy, Japan, Korea, Portugal, and Spain are all expected to have elderly dependency ratios of over 70% by 2050 (OECD, 2020[19]).

Population ageing affects the delivery and financing of public services in a number of ways. Age is not synonymous with disability or ill health, however, the prevalence of both does increase with age and as such, can put pressures on the health care system. As such, policies to promote healthy aging are important to help individuals maintain their health while at the same time lowering healthcare costs by reducing the overall burden of disability and chronic disease. Beyond this, population aging is also associated with increased demand for long-term care; although, the prevalence of long-term care systems across the OECD differs (in some countries, family-provided care is more common).

Climate change

Increasingly frequent and extreme weather events due to anthropogenic climate change are bound to challenge the provision of public services. More extreme weather events such as flooding, heat waves and forest fires put a great deal of pressure on emergency responders and the health system. Extreme weather events can wipe out critical infrastructure, leaving communities isolated and at risk. Rural areas – and especially remote ones - can be particularly vulnerable due to their relative geographical isolation.

The two trends of population aging and climate change interconnect. For example, the elderly are at greater risk during heat waves. There are also spatial considerations. Rural areas tend to have a concentration of elder respondents who may be particularly vulnerable during extreme weather events, such as coastal areas that are prone to flooding (Rapaport et al., 2015[39]). Taken together, these phenomena place a lot of pressure on public services to adapt and respond in new ways.

Planning services for today and tomorrow

The provision of services cannot be disentangled from geography as still much of provision happens in physical facilities. This consideration is important for policies because both present and future costs and access to services depend on the distribution of human settlements, the demographic profile of countries, and the future evolution of population. This section starts with a discussion on the measurement of accessibility. It then turns to discussing the role of space and distance in the cost of providing services, and continues with planning considerations regarding the right scale of provision and the integration of different types of policies for service provision.

Measuring accessibility to services

The accelerating impacts of demographic changes have brought the provision of fair and balanced accessibility to public and private services to the forefront of regional inequality debates. Accessibility measures the ease of reaching opportunities using transportation means. It indicates both the availability of an activity (e.g. work, education, and health care) and the ease with which the location where such activity occurs can be reached from a given origin, usually a residential place (Kelobonye et al., 2020[40]). Measuring the ease of access is not only useful for evaluating the performance of transport and land use interactions (Cui and Levinson, 2019[41]), but also to understand inequalities in provision, and to estimate the need for new services (Marozzi and Bolzan, 2016[42]). Existing accessibility studies for Europe have focused on regional (potential) accessibility to understand regional growth, territorial cohesion, transport infrastructure improvements, and network efficiency (López-Torres and Prior, 2020[43]; Jacobs-Crisioni et al., 2016[44]; Spiekermann, 2015[45]; Vickerman, Spiekermann and Wegener, 1999[46]; Kompil, Demirel and Christidis, 2016[47]).

Box 1.4. Measuring accessibility

Accessibility is measured in a number of ways. In general, accessibility is measured as a combination of two different functions – activities that can be reached and cost of reaching them. An extensive review of accessibility measurements classifies them broadly into seven as: spatial separation measures, contour measures, gravity measures, competition measures, time-space measures, utility measures and network measures (Curtis and Scheurer, 2010[48]).

Among these, spatial separation and contour measures are highly suitable for measuring service accessibility and are therefore the most used accessibility indicators. Spatial separation measures travel impediment or resistance between origin and destination. Contour measures (including the cumulative opportunity model) define catchment areas by drawing one or more travel time contours around a node and measure the number of opportunities within each contour (jobs, employees, customers, etc.). For instance, research on monitoring shortages in provision of services has developed accessibility measures based on travel time and/or catchment areas for health care services (Pilkington et al., 2017[49]; McGrail, 2012[50]) and schools (McDonald, 2007[51]), among others.

Examples of studies focused on accessibility to services related to the analysis of this report include:

- A study by (Milbert et al., 2013[52]) showing comparative results on accessibility of Services of General Interest (SeGI) across five regions in Europe, including accessibility to low (primary schools), medium (railway stations) and high centrality (airports) services using high-resolution spatial data.
- A recent ESPON project studying the contribution of SeGIs to the competitiveness, economic development and job growth of European regions developed various indicators to explore availability, adequacy and provision of services, including physicians and hospital beds[4] (Fassmann et al., 2015[53]; Breuer et al., 2013[54]; Rauhut et al., 2013[55]).
- Studies focusing on regional or rural/urban inequalities in access to services, including a study on regional disparities of SeGI provision (Costa, Palma and Costa, 2015[56]), and a study on the centrality of SeGI service provision in rural and urban contexts (Rauhut and Komornicki, 2015[57]).
- A study by (Papaioannou and Wagner, 2018[58]) that develops location-based accessibility indicators for measuring accessibility to the closest school and hospital weighted by population, including comparable results in the form of travel times and speeds for private cars and public transport in 18 globally selected cities
- The ESPON project PROFECY (ESPON, 2017[59]), which used accessibility measurements (on travel time by car) to identify European regions with poor accessibility to regional (economic and demographic) centres and various services of general interests such as health care and education, banks, cinemas and train stations.

Several related studies handle service provision and accessibility with a facility simulation and location-allocation model-based approach:

- (Kompil et al., 2019[60]) simulate generic services at local and regional levels to explore spatial patterns of service accessibility across the European Union, highlighting urban-rural differences in terms of accessibility to simulated services at different levels.
- (Tillväxtanalys, 2011[61]) simulates public services' allocation based on the population distribution and estimates relevant costs leading to adopt a municipal finance equalisation in Sweden.
- (Souza, 2018[62]) presents a simulation-based decision support model to help urban planners dimension and locate urban facilities, as well as to define their expansion phases.
- (Xu et al., 2020[63]) study the interplay between the distributions of facilities and population that maximise accessibility over the existing road networks. They simulate different types of facilities to

estimate the number of facilities needed for reaching a desired average travel distance given the population distribution in a city.

In terms of the spatial allocation, accessibility and cost estimation methodology, this report follows an approach that is more similar to the approaches presented in (Kompil et al., 2019[60]) and (Tillväxtanalys, 2011[61]).

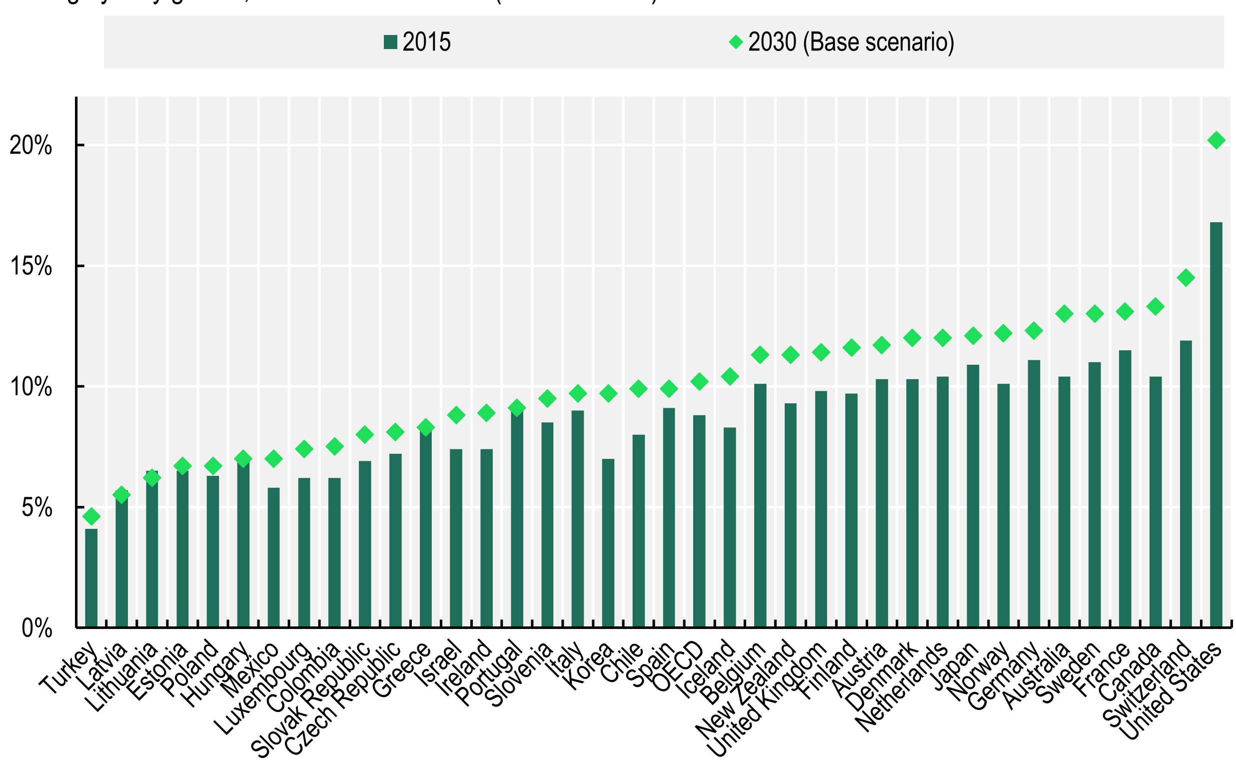
Geography and the cost of providing services

During the COVID-19 crisis, governments have raised public spending in order to strengthen the health system and support people and businesses with grants and subsidies. Already in 2017, on average general government expenditures in OECD countries amounted to 40.4% of gross domestic product (GDP), a 1.4 percentage points increase from 2007 (OECD, 2019[64]). Public social expenditures as a percentage of GDP had been already increasing by around 3.4 percentage points on average across the OECD between 1990 and 2018 (OECD, 2021[1]).

Even before the COVID-19 pandemic, an OECD study had projected health spending as a share of GDP to increase on average from 8.8% in 2015 to 10.2% by 2030 for OECD countries, with increases in 34 out of 37 OECD countries ranging from 0.1% in Greece to 3.4% in the United States (Figure 1.8) (Lorenzoni et al., 2019[65]). Across countries, demographic changes account for about one-fourth of the overall projected change for OECD countries, and contribute significantly more to projected annual spending in Canada (43%), Norway (41%), Mexico (40%), Switzerland (40%), and Korea (38%).

Figure 1.8. Country-specific growth in health spending per capita, OECD countries

Average yearly growth, 2000-15 and 2015-30 (base scenario)



Note: The baseline scenario estimates health spending in the absence of any major policy change. Empirically, this scenario uses estimates based on the preferred specification for the income elasticity, productivity constraint and time effects. Demographic effects reflect predictions of longevity gains and the evolving demographic structure of the population, accounting for changes in health status. See (Lorenzoni et al., 2019[65]) for more details and alternative scenarios.
Source: Lorenzoni et al. (2019[65]), "Health Spending Projections to 2030: New results based on a revised OECD methodology", *OECD Health Working Papers*, https://doi.org/10.1787/5667f23d-en.

StatLink https://doi.org/10.1787/888934245937

Governments face today more than ever further pressure to enhance the management of public investments in a context of tight public budgets, which will make the efficiency of the public investment a cornerstone of the recovery from the crisis (OECD, 2020[19]). Under increasing expenditures on social and health care provision, how can governments maintain and improve access to key public services across their territories, particularly those that are more remote and sparsely populated? What levels of public services should be expected in rural areas? Should these levels be different from those provided in urban contexts? In some places, should services be withdrawn or regionalised (i.e. moved to larger centres)? This report addresses these and other questions by focusing on the effect of geography and population change on the cost of providing services.

Is the provision of services more expensive in lower density and remote areas? Research on the magnitude of differences in service delivery costs due to sparsity, rurality and remoteness is scarce. An existing study for the United Kingdom (DCLG/DEFRA, 2014[66]) found sparsity (used as a proxy to rurality) to be positively and significantly related to unit costs in 11 cases, including waste collection and winter services, among the 51 local authority service expenditure groups examined. In other 15 services including public transport and libraries,[5] sparsity was significantly and negatively associated with unit costs. In the remaining 25 cases, the study did not find a statistically significant effect of sparsity on unit costs. The main themes which rural authorities associated with additional costs were: communicating/engaging with large numbers of communities and neighbourhoods; lack of “clusters” for commissioning purposes; lack of broadband availability/connectivity; increased travel time and costs due to geographical area and transport networks; supply and market factors; and greater numbers of contact/access/delivery points being required.

Analysis of public expenditures on social services in Finland and Sweden indicate that the nature of topography and settlement patterns also play a role. Service delivery costs in Finland are higher than that of Sweden due to the more dispersed settlement network in its northern territories and mountainous terrain. While Sweden also has large northern territories, rural settlements tend to be denser in configuration, thus reducing some of the costs associated with service provision and facilitating service colocation (OECD, 2017[4]). However, even in sparsely populated territories, school closures are not necessarily accompanied by cost savings: evidence for Finland shows the number of schools declined by roughly 7% in 2011-18 occurred while average costs per pupil grew by the same percentage (Lehtonen, 2021[27]).

The right scale of provision and the need for an intermediary scale

What is the right scale to deliver public services? While this question is central to debates regarding centralisation versus decentralisation, there is a great deal of nuance in terms of how scale is interpreted. Considerations include: how a geography is functionally connected; the characteristics of the service being provided and the population being served and; the regulatory environment that may influence service location and provision.

Accessibility is a key consideration for determining the right scale for services. Geographic information systems have been used since the 1970s to map and understand these dynamics (Higgs, 2004[67]). A growth of spatial data (e.g. detailed travel time data) alongside digital records has been used to develop models of access. For example, GIS has been used to examine the accessibility of health care services both in terms of their geographic location and the characteristics of usage of the population being served. By this measure, one can gauge the distances that individuals are prepared or required to travel in order to access different types of services and whether distance impacts health care consumption and health care outcomes by different kinds of groups or socioeconomic characteristics. Geography is one consideration of access. Others include availability, accommodation, affordability and acceptability of the fit between service and population being served.

Regulatory requirements also determine scale. For example, in England, school bus services are paid for by a local government authority (via a national government agency) in order to fulfil their duty under national legislation to facilitate access to school for children who live more than 3 miles from their school (Gristy, 2019[68]).

In recent decades there has been a growth of intermediary institutions across the OECD – that is, forms of service provision that exist below the regional scale but above the local one. Special purpose bodies for transportation and transit services are one such example. Here the logic for the right scale of the service is determined by how the area is functionally connected e.g. the areas across which people live, work and commute. There are economies of scale to be gained where one service provider can deliver across the functionally-connected territory. These types of institutions are most common in metropolitan areas, connecting the city to the suburbs, but less so in rural ones. They can take a variety of forms: public bodies, public entities, regional co-ordinating bodies, transport associations, public benefit corporations, intercommunal authorities or regional transportation partnerships.

The intermediary scale makes sense for transportation and transit planning because the service being delivered is a network. But what of point services such as education and health care? The types of services and the characteristics of the population are an important consideration. For example, it may not be appropriate for young children to have to travel long distances in order to access education, but be possible for older students. As such, education provision in many countries is scaled such that younger cohorts attend smaller neighbourhood schools but high school is provided at a larger scale.

One unique and emerging scale for public services is cross-border services. It can be extremely challenging to provide certain services across borders even where they are functionally closely connected or where economies of scale would make that the logical and most cost-effective choice. With free movement between borders, EU countries have spearheaded such co-ordination. The EU's Directive No. 2011/24—which stipulates that EU citizens have the right to access healthcare in any EU country and to be reimbursed for care abroad by their home country—has raised this issue on the policy agenda. This directive, combined with a number of EU financial instruments to promote border-region projects alongside facilitating legal frameworks to enhance collaboration promoted the cross-border services agenda. However, despite these incentives, a study on the desirability and feasibility of cross-border hospital collaboration in Europe notes that such collaboration encounters a number of impediments such as the challenge of navigating distinct regulatory regimes (Glinos and Baeten, 2014[69]).

Integrated spatial planning

The relationship between provision and geography implies a need to consider the location of services that are important to the daily life of residents together with settlement patterns, demographic change, and transportation and infrastructure planning. Doing so can help governments and communities plan for the future by, for example, mapping and anticipating social and economic trends and adapting needs accordingly. It can also help to identify vulnerable populations and environmental risks (e.g. flooding and climate change) (Manuel et al., 2015[70]).

In the planning literature, integrated spatial planning has arisen as a best practice to manage these and other concerns. It stems from the recognition that effective spatial management is connected to a broader range of considerations such as economic and social development and wellbeing and that sectoral policies have spatial dimensions that need to be co-ordinated e.g. the location of services and transportation infrastructure. This approach is operationalised by strategic documents across functional areas that set out scenarios and medium to long-term goals. In doing so, it can serve as a useful strategy to encourage joint investments between communities and to co-ordinate transportation and infrastructure planning. In rural and remote places, the feasibility to conduct integrated spatial plans often falls to the functional scale to co-ordinate across multiple local actors.

Geographic information systems can help identify spatial disparities in terms of access to public services and propose optimal service relocation options as part of integrated strategies. For instance, a recent project focusing on Denmark, Finland, Iceland, Norway, and Sweden determines the optimal locations of different public and private services in relation to the spatial distribution of the population (Nordregio, 2019[71]).

This report

This report summarises the results of a project that aimed at estimating the costs of schooling and health care services at different geographical scales including the degree of urbanisation (Dijkstra and Poelman, 2014[72]) and TL3 levels. To this aim, work was carried out to simulate the location of services in each country by choosing and estimating an appropriate optimisation framework for potential access at a fine geographical level. This step was followed by calculations of the cost of provision at the grid-cell level, and processing and analysing comparative cost of service provision by degree of urbanisation, regional and country levels. The project also considered estimates of future costs of service provision-based population projections and road network plans. This involved projecting the future cost of service delivery under different scenarios of population change based on current demographic and urbanisation projections up to 2035. The analysis identifies types of settlements, regions and countries facing high service costs and distances and high risk of future under-provision.

Besides this introduction, the report contains 4 chapters. Chapters 2 and 3 are dedicated to school services and Chapter 4 and 5 to health services, with Chapters 2 and 4 outlining in detail the methodology for the estimation of cost and access and Chapters 3 and 5 presenting the results of the application of the method to EU27+UK countries.

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Notes

[1] Comparative typologies or classifications of services are challenged by the different nomenclature and public service organisation across countries (Wollmann and Marcou, 2010[73]).

[2] A definition of public services by Wolmann et al. speaks to this spectrum: “a service can be considered public service if a public authority controls the supply of that service to citizens (or legal subjects) in terms of its substance, accessibility and sometimes quality” (Wollmann, Koprić and Marcou, 2016[74]).

[3] Based on preliminary life expectancy data for Europe available at https://ec.europa.eu/eurostat/databrowser/bookmark/eb24a8d3-8cc6-483a-b320-b7b0f55064f9?lang=en.

[4] Other services considered included gas, electricity, telecommunication infrastructure and labour market services.

[5] Other services in this category include open spaces; traffic management and road safety; community fire safety; street cleansing; housing strategy; advice; advances; and culture and heritage.

2 A method to estimate school costs and access

This chapter presents an innovative and flexible tool to estimate primary and secondary school costs and access. The tool simulates school placements based on the geographical distribution of students, allocates students to schools, and estimates school costs based on school sizes. Besides describing the tool, the chapter provides evidence on the geographical differences in school costs in England that serve as a guide for the design of the tool. Finally, the chapter compares the modelled and actual school costs in England and shows an application for the case of France.

Main takeaways

- This chapter describes the method and results from a tool to estimate cost and access to primary and secondary schools, inspired by the Swedish system for municipal finance equalisation.
- The analysis considers primary and secondary schools separately, setting age ranges at 6 to 11-year-olds for primary school students, and 12 to 17-year-olds for secondary school students.
- In this chapter the term "costs" refers to current annual school costs and does not include capital expenditure, which refers to spending on assets that last longer than one year. The analysis focuses on public schools and does not include final private spending.
- For England, although the method is inspired on evidence, it does not rely on England-specific parameters but rather on EU averages.
- In English primary schools, the average number of students per school increases with population density: the number of schools in towns and suburbs is 1.63 times the number of schools in sparse rural areas, even though there are 3.9 times more students in towns and suburbs than in sparse rural areas.
- The number of students per teacher in primary English schools is smaller in rural areas compared to towns and suburbs, and cities: sparse rural areas have 3.3 less students per teacher in compared to schools in towns and suburbs.
- Given that rural schools show a similar cost structure to urban schools, estimating school costs does not require explicitly model cost differences arising from geographical factors.
- Cost differences between rural and urban schools arise primarily from a larger proportion of smaller schools in rural areas, as they have higher staff costs per student.
- The tool is based on three principles: costs arise in facilities, not in areas; public services are consumed locally, and are provided close to places of residence; and additional costs arise as a result of transport costs, lack of economies of scale, and/or scope of small facilities.
- The tool proceeds in three steps: 1) simulates likely school locations based on the distribution of students in space; 2) estimates how many students frequent the simulated schools; 3) estimates school costs based on school sizes.
- The cost estimation first estimates teaching costs based on the number of teachers required for the number of students in each school, and subsequently adds other types of costs including non-teaching staff cost and remaining cost including premises, learning material, catering and other costs.
- The comparison by degree of urbanisation using actual and simulated placements to actual total costs shows that the proposed approach captures well the levels and geographical variation of cost per student for primary schools.

Introduction

While ageing and depopulation will have a considerable impact on the demand for education and will possibly jeopardise accessibility to schools in remote and rural areas, the impact of demographic changes on the geography of school provision and its cost remains unknown.

This chapter fills an important data gap by proposing a method to estimate primary and secondary education costs at the school level. The information is then aggregated spatially to understand differences across types of human settlements, classified according to their degree of urbanisation. The method has two main steps:

- The first step involves simulating school locations using a thresholds-based, bottom-up algorithm that relies on road networks and fine spatial resolution population grids, and assigning student to each school based on a spatial interaction model.
- The third step estimates school costs based on the estimated number of students per school, broken down by costs on teaching staff, non-teaching staff, and other costs.

The method is fined-tuned using publicly available school-level data for England and then applied to the case of France, where there is no publicly available school-level data on costs. The benchmarking exercise focuses on the case of England because it has exceptionally detailed public data at the establishment level from various sources. The method is flexible enough to apply to any country and/or population projection grids to obtain future cost estimates.

The next section of this chapter outlines the simulation allocation method, shows statistics on the composition of schools' costs and the geographical variation of costs for primary and secondary schools in England, and describes the method for estimating costs at the school level. The third section shows the comparison of modelled versus actual results for England. The fifth section shows an application to the case of France. The last section concludes.

Estimating school costs

This chapter describes the method and results from a tool to estimate school costs, inspired by the Swedish system for municipal finance equalisation (Tillväxtanalys, 2011[1]). The method is based on three principles:

1. costs arise in facilities (e.g. schools, hospitals), not in areas (e.g. school districts or municipalities)
2. public services are consumed locally, and are provided close to places of residence
3. additional costs arise as a result of transport costs, lack of economies of scale, and/or scope of small facilities.

The method proceeds in three steps. First, it simulates likely school locations based on the distribution of the student-age population and general thresholds. Second, it estimates how many separate schools are likely present in a location and how many students frequent those simulated schools by using a spatial interaction model. And third, it estimates school costs based on school sizes.[1] The method has been calibrated using exceptionally detailed public data for schools in England, and uses data for France to validate the results.

This section first describes the method to simulate school locations and continues by defining school costs for this and the next chapter. It then describes the evidence on geographical differences in school costs using available data for England and focuses on primary and secondary schools. The analysis of cost is solely based on primary schools, as the geographical variation of costs per student for secondary schools in the actual data follows an unclear geographical pattern, (possibly because the sample of schools is not representative of the universe. The evidence for England guides the modelling choices described in the next section, and Annex 2.C describes the data.

The estimation method discussed in the last part of this section derives school costs based solely on the estimated number of students in each school, without relying on country-specific information or other school information that is often not readily available. This includes costs that depend on school size (i.e. running costs), and does not include (capital) investments or other costs such as building costs. The next section compares estimated schools and school costs for the case of England and France.

Simulating school locations

The objective of the simulation of school locations is to obtain the number and size of schools in all EU countries with available population projections.[2] The method described in this section adapts the facility allocation procedure of (Kompil et al., 2019[2]) (see Annex 2.A for a comprehensive description of the adaptations). Figure 2.1 illustrates the placement procedure and Figure 2.2 exemplifies it for the case of Portugal.

To ensure the procedure will yield realistic values for school sizes and transport costs, the first step establishes bounding conditions by setting threshold values for (see Annex 2.B for more details):

1. the distance in kilometres that defines a potential school's largest allowed catchment area
2. the minimum number of students that a potential school needs in its catchment area
3. the optimum number of students for a school.

The boundaries of independent placement zones are TL3 regions for primary schools, and country borders regions for secondary schools.[3]

The simulation models local communities as a network of nodes (distributed on a 1 km^2 lattice) that are all potential school locations. The approach calculates travel distances via road networks from every community to all other communities within the largest allowed catchment area (TomTom, 2018[3]). Every community can be flagged as having satisfied or unsatisfied demand, and all communities are initially assigned as having unsatisfied demand. After establishing all potential locations of schools, the method chooses the highest utility location in a region[4] through an iterative procedure similar to a bidding game, in which local communities compete for the location of a school.[5] The procedure stops once demand has been completely met, or when no more potential locations meet the bounding conditions.

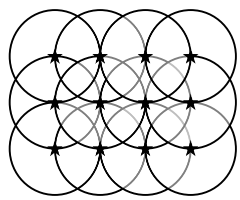
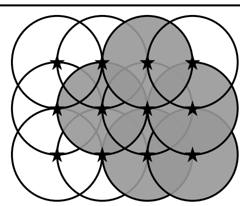
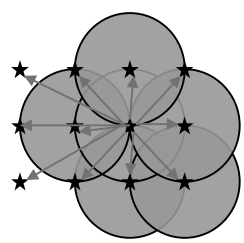
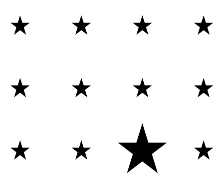
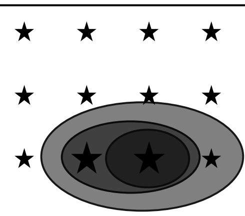
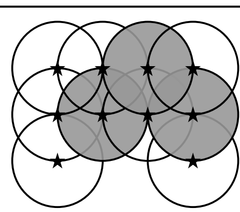
Local school demand arises from children or youth population in every community in the catchment area. Children or youth population distributions are obtained from 1 km LUISA population age grids (Goujon et al., 2021[4]; JRC, 2021[5]; Jacobs-Crisioni et al., 2020[6]; Jacobs-Crisioni et al., n.d.[7]), which in turn are based on EUROSTAT census-based, 1 km population grid (GEOSTAT, 2011[8]), and regional population projections prepared for the 2015 ageing report (EC, 2015[9]).

The analysis considers primary and broad secondary schools separately, setting age ranges at:

- 6 to 11-year-olds for primary school students
- 12 to 17-year-olds for secondary school students.

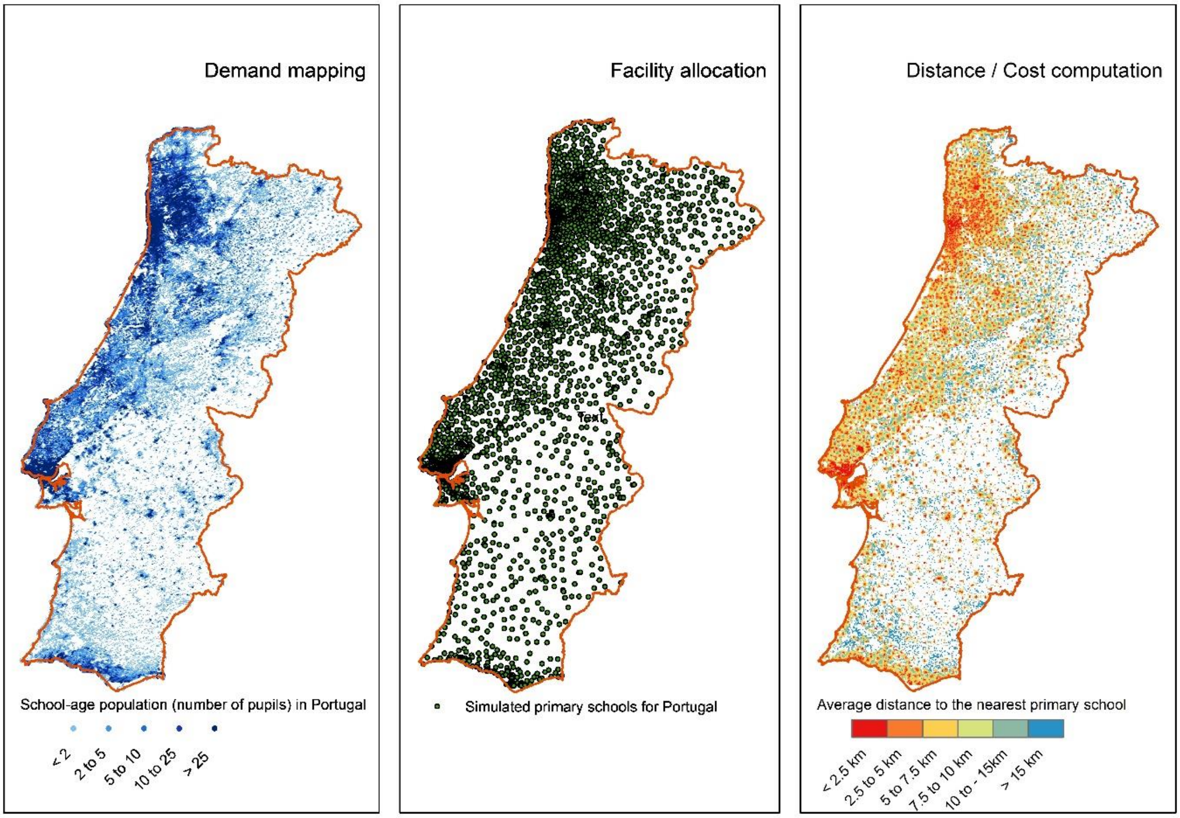
While European ages of school attendance do not necessarily align with the selected age ranges, a universal classification ensures comparability. The chosen classification aligns with International Standard Classification of Education (ISCED) levels, and the age ranges are close to those in the English educational system.[6] The approach also assumes that middle and high schools are always part of secondary schools, which does not hold true in all cases. This assumption is necessary to avoid modelling context-specific school integration choices, and based on the validation of results, does not affect the cost estimates significantly.

Figure 2.1. Schematic representation of the placement simulation procedure

	i) The method represents all communities as nodes (indicated as stars), and considers the maximum catchments of those communities (circles) in a region. The method defines catchments with a threshold maximum road distance (threshold 1).
	ii) Select nodes (grey circles) that are eligible for a school location. A node is eligible if, within its catchment area (threshold 1), there is a sufficiently large unsatisfied demand (threshold 2).
	iii) Compute the utility of a node for a school location. The method computes utility as a potential accessibility measure, summing unsatisfied demand at nodes, divided by the distance to these nodes.
	iv) The method then selects the one node that meets the eligibility criteria (ii) and has the highest utility value (iii), as indicated here by a larger star.
	v) The method then establishes for which nodes the newly selected school location satisfies demand. This is done by expanding a search radius from the new school location (ellipses, selected nodes as larger stars), in the location's catchment, until the optimum demand is met (threshold 3) or all nodes in the location's catchment are included.
	vi) The method subsequently removes the nodes where demand is met from the set of searchable nodes and from the pool of unsatisfied demand; and proceeds by selecting another school location (ii). This is repeated until all demand is met or all eligible nodes are depleted.

Note: From the top left, clockwise: i) represent all nodes (stars) and maximum catchments (circles) in a region; ii) select eligible nodes (grey circles) according to the eligibility criterion from thresholds (1) and (2); iii) compute utility according to accessibility to all unsatisfied demand in the catchment; iv) select the highest utility location; v) attribute students to the selected node from the closest nodes (big stars) based on a distance search (concentric circles), until the location has reached optimum size in threshold (3); vi) for the next placement cycle, again select eligible nodes (grey circles) based on the criterion from (1) and (2). Do not consider already attributed students in the next cycle.

Figure 2.2. Example of simulated placement of primary schools in Portugal



Note: Left, spatial distribution of relevant service users (e.g. children in primary school age); Middle, step by step, distribute schools based on bounding conditions; Right, allocate users to schools (e.g. children to schools), measure average travel times and estimate school costs per user.
Source: Children or youth population distributions are obtained from 1 km LUISA population age grids (Jacobs-Crisioni et al., 2020[6]; Jacobs-Crisioni et al., n.d.[7]), which in turn are based on I) EUROSTAT census-based, 1 km population grid (GEOSTAT, 2011[8]) and II) regional population projections prepared for the 2015 ageing report (EC, 2015[9]).

The student placements obtained during the procedure described previously are only a rough approximation of final school sizes, as the number of schools at a selected location may be larger than one, and free school choice is not taken into account. The approach uses a two-stage approach described in Annex 2.B to adjust the number of schools at a location and balance student populations over available schools.

What is understood by school costs?

Expenditure on education is composed of current and capital expenditure. In OECD countries, current expenditure represents the largest proportion of total expenditure on education. In 2017, it accounted for 92% of total expenditure, with the remainder devoted to capital expenditure. Current expenditure in education includes:

- *Spending on teachers and other staff compensation*. The compensation of teachers and non-teaching staff – other pedagogical, administrative, professional and support personnel – comprises gross salaries and contributions, expenditure on retirement, and expenditure on other non-salary compensation (healthcare or health insurance, disability insurance, unemployment compensation, maternity and childcare benefits and other forms of social insurance).

- *Spending on the goods and services needed within the current year*. Goods and services require recurrent production in order to sustain educational services, such as expenditure on support services, teaching materials and supplies, ordinary maintenance of school buildings, provision of meals and dormitories to students, rental of school buildings and other facilities, among others. These services are obtained from outside providers, unlike the services provided by education authorities or by educational institutions using their own personnel.

For the purposes of the analysis in this report, the term "costs" refers to current school expenditure (costs). The term "costs" does not include capital expenditure, which refers to spending on assets that last longer than one year, including construction, renovation or major repair of buildings, and new or replacement equipment. Unlike current expenditure, capital expenditure can have large fluctuations over time, with peaks in years when significant investments are undertaken, followed by years of lows. Differences in the allocation of current and capital expenditure indicate the degree of investment by a country in the construction of new buildings, for instance in response to rising enrolment rates, or in the restoration of existing school buildings, resulting from the obsolescence and ageing of existing structures. Nevertheless, capital expenditure accounted for only 9% and 7.7% of total expenditure of primary and secondary schools across OECD countries in 2011 (Santiago et al., 2016[10]), so current school expenditure represents the bulk of educational expenditure in schools.

Moreover, educational expenditure can be from both public and private sources. Final public spending includes direct public purchases of educational resources and payments to educational institutions, and it is this type of expenditure that the analysis in this report captures. The analysis thus does not include final private spending, which comprises all direct expenditure on educational institutions, including tuition fees and other private payments to educational institutions (whether partially covered by public subsidies or not), and expenditure by private companies on the work-based element of school and work-based training of apprentices and students (OECD, 2020[11]).

Geographical differences in schooling costs: Evidence for England

The data for England illustrates the differences in the average size of schools across degrees of urbanisation. The data shows that the average number of students per school increases with population density, with primary schools with the smallest average ratio located in sparsely populated areas. This means there are more schools in lower-density areas for a comparable number of students. For instance, the number of schools in towns and suburbs is 1.6 times the number of schools in sparse rural areas, even though there are 3.9 times more students in towns and suburbs than in sparse rural areas.

The number of students per teacher is also smaller in rural areas (villages and sparse rural areas) compared to towns and suburbs, and cities. Among rural areas, schools in sparse rural areas have 3.3 less students per teacher compared to schools in towns and suburbs (Table 2.1). However, students per teaching staff (which includes both teachers and teaching assistants, all measured in full-time equivalent) differ less across settlement types. This is because the ratio of teaching assistants to teachers is higher in towns and suburbs, and cities compared to rural areas. The variation in the number of students per teacher among schools in rural areas is larger than in towns and suburbs or cities.

Table 2.1. Summary statistics, primary schools (actual placement)

Degree of urbanisation	Number of schools	Number of students	Students per school	Students per teacher	Students per teaching staff	Standard dev. students per teaching staff
Sparse rural	1 584	171 391	108.2	18.5	11.1	2.7
Villages	1 023	169 165	165.4	20.5	12.0	2.5
Towns and suburbs	2 586	675 712	261.3	21.7	12.3	2.1
Cities	4 789	1 711 388	357.4	21.5	12.0	2.2

Source: Authors' elaboration based on (UK Department of Education, 2021[12]).

In the actual data for England, teaching staff costs make up 57.6% of total school costs. There are no noticeable differences in average cost shares by degree of urbanisation (Table 2.2). This suggests that the average school located in a rural area has a similar cost structure to one located in a town & suburb or even a city. The implication for the cost estimation exercise is that it suffices to estimate school costs from first principles, i.e. the number of teaching staff required for the school size, instead of explicitly modelling cost differences arising from geographical factors.

Table 2.2. Cost structure, primary schools (actual placement)

Degree of urbanisation	Annual cost per student (GBP)	Annual cost per teacher (GBP)	Cost share teaching staff (%)	Cost share non-teaching staff (%)	Cost share premises (%)	Cost share teaching resources (%)	Cost share catering (%)
Sparse rural	4 659	4 659	57.1	17.7	8.9	7.0	5.8
Villages	4 166	4 166	57.9	16.6	8.7	6.7	6.1
Towns and suburbs	3 935	3 935	57.9	16.7	8.9	6.3	6.3
Cities	4 246	4 246	57.5	17.8	9.1	5.9	5.9

Note: Five cost categories aggregated from more disaggregated categories in the original data for presentation purposes.
Source: Authors' elaboration based on (UK Department of Education, 2021[12]).

The lack of difference in the cost structure of schools does not mean however that there are no differences in average cost per student across geographical areas. While the share of costs in teaching staff does not vary significantly across settlements (in line with nationally-set wages), teaching staff annual cost per student are higher in lower-density areas -e.g. it is about GBP 700 higher per student in sparse rural areas compared to towns. These differences are reflected in differences in annual cost per student in rural areas compared to the national average, which are as high as GBP 921 per student in mostly uninhabited areas.

Both annual cost per student and annual cost of teaching staff per student are higher in rural versus urban areas, while towns and suburbs hold the lowest costs (Table 2.2). Differences in cost per student across degrees of urbanisation are to a large extent driven by differences in staff cost per student, as they comprise the bulk of school costs. This confirms that cost differences based on school locations are not primarily driven by geographical wage differences or different cost structures between rural and urban schools.

A method to estimate school costs

The method to obtain school costs from any school using only the number of students focuses first on deriving staff costs because they represent the bulk of costs in schools. Teaching staff annual cost alone constitute more than half of total school costs in England (Table 2.2), and in fact compensation of all staff represented 74% and 80% of current expenditure in primary and secondary schools in OECD countries in 2011 (Santiago et al., 2016[10]).

Teaching staff annual cost is the product of the number of teaching staff, multiplied by their corresponding salaries. To estimate the number of teaching staff in each school, values are drawn from an ordered normal probability distribution of student-to-teacher ratios, following the distribution displayed by the actual data for England (see Annex 2.C). Assigning teaching staff in this way ensures having schools with teaching staff counts proportional to their size, while allowing for some variation in the number of staff across schools in the same size range. Table 2.3 summarises the assumed parameters for the primary and secondary school cost estimation.

Table 2.3. Assumed parameters for school cost estimation

	Primary	Secondary
Mean student-to-teacher ratio (standard deviation)	13 (1)	12 (1)
Mean annual cost on teaching staff per head (standard deviation)	EUR 43 000 (1 000)	EUR 55 000 (1 000)
Fixed full-time staff paid at average cost levels	1	2
Percentage teaching assistants in total teaching staff (paid at half the average cost on teaching staff)	40%	20%
Proportion of non-teaching staff to teaching staff	1/4	1/4
Annual cost on non-teaching staff per head	EUR 34 000	EUR 23 000
Remaining annual cost (standard deviation)	EUR 9 000 (1 000)	EUR 20 000 (1 000)

Note: Parameters based on EU-average values and actual school cost data for England.
Source: Author's elaboration based on (Eurostat, 2021[13]; UK Department of Education, 2021[12]).

The mean student-to-teacher ratios for primary and secondary schools are based on average ratios across the EU in 2017.[7] A lower student-to-teacher ratio in secondary schools is in line with OECD average values. Furthermore, the distribution of student-to-teacher ratio in the actual data follows a normal distribution with mean 11.9 and standard deviation 2.3. In mathematical terms, given schools in j, student-to-teacher ratio PT is distributed randomly in a Gaussian distribution. Subsequently teaching staff in schools T_j is computed as $T_j = s_j * PT_j$, where s is students, and schools in j are ordered by size (measured by number of students).

To obtain teaching annual cost, each school is assumed to have one base full-time staff paid at mean school salary levels. This puts a bottom limit on the teaching staff in each school. On top of this fixed cost, there is a percentage of the teaching staff paid at half the mean school salaries and the remaining share paid at mean school salaries. This is equivalent to assuming that a share of the teaching workforce in each school has low qualifications and/or experience. In the primary school data for England, teachers make up 56% of the school teaching staff, and teaching assistants make up the remaining 44%, while secondary schools have a lower share of teaching assistants (21%). As a reference, the mean annual gross salary for teachers in England in primary schools is USD PPP (2019) 46 644 and in secondary schools it is USD PPP 63 307. Also, average teachers' statutory annual salaries after 15 years of experience for primary and higher secondary school levels across OECD countries stands around USD PPP 46 801 and 50 701 respectively. Furthermore, the distribution of annual cost per teacher also follows a normal distribution (with mean GBP 29 600). The primary school data shows that the mean annual gross salary for teachers is GBP 38 716.

In technical terms, this means that total teaching cost is estimated based on mean school teacher salaries $\overline{TS_j}$, which are also normally distributed, as $E_j = \sigma * Ft + 0.5\left(\%TA * T_j * \overline{TS_j}\right) + (1 - \%TA) * \left(T_j * \overline{TS_j}\right)$, where Ft is the number of fixed full-time teaching staff, and %TA is the share of teaching assistants in the teaching staff. Ft = 1 and %TA=0.6 if the school is primary, and Ft = 2 and %TA = 0.2 if the school is secondary.

To estimate non-teaching staff cost, the method assumes that every four teaching staff requires one non-teaching staff. These proportions follow those observed in the actual data for England. Median salaries per non-teaching staff are set at a lower value than those of teaching staff under the assumption that non-teaching staff require lower qualifications than teaching staff. Total cost of non-teaching staff in each school is equal to one fixed non-teaching staff (plus the count of non-teaching staff times the mean salary).

Finally, the sum of the remaining cost, which includes premises, learning material, catering and other costs, is assigned by drawing ordered random values for RES_j, a normal distribution of remaining cost per student (5) to compute total remaining school cost RE_j (6) and compute total school cost as $RE_j = s_j * RES_j$. Total cost is then equal to the sum of teaching and remaining cost $E_j = TE_j + RE_j$.

Comparing observed and modelled school costs in England

A comparison across degree of urbanisation levels helps to verify whether the adopted method reproduces observed spatial pattern and cost differences across degree of urbanisation types. This section discusses results for primary schools at length and presents a more limited set of results for secondary schools given the limitations of the actual data. While in this analysis, all results are based on the degree of urbanisation of the grid cell in which a school is placed, Chapter 4 discusses results based on results at place of residency of students.[8]

Primary schools

The approach mimics well the geographic distribution of the number of teachers and the average number of teachers per school by degree of urbanisation. Estimating the number of teaching staff based on actual student numbers data leads to 202 077 estimated teaching staff, 28 404 teaching staff lower than the actual count but with a similar geographical distribution (compare columns 3 and 4 of Table 2.4). This lower count of estimated teaching staff results largely from assuming a student-to-teacher ratio (13) higher than the actual one (11.9).

While the simulated placement estimates more schools than the actual data, it correctly captures the increasing number of schools when moving from villages to urban degree of urbanisation types (compare columns 1 and 2 in Table 2.4). The differences in average teaching staff between the actual and simulated data (columns 6 and 7 in Table 2.4) are due to both different numbers of simulated versus actual schools and different teaching staff numbers arising from different student numbers per school. This is because the simulated placement generates more schools in cities and towns and suburbs than those observed in the actual data.

Table 2.4. Comparison actual and estimated school and teaching staff counts, primary schools

Degree of urbanisation	Number of schools (actual placement)	Number of schools (simulated placement)	Number of teaching staff (actual placement)	Number of teaching staff – Estimated (actual placement)	Number of teaching staff – Estimated (simulated placement)	Average teaching staff per school (actual placement)	Average teaching staff per school (simulated placement)
Sparse rural	1 584	1 747	15 234	14 156	17 500	9.6	10.0
Villages	1 023	1 249	13 967	13 439	18 703	13.7	15.0
Towns and suburbs	2 586	3 070	55 676	50 904	73 341	21.5	23.9
Cities	4 789	5 642	145 604	123 579	168 793	30.4	29.9
England	9 982	11 708	230 481	202 077	278 336	23.1	23.8

Source: Authors' elaboration based on (UK Department of Education, 2021[12]; Goujon et al., 2021[4]; Jacobs-Crisioni et al., n.d.[7]).

The percentage of small schools across degree of urbanisation types in the sample can be compared to the percentage in the simulated placement using the definition of small schools (an average year group size of less than 21.4 students for primary schools and 100 for secondary schools) used in the block national funding formula of schools eligible for sparsity funding.[9] As Table 2.5 shows, although the allocation simulation produces a slightly smaller number of small schools, it also places most of the small schools in rural areas (with a positive bias towards sparse rural areas compared to the actual data). The lower counts of small schools in cities are present in both the actual and simulated data.

Table 2.5. Actual versus simulated placement, primary small schools

Degree of urbanisation	Number of small schools, actual placement	Share of small schools (%)	Number of small schools, simulated placement	Share of small schools (%)
Sparse rural	1 180	62.7	1 082	82.4
Villages	387	20.6	198	15.1
Towns and suburbs	246	13.1	22	1.7
Cities	70	3.7	11	0.8
England	1 883	100	1 313	100

Note: A small school has an average year group size lower than 21.4 students.
Source: Authors' elaboration based on (UK Department of Education, 2021[12]; Goujon et al., 2021[4]; Jacobs-Crisioni et al., n.d.[7]).

Table 2.6 compares actual and estimated costs based on simulated school placements by cost type. Despite differences in average teachers per school between the actual and simulated placement, applying the cost estimation approach to the simulated placement still reproduces the size and geographical variation of actual teaching staff costs (see columns 2 and 3 of Table 2.6). Both teaching and non-teaching annual cost, which represent the bulk of school costs, decrease more rapidly with distance in the simulated data compared to the actual data. This largely explains that the estimated costs per student differences between cities and other areas are larger in the simulated data compared to the actual data.

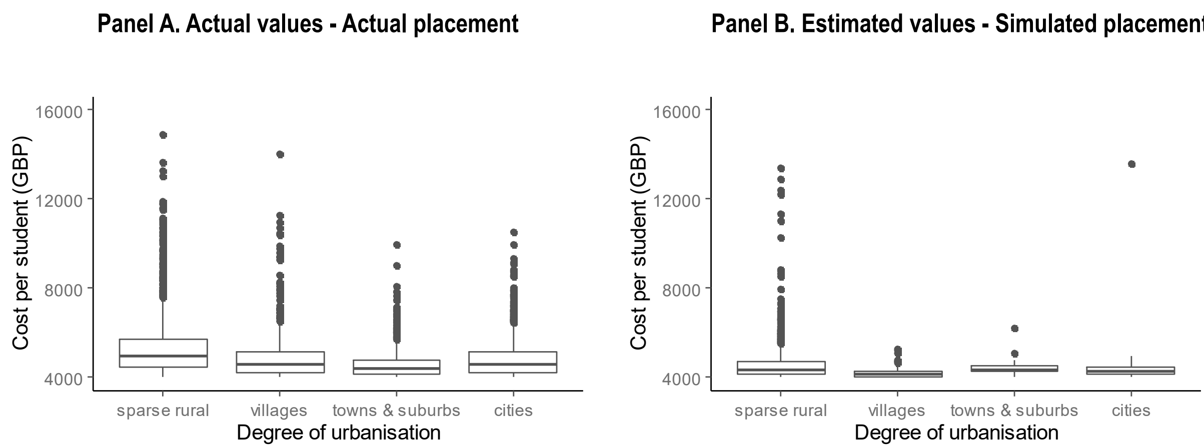
Table 2.6. Comparison of estimated versus actual annual cost, primary schools

Degree of urbanisation	Teaching staff cost per student (actual placement) (GBP)	Teaching staff cost per student (simulated placement) (GBP)	Non-teaching staff cost per student (actual placement) (GBP)	Non-teaching staff cost per student (simulated placement) (GBP)	Cost per student (actual placement) (GBP)	Cost per student (simulated placement) (GBP)
Sparse rural	2 635	2 508	816	891	4613	3974
Villages	2 405	2 348	690	782	4150	3718
Towns and suburbs	2 276	2 176	656	677	3930	3467
Cities	2 436	2 059	755	615	4 233	3 312

Source: Authors' elaboration based on (UK Department of Education, 2021[12]; Goujon et al., 2021[4]; Jacobs-Crisioni et al., n.d.[7]).

After estimating each of the three cost types, the comparison by degree of urbanisation using actual and simulated placements to actual total costs shows that the proposed approach captures well the levels and geographical variation of cost per student for primary schools, including the variation within categories, with more dispersion and relatively large values in sparse rural areas (Figure 2.3).

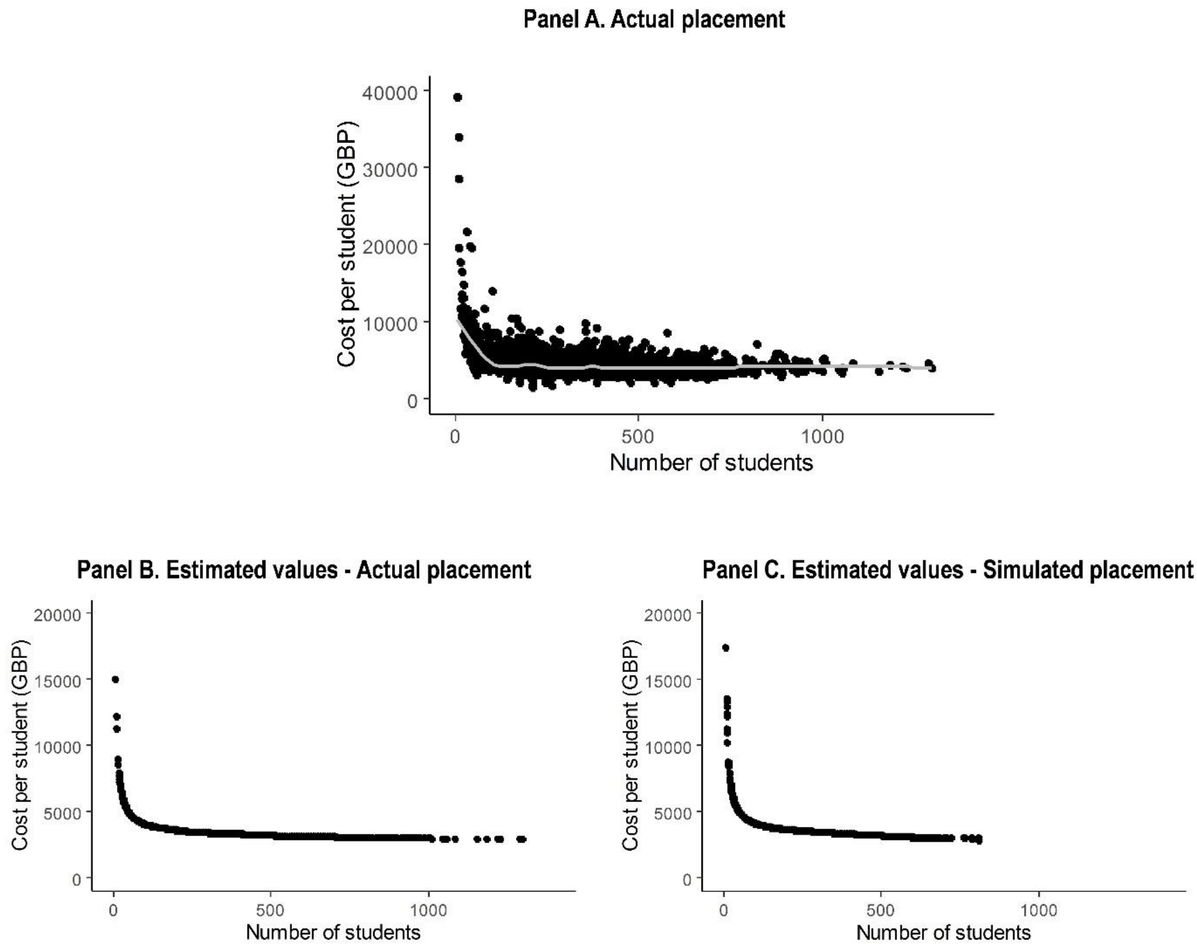
Figure 2.3. Distribution of actual versus estimated annual cost per student, primary schools



Source: Authors' elaboration based on (UK Department of Education, 2021[12]; Goujon et al., 2021[4]; Jacobs-Crisioni et al., n.d.[7]).

The relationship between cost per student versus school size (measured by total number of students) captures the extent of scale economies present in primary schools. The plot of this relationship based on actual cost data shows that cost per student decreases quickly from high levels as school size increases. Both the estimated cost based on actual placement as the one based on simulated placement capture this behaviour (Figure 2.4).

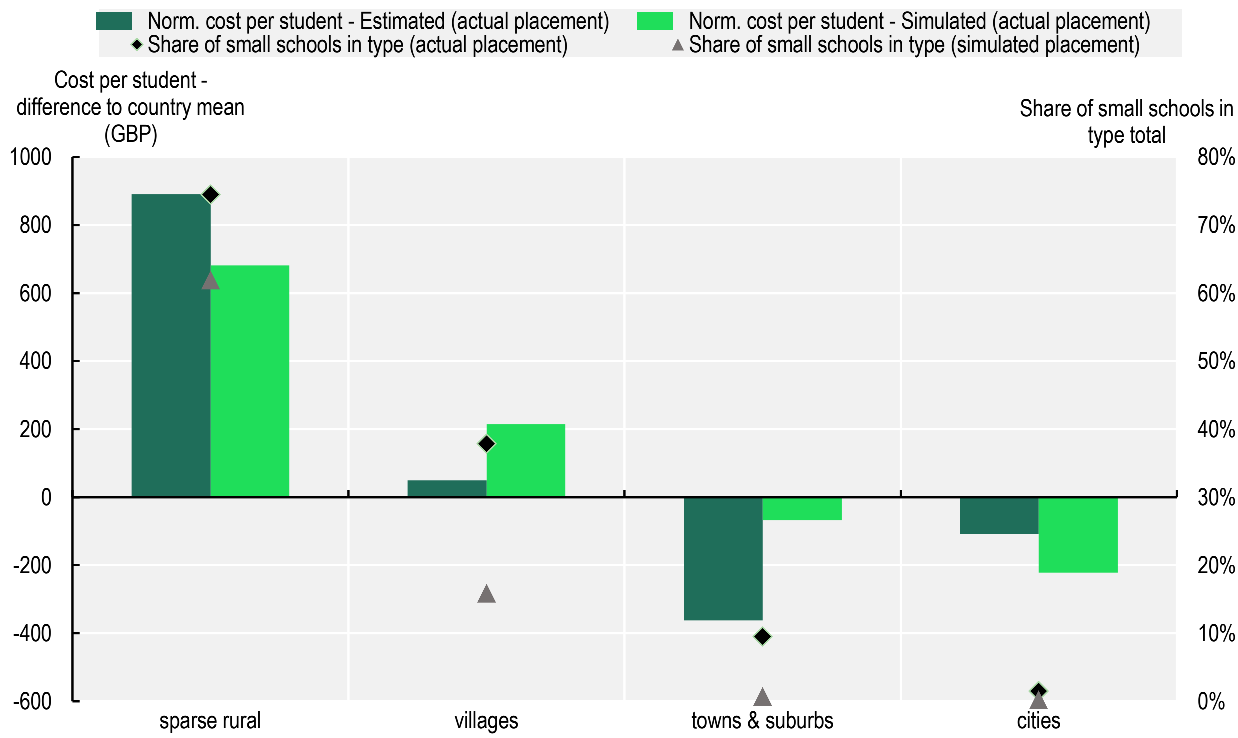
Figure 2.4. Comparison actual and estimated annual cost per student versus school size, primary schools



Source: Authors' elaboration based on (UK Department of Education, 2021[12]; Goujon et al., 2021[4]; Jacobs-Crisioni et al., n.d.[7]).

As Figure 2.5 shows, the key to getting the geographical differences in school costs lies in successfully reproducing the share of small schools in every degree of urbanisation level. This can be traced back to the introduction of a balancing mechanism in the simulation approach to lower the concentration effects of competition and scale.

Figure 2.5. Normalised annual cost per student and share of small primary schools, actual versus simulated values



Source: Authors' elaboration based on (UK Department of Education, 2021[12]; Goujon et al., 2021[4]; Jacobs-Crisioni et al., n.d.[7]).

StatLink https://doi.org/10.1787/888934245956

Secondary schools

Given that the sample of secondary schools with financial information does not have a similar size distribution compared to the universe of schools, this chapter does not present as much detail for secondary schools as for primary schools. This section discusses a limited set of results for secondary schools, summarised in Table 2.7.

The simulated placement allocates a larger share of small secondary schools in rural areas while still preserving some small schools in cities and towns and suburbs even when distance ranges are larger for secondary students (see second column of Table 2.7). This is achieved with the help of the balancing procedure in the allocation of schools (see Annex 2.A) that enables locating small schools in dense areas.

The average number of teachers per school increases with distance and unlike the case of the actual placement of primary schools, it peaks in cities instead of towns and suburbs. The estimated per head differences in costs for secondary schools between the most costly (sparse rural areas) and the least costly (cities) are higher at EUR 1 047 per head (compared to EUR 662 for primary schools). Finally, the relationship between cost per student and school size also shows evidence for scale economies related to the method's assumption on fixed staff (Figure 2.6).

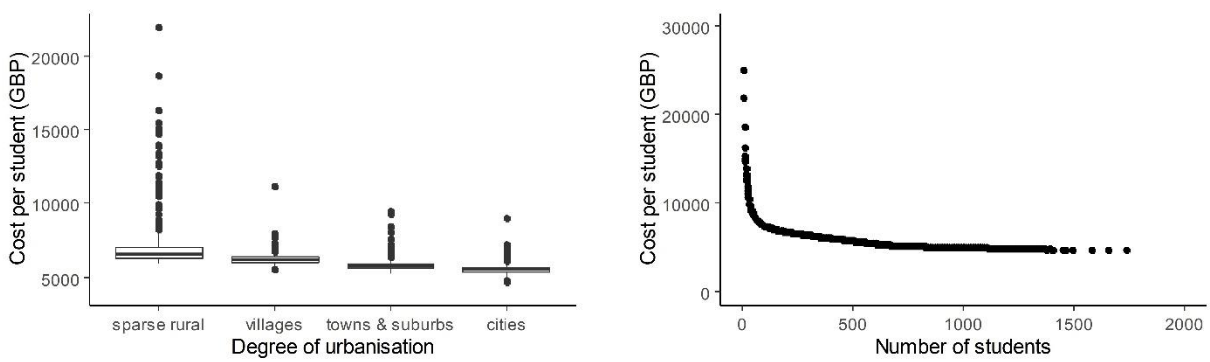
Table 2.7. Summary of simulated results, secondary schools

Degree of urbanisation	Number of schools, simulated placement	Share of small schools, simulated placement (%)	Teaching staff, simulated placement	Average teaching staff per school, simulated placement	Teaching staff costs, simulated placement (GBP)	Non-teaching staff costs, simulated placement (GBP)	Cost per student, simulated placement (GBP)
Sparse rural	226	44.1	5 262	23.3	4 435	567	6 487
Villages	792	39.7	26 943	34.0	4 170	519	6 153
Towns and suburbs	2 007	10.8	84 457	42.1	3 875	470	5 773
Cities	4 234	5.4	207 738	49.1	3 617	428	5 440

Note: A small school has an average year group size lower than 100 students.
Source: Authors' elaboration based on (UK Department of Education, 2021[12]; Goujon et al., 2021[4]; Jacobs-Crisioni et al., n.d.[7]).

Figure 2.6. Estimated annual cost per student by degree of urbanisation and number of students, secondary schools

Based on simulated placements



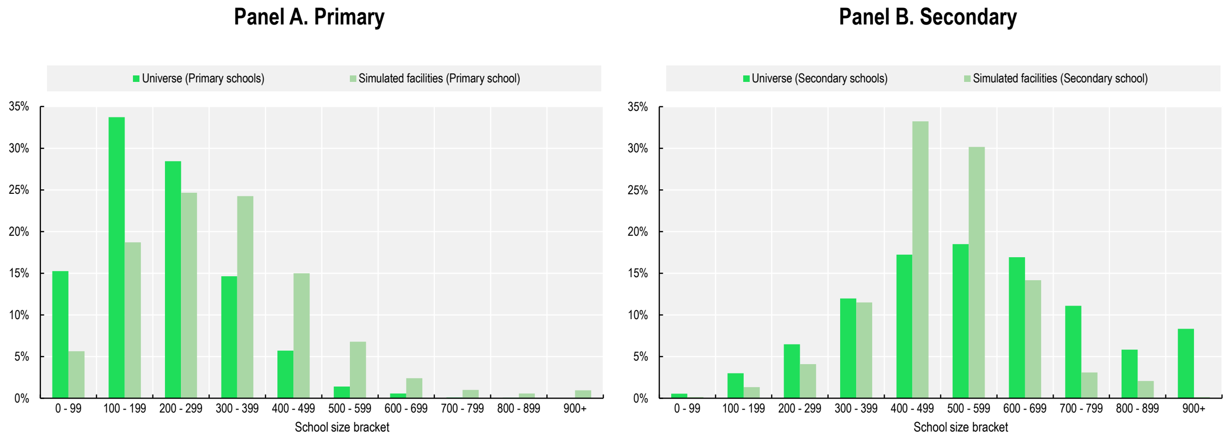
Source: Authors' elaboration based on (UK Department of Education, 2021[12]; Goujon et al., 2021[4]; Jacobs-Crisioni et al., n.d.[7]).

School placement comparison for France

To verify the validity of the school placement method outside England, the approach is applied to available school data for France. Geolocalised data for each school including number of students per school in France is available for the year 2017 for primary (*école élémentaire*, ages 6-11) and secondary schools (ages 12-18) (French Ministry of National Education and the Youth, 2021[14]).

The procedure to derive teaching staff counts per school from the number of students is applied to the actual and simulated schools. In line with the exercise for England a mean of 13 and a standard deviation of 1 are assumed for primary schools, and a mean of 12 and a standard deviation of 1 for secondary schools. The resulting total number of teaching staff in primary schools using actual schools is 369 508 and in secondary schools it is 318 993. As a benchmark, the number of teaching staff in public schools in France in 2015 was 340 500 in pre-school and primary schools (premier degree), and 304 500 in secondary schools (second degree).[10] The approach reproduces the size variation of the actual data for primary and secondary schools (Figure 2.7).[11] As in England, average school sizes increase with density.

Figure 2.7. Size distribution of actual versus simulated placements, France



Source: Authors' elaboration based on (French Ministry of National Education and the Youth, 2021[14]; Goujon et al., 2021[4]; Jacobs-Crisioni et al., n.d.[7]).

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Table 2.8 shows the comparison of the simulated placement results with the actual school data for primary and secondary schools. While the aim of the simulated placement is not to reproduce actual numbers of schools and students, the information in the table is useful to evaluate whether there are salient geographical differences between the simulated placement (which is benchmarked using data for Portugal) and the actual distribution of schools in France.

The simulation places less primary schools in every degree of urbanisation except for mostly uninhabited areas, where it places more. Still, the simulated approach also places the majority of small schools in rural areas (Table 2.8). In contrast, the simulated approach places more secondary schools than observed generally, and proportionally more in towns and suburbs. The simulations place a larger share of small secondary schools in rural areas compared to the actual data. As the data shows, primary education in France is geographically more disperse than the simulation approach captures, while secondary education in France is more centralised than simulated. There are many potential reasons for the differences between actual and simulated placements, for instance, because of policies that prefer to reduce travel distances for primary school students even at the possible penalty of reduced cost efficiency; or simply a preference for relatively small primary and secondary schools, as can be seen by the fairly equal distribution of small secondary schools across France's degrees of urbanisation.

Table 2.8. Comparison of number of students and schools, France

Actual versus simulated placement

Degree of urbanisation	Number of schools, actual placement	Number of schools, simulated placement	Number of students, actual placement	Number of students, simulated placement	Share of small schools, actual placement (%)	Share of small schools, simulated placement (%)	Students per school, actual placement	Students per school, simulated placement
Primary schools								
Sparse rural	13 819	8 789	932 720	984 601	65.9	92.5	67	112
Villages	7 076	4 121	1 021 620	839 346	18.5	7.0	144	204
Towns and suburbs	7 295	3 872	1 382 824	1 199 923	10.9	0.4	190	310
Cities	7 112	3 518	1 702 925	1 580 224	4.8	0.1	239	449
Secondary schools								
Sparse rural	824	163	289 463	46 053	19.6	53.0	351	283
Villages	1 736	313	652 808	111 523	31.9	45.8	376	356
Towns and suburbs	2 925	522	1 463 429	254 842	26.0	0.6	500	488
Cities	2 945	375	1 509 687	221 168	22.6	0.6	513	590

Source: Authors' elaboration based on (French Ministry of National Education and the Youth, 2021[14]).

Conclusions

This chapter described a method to estimate primary and secondary education cost differences across human settlements. The method involves two steps. The first step simulates school placements using a spatial access optimisation algorithm that relies on road networks and population grids. The second step estimates costs based solely on student counts by using the distributional properties of actual school costs. The method was tested using data for France where there is no school-level data on cost.

The analysis of data for primary schools in England showed that teaching staff represents the bulk of school cost, and that the average school located in a rural area has a similar expenditure structure to one located in a city, town or suburb. The method proposed in this chapter departs from first estimating teaching costs based on the number of teachers required for the number of students in each school (as per an assumed teaching-to-pupil ratio), subsequently adding other types of costs including non-teaching staff cost (that depend on the number of teachers) and remaining cost including premises, learning material, catering and other costs (that depend on the number of students).

The comparison by degree of urbanisation using actual and simulated placements to actual total costs shows that the proposed approach captures well the levels and geographical variation of cost per student for primary schools. Although it is based on data for England, the method outlined in this chapter does not rely on England-specific parameters but rather on EU averages. In this sense, the application of the model for all EU countries undertaken in the next chapter is not expected to be biased by the use of English data to guide the methodological design. It is important to stress here, however, that the exercise tries to capture differences in school costs solely driven by geographical differences and not by national factors such as the efficiency in the use of education resources, payment levels, etc.

Annex 2.A. Extensions to placement model

This annex describes several extensions to the simulated placement model described in (Kompil et al., 2019[2]).

Inclusion of road-based distances

(Kompil et al., 2019[2]) allocate service locations based on Euclidean distances to potential service users. This approach has been refined somewhat by deriving distances as shortest-path distances from a proprietary finely grained road network obtained from (TomTom, 2018[3]), predominantly known as a provider of in-car navigation equipment. Those shortest path distances have been loaded into sizeable matrices indicating the distances between all grid cells in a country that meet the threshold for maximum catchment area, plus one. These matrices are stored in memory, and used throughout the school placement simulation procedure.

Reverse accessibility weighting

The locational utility of each node is measured as potential accessibility to unsatisfied demand. However, the developed mechanism includes functionality to weigh people with relatively poor access to service disproportionally. This is included to mimic top-down equity considerations in facility location. Thus, in any allocation iteration in *iter*, we first define access to facilities as (A.1):

$$A_i^{iter} = \sum_{d_{ij} \leq \gamma}^{n} D_j^{(iter-1)} (d_{ij} \leq \ 0.1)^{-1} \qquad \text{(A.1)}$$

In which d_{ij} indicates travel distance between origin node *i* and destination node *j*; γ indicates the threshold maximum catchment size (1); and 100 metres is kept as the minimum distance between population and facilities relevant for the special case that *j* = *i*. D_j^{iter} is a vector of dichotomous values that indicate whether facilities have been allocated in prior iterations in the destination nodes in *j*. Subsequently, through iteration-specific weighting values W, population is weighted by their access to services in A, relative to the average of the collection of nodes in a region in *I*, so that (A.2):

$$W_i^{iter} = P_i^{(iter-1)} \cdot f(\frac{1}{n} \sum_{i \in I}^{n} A_i^{iter} \Big/ A_i^{iter}, w) \qquad \text{(A.2)}$$

In which $P_i^{(iter-1)}$ contains all population, passed on from the previous iteration, that is not yet attributed to an already allocated facility. The function $f(A, w)$ rescales the relative facility accessibility between the lowest value in 0.1 and the highest value in *w*. For schools, *w* is set to 2. Subsequently, locational utility of a node is computed as (A.3):

$$U_i^{iter} = \sum_{d_{ij} \leq \gamma}^{n} W_j^{iter} (d_{ij} \leq \ 0.1)^{-1} \qquad \text{(A.3)}$$

User allocation based on spatial interaction model

To compute the cost incurred by having a facility, users have to be attributed to facilities. The most straightforward approach is by attributing users to whichever facility is nearest. However, such an approach is unattractive because, on the one hand, it does not take into account the free choice users experience in contexts with many relevant options; and on the other hand, it does not take into account that facilities may have maximum capacities. To optimise user distribution, given inherent facility capacities, a user balancing mechanism has therefore been put in place. That mechanism is essentially based on an origin-constrained spatial interaction model, although with modifications that require a two-stage approach.

In *stage 1* users are allocated to facilities based on distance decayed travel distance in C, so that (A.4):

$$C_{ij} = \left[\acute{d}_{ij}\right]^{-\alpha},$$

with (A.4)

$$\acute{d}_{ij} = \left[d_{ij} - \min d_i\right] \geq 1$$

and distance decay parameter $\alpha = 2$ and $\alpha = 1.25$ for primary and secondary schools, respectively. Here d_{ij} contains travel times from every origin grid to the five closest facilities. Thus the size of the matrix here is limited to 5 times the number of origin points.

Using $\acute{d}_{ij}$ rather than the actual travel distances in d_{ij} imposes that the distance-decayed travel distances retain high sensitivity to farther destinations even if the closest facility is relatively far. As the distance decay computation may be unstable at small changes in travel distances smaller than 1 minute, the system uses 1 km as minimum travel distance.

Flows in F are computed through (A.5):

$$F1_{ij} = O_i D1_j A1_i^{-1} C_{ij}, \qquad \text{(A.5)}$$

in which and D_j contains weights per facility. In the first step, D_j has the value 1 for all facilities so that initially all facilities are equally attractive. Total flow production is limited to the relevant population O through accessibility measure A, which is defined as (A.6):

$$A1_i = \sum_{j=1}^{n=5} D1_j C_{ij}. \qquad \text{(A.6)}$$

The calculation of F1 yields a pattern of attendance of students to schools in ATT, so that (A.7):

$$ATT1_j = \sum_{i=1} F1_{ij}, \qquad \text{(A.7)}$$

From which can be obtained a crude estimate of facilities FAC needed at location *j.* To obtain realistic school size distributions, likely number of schools in a location are estimated based on a function that explains number of schools in 1 km nodes based on the number of students that are observed in those nodes. This procedure allows for larger-scale schools in contexts with many users, and relatively small schools in contexts with few students. For primary and secondary schools, this function has been estimated based on aggregate number of students in a grid cell in *S.* It takes the form (A.8):

$$\ln FAC_j = \beta 0 + \beta 1 \ln S_j + \varepsilon \qquad \text{(A.8)}$$

And is estimated separately for France, Portugal and England on all 1 km nodes that contain at least one facility. The results of this estimation exercise are given in Annex Table 2.A.1.

Annex Table 2.A.1. Results of facility number function estimates

	Log (number of primary schools)			Log (number of secondary schools)		
	France	Portugal	United Kingdom	France	Portugal	United Kingdom
Log (users)	0.207*** (0.002)	0.187*** (0.004)	0.233*** (0.003)	0.319*** (0.006)	0.241*** (0.010)	0.160*** (0.007)
Constant	-0.830*** (0.008)	-0.717*** (0.019)	-1.138*** (0.016)	-1.792*** (0.035)	-1.331*** (0.060)	-1.056*** (0.047)
Observations	28 342	3 469	12 246	6 405	1 207	2 716
Adjusted R^2	0.369	0.402	0.354	0.333	0.348	0.166

Note: Standard errors are given between brackets. All estimators indicated by *** are significant at p<0.01.

This function is subsequently used to establish likely number of schools in a grid cell (A.9):

$$FA\acute{C}_j^{cont} = e^{(\beta 0+\beta 1 \, ln \, ATT1_j)}$$
$$FA\acute{C}_j^{round} = round(FA\acute{C}_j^{cont}) \geq 1 \quad \text{(A.9)}$$

So that number of schools is rounded, and any selected location gets at least one school. This leads to *stage 2* of the student attribution procedure, in which users are redistributed so that school sizes further converge towards realistic school sizes. To do so, facility attractiveness in *D* is rebalanced by the unrounded estimate of number of facilities, so that (A.10):

$$D2_{ij} = \frac{\max\left(ATT1_j/FA\acute{C}_j^{cont} \mid i\right)}{\left(ATT1_j/FA\acute{C}_j^{round}\right)} \quad \text{(A.10)}$$

implying that allocated schools that, in the first stage, are smaller than the expected largest school in range increase in attractiveness, while facilities that are bigger than the expected largest school in range decrease in attractiveness. Subsequently compute $A2_i = \sum_{j=1} D2C_{ij}$ and $F2_{ij} = O_i D2_j A2_i{}^{-1} C_{ij}$, the latter yielding a rebalanced distribution of attendance. Note that due to the distance decay function enforced through *C,* the rebalancing in *D* may be expected to have a limited effect on total travel costs. Finally this yields a final estimate of school sizes s, so that (A.11):

$$s_j = \sum_{i=1}^{n} F2_{ij} \quad \text{(A.11)}$$

Annex 2.B. Calibration procedure

This annex describes the procedure to calibrate the thresholds used in the placement simulation.

The valuation of imputed threshold values was done through a grid search that aimed at most accurately reproducing observed school distributions. The grid search has been performed for primary and secondary schools in Portugal based on (Directorate General of Education and Science Statistics of Portugal, 2021[15]) and additional detail provided by the Ministry of Education of Portugal. Due to its relatively small size and the implications of country size for computational burden, Portugal was found a better fit for this exercise than the other countries for which observed school distributions were readily available (France and England). From the results that were computed with the adopted threshold values based on Portugal, it may be concluded that English school distributions and costs can be reproduced accurately.

The adopted location-allocation approach is meant to reproduce observed school placement patterns accurately, under the assumption that the real-world placement patterns yield a societally acceptable balance between school cost (as a function of the size) and travel costs.

The grid search was performed by adapting values related to maximum distance, minimum size, optimal size and accessibility weighting. A composite objective function was computed to measure model accuracy given the imputed values. That function was composed of three criteria, namely percentage difference between modelled and observed nationwide number of facilities; the difference between modelled and observed rates of number of urban vs rural facilities; and the mean squared error of percentage points for shares of number of schools per level 2 degree of urbanisation (see Box 1.2 in Chapter 1), thus discerning school provision in cities, towns, suburbs, villages, dispersed rural areas and mostly uninhabited areas.

Annex Table 2.B.1 shows the thresholds that yield the most accurate results in Portugal. The imputed optimum school sizes are lower than what is considered optimal for US primary and high schools (Zimmer, DeBoer and Hirth, 2009[16]; Andrews, Duncombe and Yinger, 2002[17]); reflecting preference for relatively small schools in European countries compared to the United States.

Annex Table 2.B.1. Selected threshold values

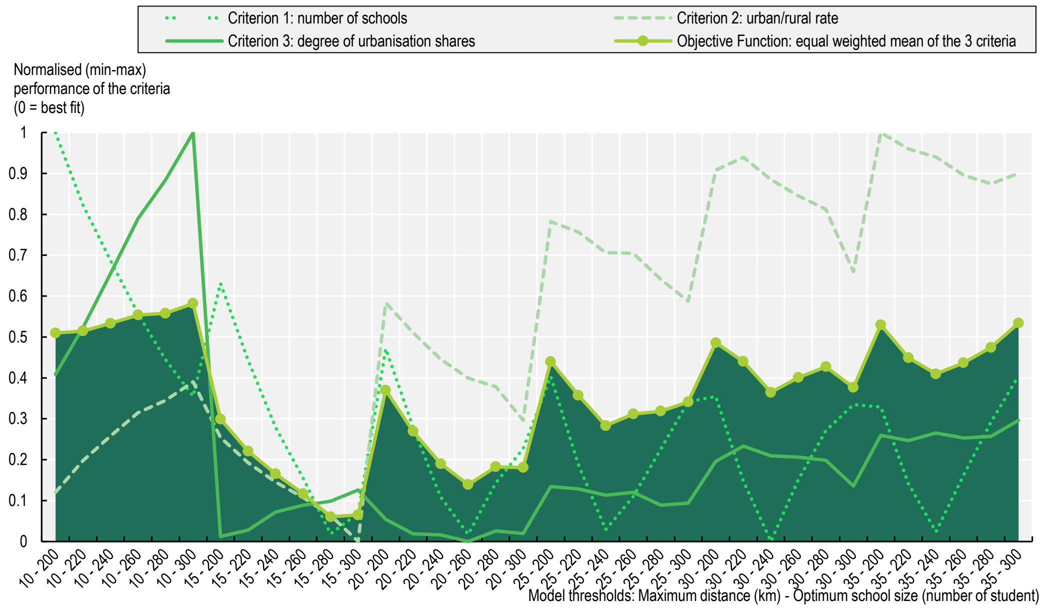
	Primary schools	Secondary schools
(1) Maximum catchment area (km)	15	35
(2) Minimum size (number of students)	7	32
(3) Optimal size (number of students)	280	450

The calibration exercise also showed that some parameters have a much more substantial impact on allocation outcomes than others. In particular, the maximum catchment area distance and the school's optimal size, which both come into play in the school placement stage of the modelling procedure, have a considerable impact on facility distribution.

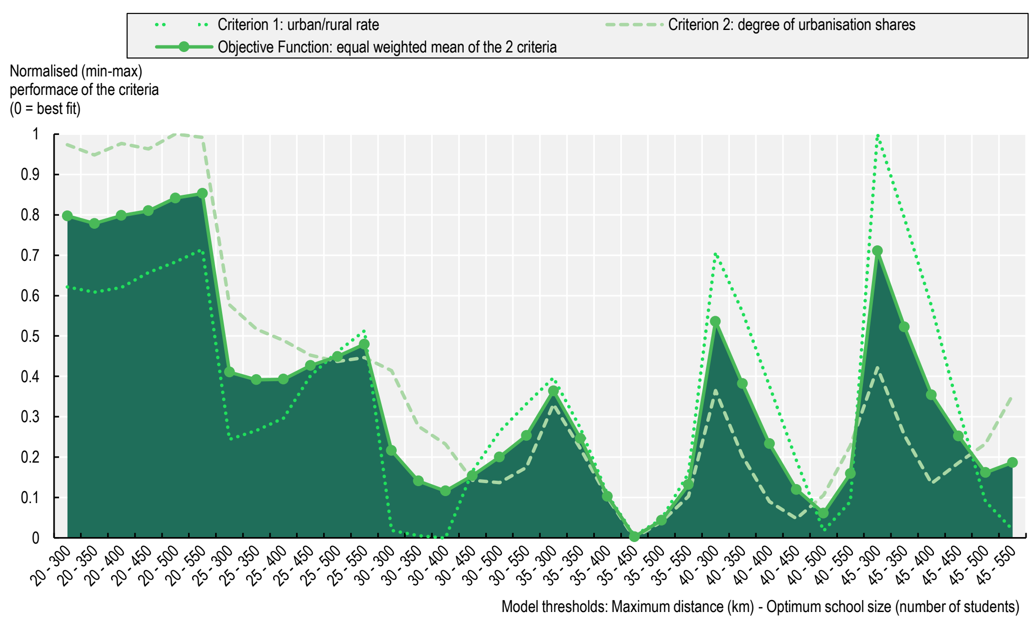
A grid search of Portuguese primary school allocation yielded that the allocation procedure performs best with a maximum distance of 15 km, and an optimal school size of 280. For secondary schools, the same exercise yielded the higher threshold values, with a maximum catchment area distance of 35 km and an optimal size of 450. These threshold values have therefore been selected as baseline values for allocation of primary and secondary schools throughout Europe (Annex Figure 2.B.1).

Annex Figure 2.B.1. Results of adapting maximum distance and optimal size in allocation procedure for primary and secondary schools in Portugal

Panel A. Primary schools



Panel B. Secondary schools



Note: Criterion 1: number of obs. and modelled schools (% difference in modelled vs observed total number of schools). Criterion 2: urban/rural rate (difference between modelled and observed urban/rural rate in number of schools). Criterion 3: degree of urbanisation shares (mean squared error of percentage points for degree of urbanisation shares of schools). Objective function: Equal weighted mean of the 3 criteria. Best fitting model thresholds for primary (secondary) schools: 15 km (35 km) maximum distance and 280 (450) students optimum size.

Source: Authors' estimations based on (Directorate General of Education and Science Statistics of Portugal, 2021[15]; Goujon et al., 2021[4]; Jacobs-Crisioni et al., n.d.[7]).

StatLink https://doi.org/10.1787/888934245994

Annex 2.C. Data description

The main data source for benchmarking school costs is publicly available data on school workforce composition for England provided by the UK Department of Education (UK Department of Education, 2021[12]).[12] This database includes maintained primary, secondary and special schools that were open for the period April 2018 to March 2019. Maintained schools make up the vast majority of schools in England. The data contains the precise school location (geographical coordinates) and the number of students of each school. Data for cost disaggregated by type (e.g. staff, maintenance, etc.) for the year 2018-19 can be matched to this data for a representative subset of schools.

The dataset contains information for 14 963 (90%) primary schools and 2 854 (83%) secondary schools, accounting for 4 200 779 primary and 2 882 185 secondary school students. The data with financial information for each school is more limited in scope, covering 60% of primary schools (2 727 656 students) and 20% of secondary schools (686 163 students). Schools recorded with less than one student are removed from the analysis.

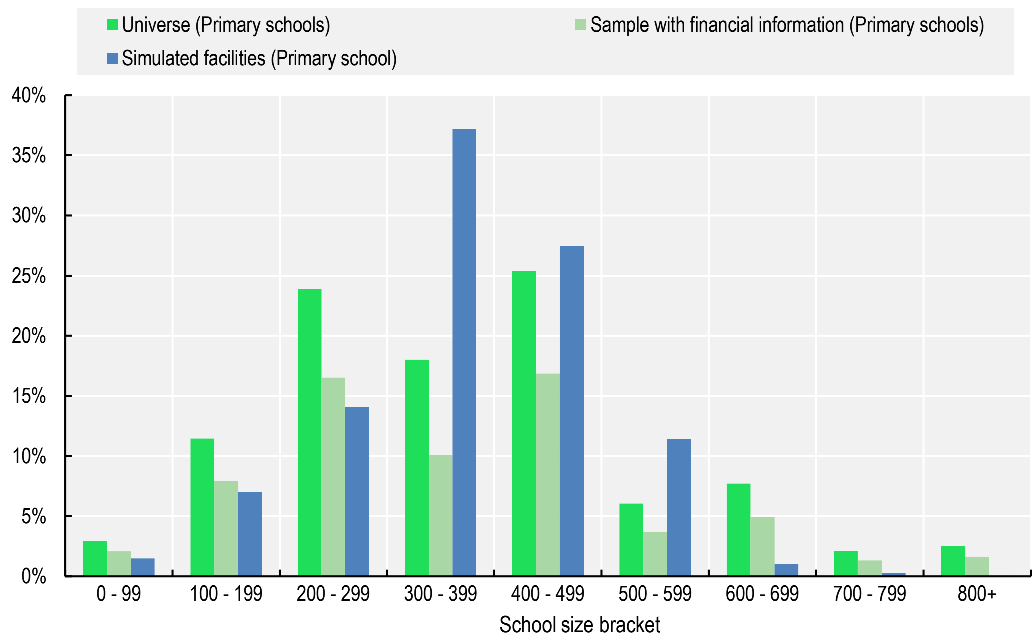
In England, primary education covers key stages 1 (5-7-year-olds) and 2 (8-11-year-olds) and the phase of education offered by each school is specified in the data. Although in England primary schools can also provide early years foundation stage (*kindergarden*) education, the aggregate number of students in the subset of primary schools corresponds to the national figures.[13]

The data for primary schools includes schools with statutory age range from 0 to 7 years. To get the number of students per grade, schools with statutory low ages above 7 (812/12 809 schools) are dropped. Although some schools offer levels 2-4, the percentage of students in nursery state-funded schools is small (43 785 versus 4 689 660 students in primary schools). Furthermore, not all schools offer all grades. For instance, some schools may offer all grades for 2 to 11-year-olds, while others may only offer 2 to 7. Consequently, student-to-teacher ratios are computed at the school level.

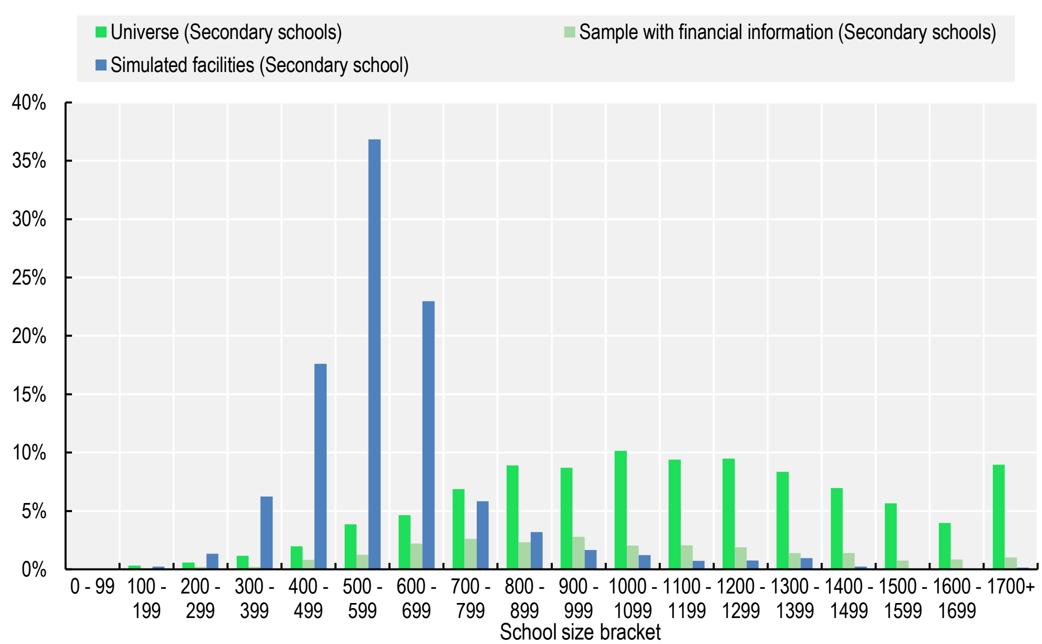
As shown in Annex Figure 2.C.1, the sample of schools with financial information has a similar size distribution compared to the universe of schools, suggesting the sample is representative of the universe. The simulated placement is less skewed to the left than the universe, suggesting the simulated placement produces less small schools than those observed in the universe. Unlike the case of primary schools, the sample of secondary schools with financial information does not have a similar size distribution compared to the universe of schools. For the purpose of the descriptive analysis, the cost data is grouped into five categories: teaching staff, non-teaching staff, school premises (including utilities), teaching resources (including ICT), and catering. For the cost estimation, cost is grouped into three categories: teaching staff, non-teaching staff and other costs (including school premises, teaching resources, and catering).

Annex Figure 2.C.1. Size distribution of primary and secondary schools, England

Panel A. Primary



Panel B. Secondary



Source: Authors' elaboration based on (UK Department of Education, 2021[12]; Goujon et al., 2021[4]; Jacobs-Crisioni et al., n.d.[7]).

StatLink https://doi.org/10.1787/888934246013

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Notes

[1] School provision costs are expressed in a monetary value. Transport costs are expressed in distances travelled, while their monetary value remains unknown, so that we will assume that longer distances travelled are linear with transport costs. Monetary values of transport distance remain unknown because the means to travel to schools, as well as the organisation of school transport, likely differs substantially between contexts and countries in Europe. In addition, establishing the value of transport opportunity costs is beyond the scope of this study.

[2] This is in contrast to other approaches (Xu et al., 2020[20]; Pacheco and Casado, 2005[18]) where there is no central optimisation process and the number of locations is not defined a-priori.

[3] The imposed regional boundaries allow parallel placement of schools across regions, which is useful to speed up the modelling process, and has a negligible influence on simulation results.

[4] The boundaries of independent placement zones are drawn based on TL3 regions for primary schools and TL1 regions; for secondary schools.

[5] This is analogue to the bid-rent assumptions in other land-use modelling applications (Hilferink and Rietveld, 1999[19]).

[6] See https://eacea.ec.europa.eu/national-policies/eurydice/content/united-kingdom-england_en.

[7] See http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=educ_iste&lang=en.

[8] Conceivably, students from different degrees of urbanisation visit the same school, and the chosen aggregation method therefore does not accurately describe cost differences between the places where students live. Through the spatial interaction model used for student attribution, school costs for the simulated school placements can in fact be linked to the origins of students; however, for the observed costs, such data are unavailable.

[9] For secondary schools the threshold of 100 is based on the values for the national funding formula: 69.2 for middle schools and 120 for secondary schools. See https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/844007/2020-21_NFF_schools_block_technical_note.pdf

[10] See http://cache.media.education.gouv.fr/file/2015/67/6/depp_rers_2015_454676.pdf

[11] See https://www.education.gouv.fr/les-chiffres-cles-du-systeme-educatif-6515

[12] See also https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/811622/SWFC_MainText.pdf.

[13] Accessible at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/826255/Schools_Pupils_and_their_Characteristics_2019_Accompanying_Tables.ods.

3 Present and future school costs and access

This chapter analyses present and future estimates of primary and secondary school cost and access across Europe. It first reviews the main discussions and concepts around the balance between school costs and access, including the effects of consolidation of the school network on this balance. It then presents a detailed analysis of present cost and access estimates for Europe at different territorial aggregations including the regional, municipal and degree of urbanisation levels. Finally, the chapter presents a similar discussion for future school cost and access estimates, highlighting the most pressing cases facing challenges in the face of demographic change.

Main takeaways

- This chapter assumes that students choose schools that minimise their travel time or those that are less crowded, without being limited to a specific area. In practice governments often impose bounding conditions: on average across OECD countries, 41% of students are in schools where admission to school always considers residence in a particular area.
- While school consolidation has possible negative implications on school attendance and performance when distances to school increase considerably, maintaining schools open at any cost may not act as a deterrent for out-migration in communities already experiencing population decline.
- For the average of TL3 regions, annual costs per student in primary and secondary schools are EUR 4 034 and EUR 6 571, with a difference between the regions with the maximum and minimum costs of EUR 3 302 for primary schools and EUR 2 495 for secondary schools.
- When aggregated by type of TL3 regions, for all countries with remote regions except Croatia, costs per primary and secondary school student are lowest in metropolitan regions and highest in remote regions.
- While non-metropolitan regions have generally higher costs per student than metropolitan regions, costs can be relatively high in metropolitan regions with a small share of population in school age.
- In countries with strong municipal consolidation, the share of municipalities with only small schools is negligible because a larger number of students are hosted in larger municipal borders. On the other hand, countries with high municipal fragmentation have a relatively large share of municipalities with no schools or only small schools.
- School-based costs per primary school student by municipality increase when at least half of the municipality schools are small. Extreme cases - with costs over four times the average expenditure - all occur in municipalities with one small school and a very small population.
- Costs per student in primary and secondary schools are highest in sparse rural areas and lowest in cities. For EU27+UK, the difference in annual cost per student between cities and sparse rural areas is about EUR 650 and EUR 681 per primary and secondary school student, respectively.
- For secondary schools, the difference between costs per student in villages and sparse rural areas is smaller than for primary schools.
- In both primary and secondary schools, villages have the largest share of students coming from other types of settlements: 39% (54%) of all primary (secondary) students attending school in villages do not come from villages. The large majority of these students actually comes from sparse rural areas.
- Primary school students in sparse rural areas travel on average four to five longer distances than students in cities. In fact, in the majority of countries, more than half of the primary school student population in sparse rural areas has to travel far to go to school.
- While differences in travel distances for secondary schools are smaller in general due to the higher geographic concentration of secondary schools, in some countries over 30% of sparse rural secondary students has to travel far to access a school.
- By 2035 projections show considerable additional demand for schools in cities, and a demand shift from rural to urban areas, in particular in Eastern, Central and North-western Europe.

- In the 2035 scenario with future school placements, changes for primary schools are close to zero in all areas except sparse rural areas, where costs per primary school student are expected to increase by 2.6% on average for EU27+UK countries, while distances are expected to increase in all areas except cities, and proportionally more in villages. Secondary schools are expected to follow a similar pattern with lower increases in expected cost increases, but higher distance increases.
- Keeping the 2011 primary school network – and consequently maintaining distances to schools similar to the present scenario - implies even larger average cost increases for EU27+UK countries of about EUR 36 per student in sparse rural areas and EUR 21 in villages, with substantial variations across countries depending on their expected change in future demand.

Introduction

Population trends are highly relevant for the provision of sustainable schools. Population decline is an OECD trend that will lead to a decline in the number of students in rural areas, raising additional challenges for the attraction of teachers and principals in these locations, and exacerbating the costs of educational provision, which in turn can lead to further school consolidation (OECD, 2021[1]). Given governments' mandate to provide access to basic education to children and adolescents, regardless of where they live, identifying sustainable strategies to provide schooling in areas of expected population decline is of chief importance, especially under tight budgets.

Chapter 2 presented a method to estimate school access and costs. This chapter applies this method to estimate the present and future effect of demographic change within regions, and across European countries. The analysis relies on new comprehensive and internationally comparable data for EU27+UK countries on schooling services, access and costs, which in turn rely on recently published local demographic projections (Goujon et al., 2021[2]; Jacobs-Crisioni et al., n.d.[3]).

In the analysis, supply of educational facilities, and consequently costs per student, depend only on population distribution in each country, which ensures international comparability. This analysis also uses future youth population projections to simulate changes in costs and access under two future scenarios: one where the school network adapts to future student levels and distribution, and another one where the school network remains constant. More specifically, this chapter compares travel distances to simulated primary and secondary schools and their cost per student by degree of urbanisation. It also estimates changes in school costs driven by future population changes under different policy scenarios, emphasising how demographic change drives changes in students' access to school, especially in rural areas.

The next section presents concepts and evidence on school costs while specifying the costs considered in this report. The third section analyses estimated costs on current primary and secondary school across territories, including regions and municipalities, and by degree of urbanisation. The fourth section discusses projected changes in primary and secondary education as well as future cost estimates. The last section concludes.

School costs: Concepts and evidence

This section starts explaining the type of costs covered in this report, and outlining the subnational school costs by different factors, including the level of education and the demand for educational services. It then outlines the relationship between school access and choice by discussing school competition across OECD countries. Finally, the section examines the financial consequences and impact on declining communities of school network consolidation.

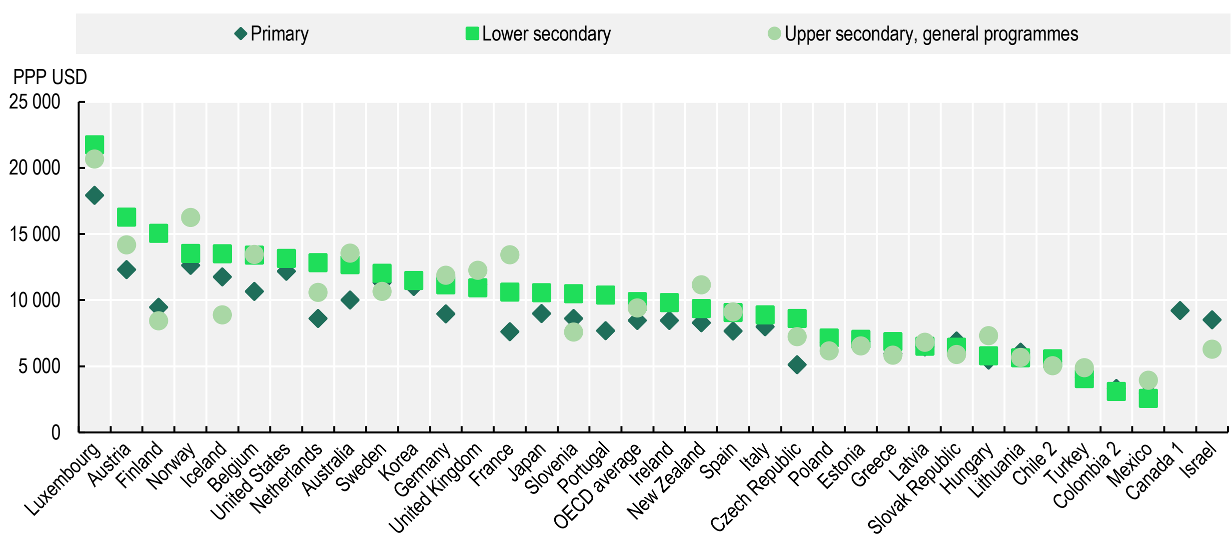
Subnational school costs: drivers and evidence

Educational expenditure tends to vary across levels of education and country regulations. Current expenditure per student depends on several different factors, such as teachers' salaries, pension systems, instructional and teaching hours, the cost of teaching materials and facilities, the type of programme provided (e.g. general or vocational), and the number of students enrolled in the education system, including the number of students per teacher. This report considers costs included in current expenditure incurred in schools. In this sense, the term "school costs" does not include privately incurred costs such as travel costs or other costs related to attending schools that do not relate to the costs of running schools. See the section "what is understood by costs in this report" in Chapter 2 for more details.

Across OECD countries, primary education expenditure per student tends to be lower than secondary education expenditure (Figure 3.1). This is especially true in countries with the highest expenditure on the lower secondary level, such as Luxembourg, Austria and Finland, where the differences in expenditures between primary and secondary are significant (OECD, 2021[1]). Countries with the lowest expenditure per student in both educational levels include Colombia, Mexico and Turkey, all being countries where teacher salaries are relatively low.

Figure 3.1. Total expenditure on educational institutions per full-time equivalent student by level of education, OECD countries

2016 USD PPP values

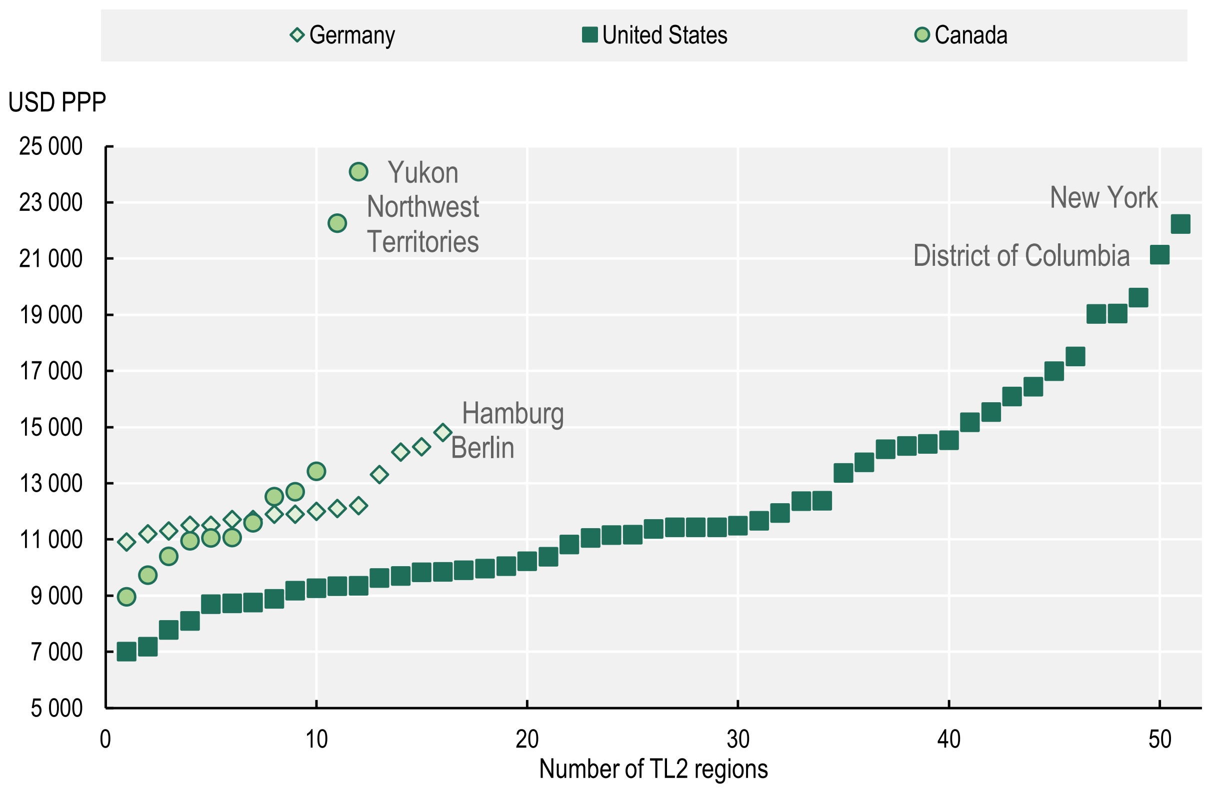


Notes: In equivalent USD converted using PPPs for GDP, direct expenditure within educational institutions, by level of education, based on full-time equivalents. For notes, see Annex 3 in OECD (2019[4]), *Education at a Glance 2019*, OECD Publishing, Paris, https://doi.org/10.1787/f8d7880d-en.
1. Primary education includes pre-primary programmes. Post-secondary non-tertiary figures are treated as negligible.
2. Year of reference 2017.
3. Data on expenditure on public vs. private educational institutions are displayed in OECD Education at a Glance 2019, Table C1.5 available on line.
Source: OECD (2019[4]), *Education at a Glance 2019*, OECD Publishing, Paris, https://doi.org/10.1787/f8d7880d-en.

Data for total educational expenditure or costs per student is usually not available across geographical and subnational levels. Available data on expenditure per student in primary to upper secondary education at the TL2 level for the United States, Canada, and Germany reveal that geographical variations can be quite substantial (Figure 3.2). In Canada, expenditure per student is about USD 10 000 higher in two remote regions compared to the national average. In the United States, both total expenditure on educational institutions per full-time equivalent student vary widely across TL2 regions, from a minimum of USD 7 003 in Utah to a maximum of USD 22 231 in New York.

Figure 3.2. Expenditure per student in primary to upper secondary education by TL2 region, Germany, United States, and Canada

Total expenditure on educational institutions per full-time equivalent student, USD PPP, 2017



Note: Primary to upper secondary education corresponds to ISCED2011 levels 1, 2 and 3.
Source: OECD (2021[5]), "Fertility rates" (indicator), http://dx.doi.org/10.1787/8272fb01-en (accessed on 24 February 2021).

StatLink https://doi.org/10.1787/888934246032

Local adjustment to local living costs resulting in differences in teacher salaries are behind these geographical differences, as salaries are the largest contributor to expenditure. In New York State, for example, the starting salary for a primary school teacher is USD 60 500, while it is USD 37 100 in Arizona. Smaller local adjustments to teacher salaries may be behind the lower geographical variation in the case of Germany, where the difference between the region with the largest and lowest expenditure is USD 3 900. However, these estimations rely on a national price deflator, so urban-rural differences may be smaller than portrayed here once real wages in urban areas are adjusted to higher cost of living in cities. The estimations in this chapter assume a common salary across EU27+UK countries and consequently do not reflect any real wage differences across and within countries.

The geographical differences in costs will also depend on where costs are measured – at schools or at places of residency. For instance, adding up the expenditure observed in schools within a certain geographical category or boundary does not need to coincide with the expenditure incurred to provide schooling services to children and adolescents within the same boundaries, because they may have attended schools outside those borders. Box 3.1 offers more explanation on how this report considers this issue.

Box 3.1. School-based and residency-based expenditure estimates

This report estimates school costs for simulated school locations, given demand for the school location. Geographical variation in demand drives variation in school expenditure. The costs of education are thus not only borne in the community where the school is located but rather in the wider area that the school serves.

To represent geographical variation in costs accurately, a process of ‘cost porting’ allows translating estimated at the school level into costs at the residency level. This process entails distributing total school costs estimates equally over the students that attend the school. This in turn creates a fine-grained map that indicates total costs per student at the residence of those students. An example may help clarify the concepts. Total costs of EUR 60 000 of a school with 3 students of which 2 are in the school's village, and 1 is in a sparsely inhabited rural location would be distributed equally over the three students, implying a 40 000 expenditure for the village and a 20 000 expenditure for the sparsely inhabited rural location.

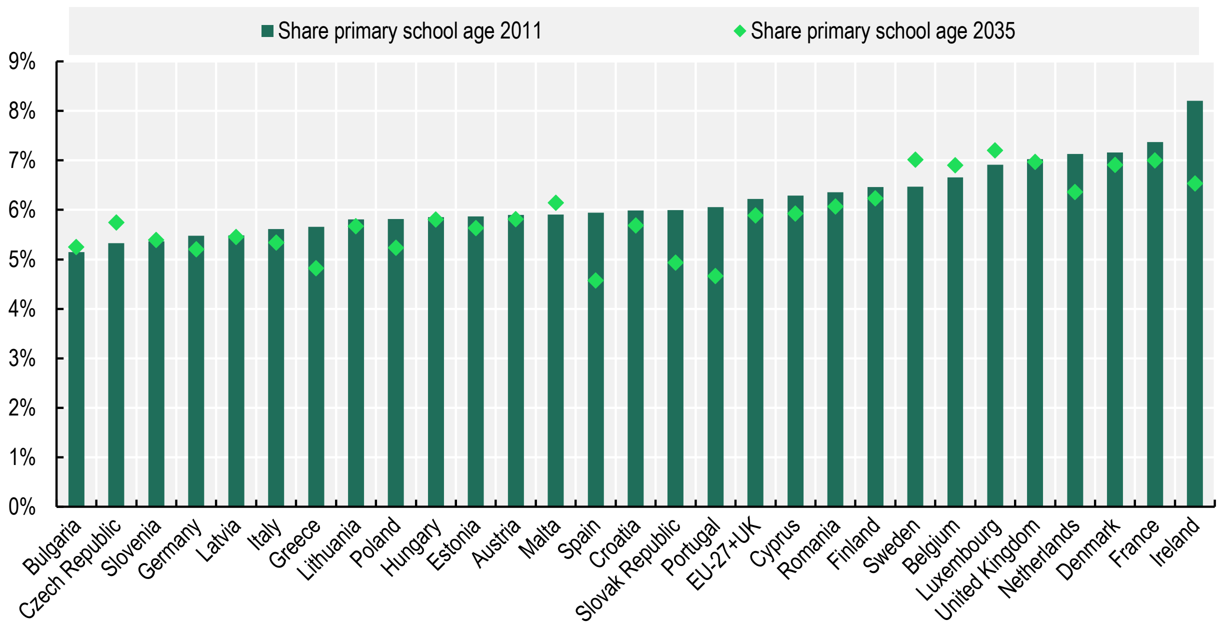
The fine-grained map with ported costs is used to aggregate residency-based costs at different geographical levels (TL3 region and degree of urbanisation).

Besides differences in teacher wages and efficiency in the use of educational resources as reflected for instance in pupil-to-teacher ratios, the levels and distribution of demand for educational services also influence costs per student. Abstracting from differences in the cost of living across locations, a larger and more spatially concentrated demand means that education can be provided at a higher scale in relatively large schools, driving down costs per head. Available evidence confirms that schools are in principle subject to economies of scale (Zimmer, Timothy, Larry DeBoer, and Marilyn Hirth, 2009[6]; Duncombe and Yinger, 2007[7]; Andrews, Duncombe and Yinger, 2002[8]).

Across Europe, Ireland, France, Denmark, the Netherlands and the United Kingdom had a relatively large share of population in primary and secondary school age in 2011 (Figure 3.3 and Figure 3.4). In contrast, Bulgaria, Czech Republic, Slovenia, and Germany had a relatively low share. By 2035, the share of children in the primary school age is projected to remain stable or decrease in all countries except for Czech Republic, Malta, Sweden, Belgium, and Luxemburg, with the largest projected declines in shares of the population occurring in Ireland, Portugal, Slovak Republic, and Spain (Figure 3.3). The situation is similar for children and adolescents in secondary school age, with stability or decline in all countries except for Czech Republic, Germany, Latvia, Italy, Poland, and Slovak Republic (Figure 3.4).

Figure 3.3. Share of population in primary school age, EU27+UK

2011-35



Source: Authors' elaboration based on (Goujon et al., 2021[2]; Jacobs-Crisioni et al., n.d.[3]).

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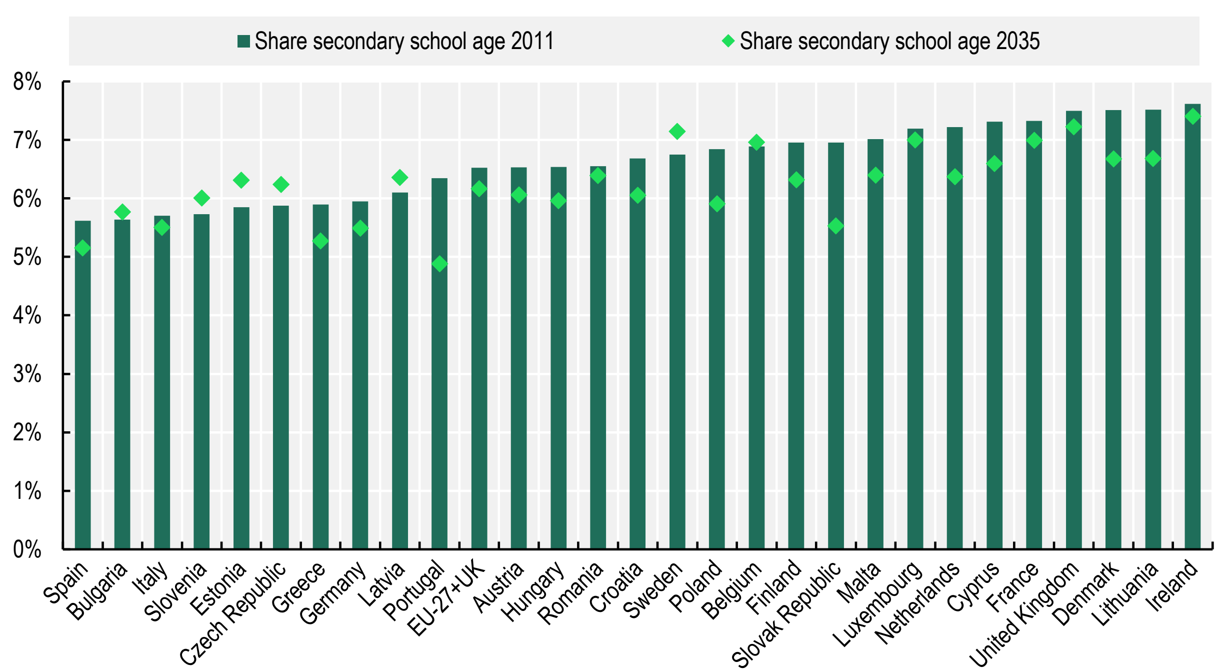
Figure 3.4. Share of population in secondary school age, EU27+UK

2011-35



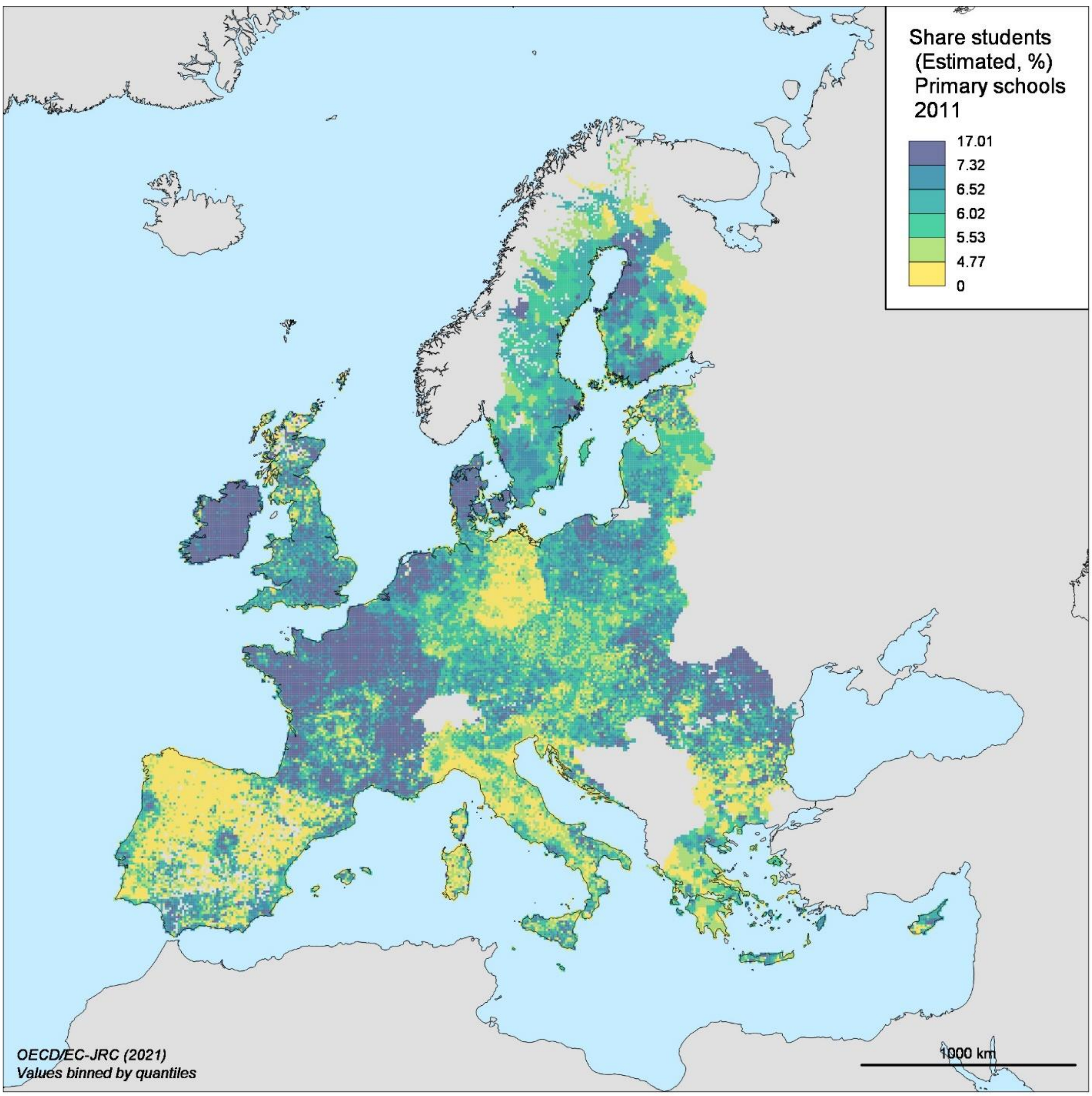
Source: Authors' elaboration based on (Goujon et al., 2021[2]; Jacobs-Crisioni et al., n.d.[3]).

StatLink https://doi.org/10.1787/888934246070

Chapter 1 discussed the wide variations in population density that imply different levels of dispersion of existing demand for education. Besides settlement density, the share of children and adolescents in primary and secondary school age also varies widely within European countries. For instance, parts of Eastern Germany and Northern Spain have a small share of population in school age, while in parts of Ireland and France, primary or secondary school students account for 10% or more of the population (Figure 3.5 and Figure 3.6).

Figure 3.5. Share of population in primary school age, EU27+UK

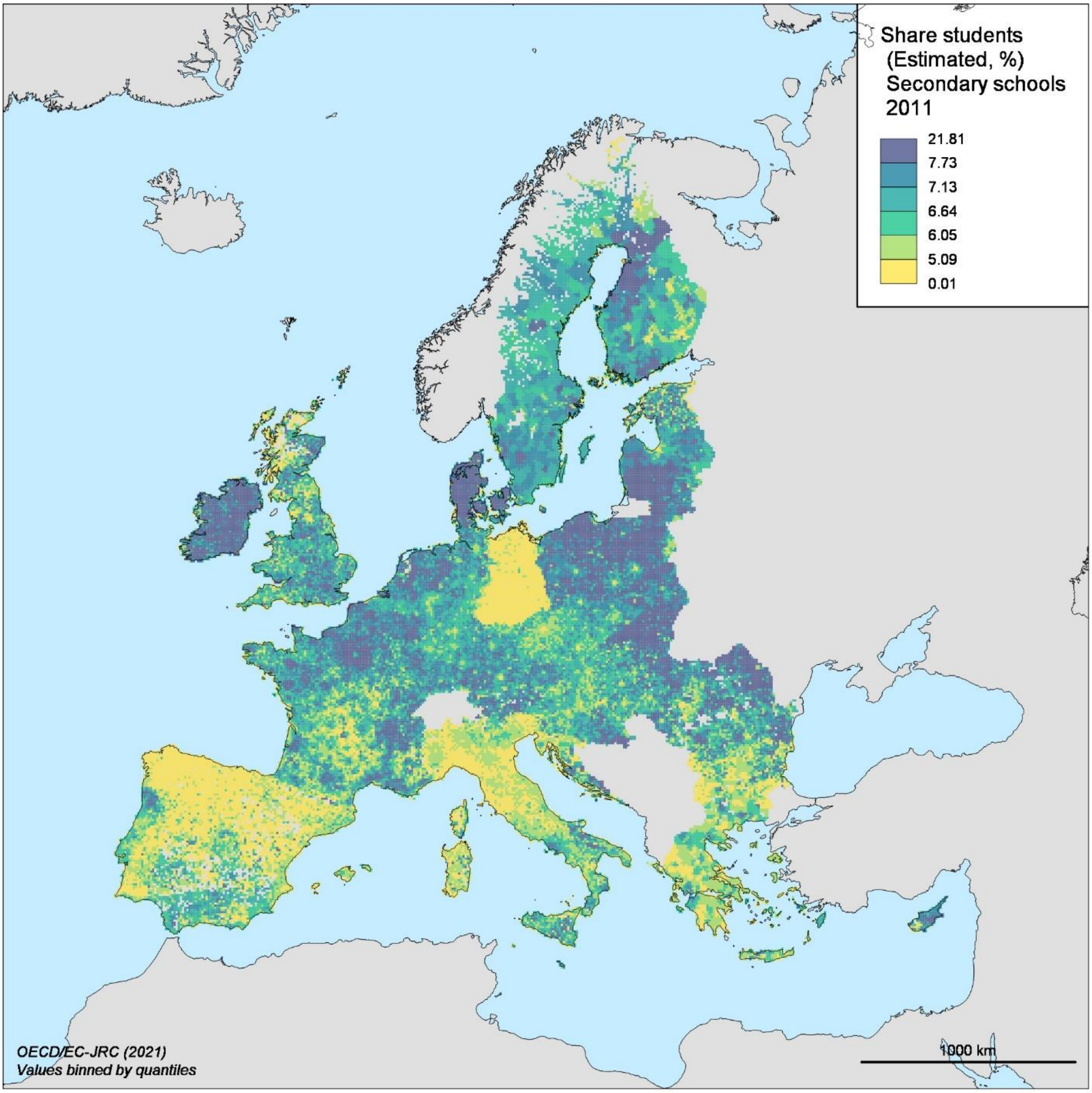
2011



Source: Authors' elaboration based on (Goujon et al., 2021[2]; Jacobs-Crisioni et al., n.d.[3]).

Figure 3.6. Share of population in secondary school age, EU27+UK

2011



Source: Authors' elaboration based on (Goujon et al., 2021[2]; Jacobs-Crisioni et al., n.d.[3]).

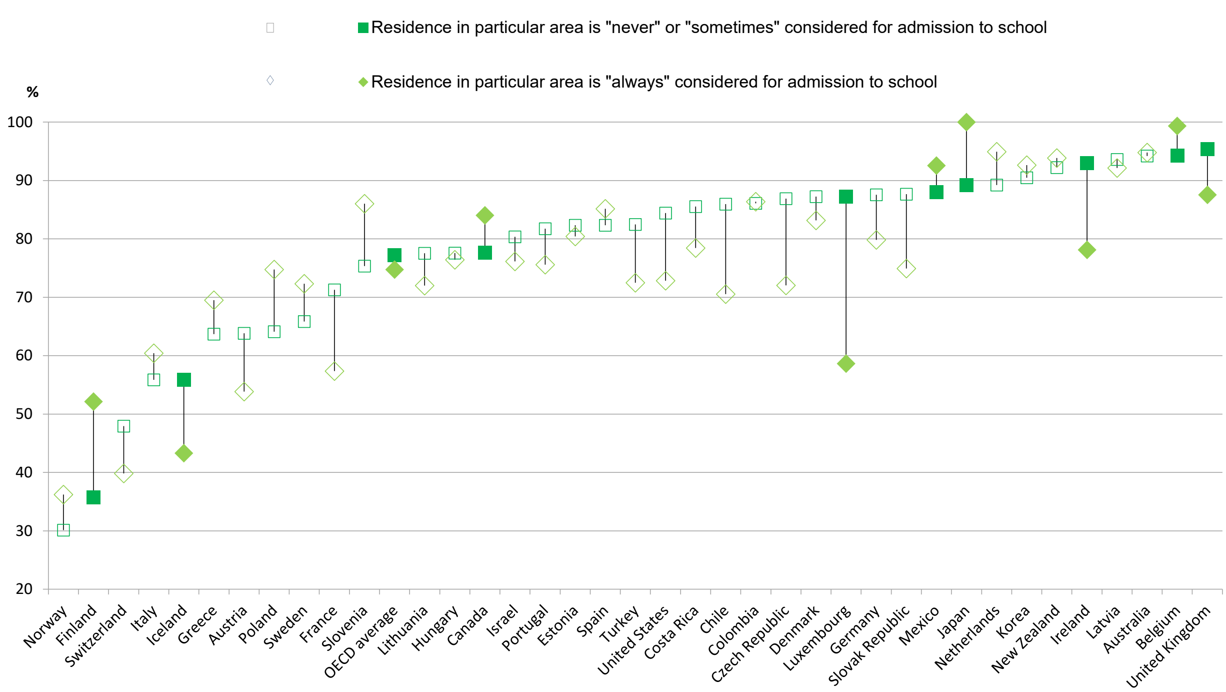
The relationship between school access and choice

While the levels and concentration of demand for educational services drive the potential size of schools, school choice determines actual school sizes. In modelling the access to educational services, this report assumes that students at any given location have some freedom to choose the most convenient school for them – for instance, the one that minimises their travel time, or a school of a limited size. In practice, however, governments can impose bounding conditions on service provision as a requirement for financial support to local authorities (Haan, M. de, E. Leuven, and Ooserbeek. H., 2011[9]) (Tillväxtanalys, 2011[10]), which means that schools may need to be placed in designated communities, and that students may not be allowed to cross a certain boundary (e.g. a municipal boundary or a pre-defined school district). On average across OECD countries, 41% of students are in schools where admission to school always considers residence in a particular area, while 59% are in schools where admission to school never or sometimes considers residence in a particular area (Figure 3.7).

Additionally, school systems in which more schools use admissions criteria other than the school catchment area have more competition among schools.[1] On average across OECD countries, 16% of students are in schools that compete with another school and 61% are in schools that compete with two or more other schools. Fewer than 50% of students in Norway, Switzerland, Finland and Iceland are in schools that compete with at least one other school for students, while over 90% of students in Belgium, Australia, Latvia, New Zealand, the United Kingdom, Korea, the Netherlands, Japan, Mexico, and Ireland attend such schools (Figure 3.7). Under this criterion, school competition is more common at the upper secondary level of education, where there is generally greater differentiation of education programmes than at lower levels of education. In Sweden, the Slovak Republic, Greece, and the Czech Republic, the difference between lower secondary students attending schools that compete with at least one other school, and upper secondary students attending such schools, is between 21 and 39 percentage points (OECD, 2013[11]).

Figure 3.7. School competition and school policy on catchment area, OECD countries

Percentage of students in schools whose principals reported that one or more schools compete for students in the area, according to whether



Note: White symbols represent differences that are not statistically significant.
Countries and economies are ranked in descending order of the difference in the percentage of students in schools whose principal reported that one or more schools compete for students in the area between schools where residence in a particular area is "never" or "sometimes" considered, and schools where residence in a particular area is "always" considered for admission to school (never/sometimes - always).
Source: OECD, PISA 2012 Database, Figure IV.4.6., http://dx.doi.org/10.1787/888932957346.

Geographic restrictions on school locations and school choices, such as those imposed by school districts, influence cost efficiency and accessibility.[2] Restricted access areas have different sizes and shapes and are therefore not comparable across countries. In fact, the inclusion of such restrictions causes that outcomes not only depend on demographic differences, but also on arbitrarily defined administrative boundaries. To ensure comparability, the method adopted in this report allows for competition for school locations across local communities[3] that result entirely from the distribution of the population and in no case depend on exogenously defined administrative borders. At the same time, students are allocated to schools according to travel distances and a mechanism that balances student counts between adjacent school locations.

School network consolidation and its consequences

School consolidation is a response to declining student numbers and economic rationalization (López-Torres and Prior, 2020[12]; European Commission, 2020[13]; Eurostat, 2019[14]; Agasisti, 2014[15]; Witten, McCreanor and Kearns, 2007[16]; Stockdale, Aileen, 1993[17]) (Stockdale, Aileen, 1993[17]). School consolidation means that some students need to travel farther, with possible implications on school attendance and performance. Available evidence shows travel to school affects student performance and participation negatively (Williams and Wang, 2014[18]; Talen, 2001[19]).

Does school network consolidation lead to cost savings? Evidence for school districts (i.e. the areas served by each school) in the United States shows that school consolidation leads to cost savings on average (Andrews, Duncombe and Yinger, 2002[8]). However, diseconomies of scale come into play with larger school districts through poor student attendance and performance, lesser parent involvement, higher transport costs and higher teacher wages (Williams and Wang, 2014[18]; Zimmer, Timothy, Larry DeBoer, and Marilyn Hirth, 2009[6]). In fact, optimal school sizes may be much lower than suggested in other consolidation studies that do not account for travel time impacts (Andrews, Duncombe and Yinger, 2002[8]). This is because studies of consolidation effects often oversee the opportunity costs of longer travel times, leading in many cases to severe underestimation of the welfare implications of school consolidation for students and their families (Kenny, 1982[20]).

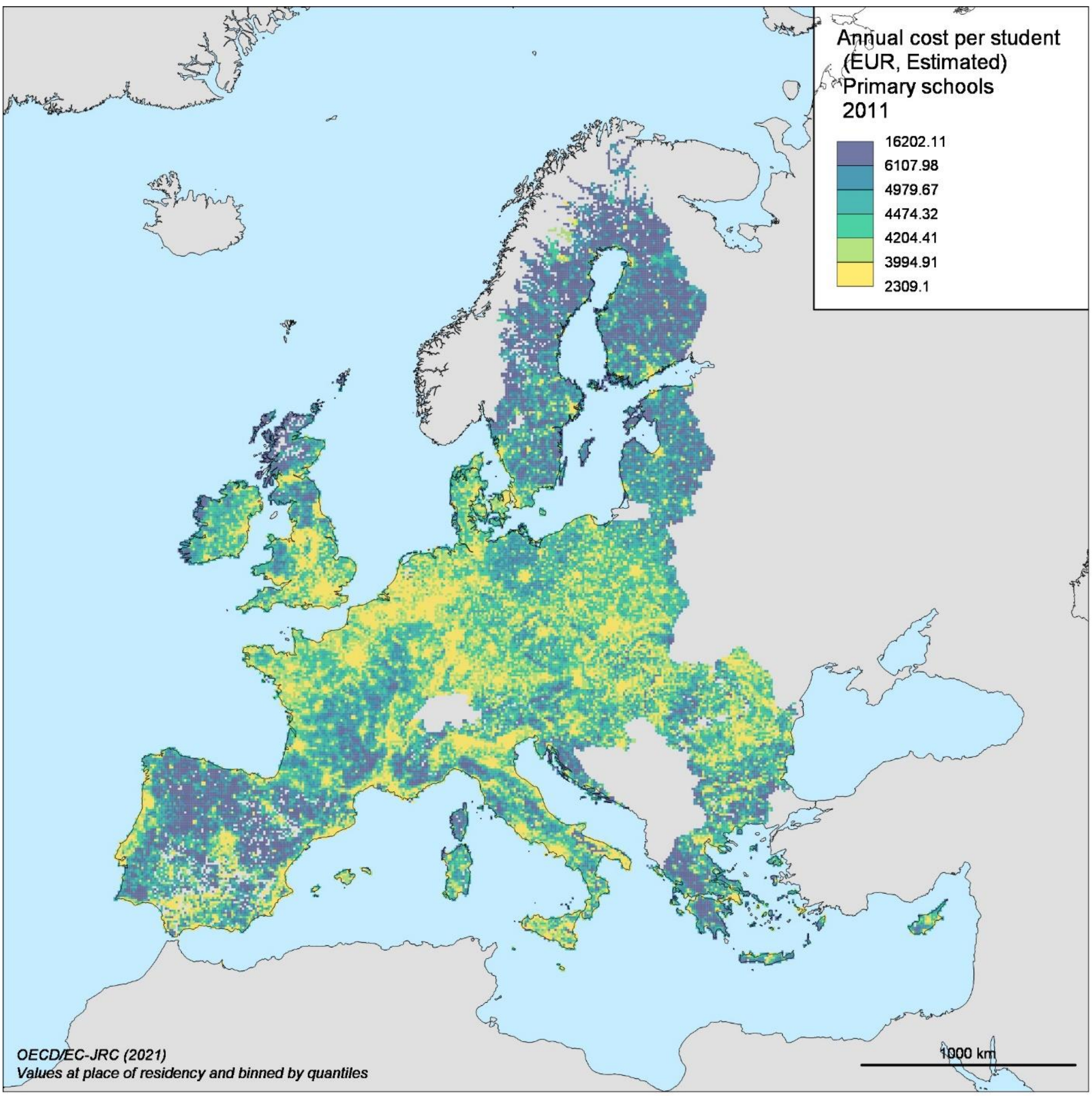
Analyses that link demography, school provision and school costs are scarce despite the clear link between demographic change and school costs. School costs studies take school distributions as independent of population change, with some exceptions (Andrews, Duncombe and Yinger, 2002[8]). In reality, they depend on the evolution and geographical distribution of the number of students. The link between changes in local education demand and supply remains generally unexplored in the literature. The seminar work of (Holland and Baritelle, 1975[21]) links school network reorganisation with current and expected future operating and transport costs for schools in rural areas in the United States.

School closures may also have a broader impact on communities that are already in decline (Barakat, 2014[22]; Elshof, van Wissen and Mulder, 2014[23]; Witten, McCreanor and Kearns, 2007[16]; Lyson, Thomas A., 2002[24]; Salant, P. and Waller, A., 1998[25]). (Elshof, van Wissen and Mulder, 2014[23]) consider population decline and facility closure to be self-reinforcing processes, so that community decline is a cause for school closure, and vice versa. (Christiaanse, 2020[26]) finds that facility decline is dominant in smaller Dutch villages. However, there is no clear evidence that maintaining a school can prevent out-migration in communities experiencing population decline (Lehtonen, 2021[27]), or that school closures necessarily lead to further decline in communities where other services and spaces for social gatherings are maintained.

Present estimated school costs and access

Figure 3.8 and Figure 3.9 show the geographical distribution of estimated annual costs at place of residency for primary and secondary schools in EU27+UK countries, aggregated in 10x10 km grid cells. The estimated costs, which aim to capture differences in costs related only to demographic and population distribution differences, vary considerably across territories. They are highest in the most sparsely populated areas of Europe. This section discusses present primary and secondary school cost across small (TL3) regions, (LAU2) municipalities and by degree of urbanisation. The next section will discuss the future cost estimates.

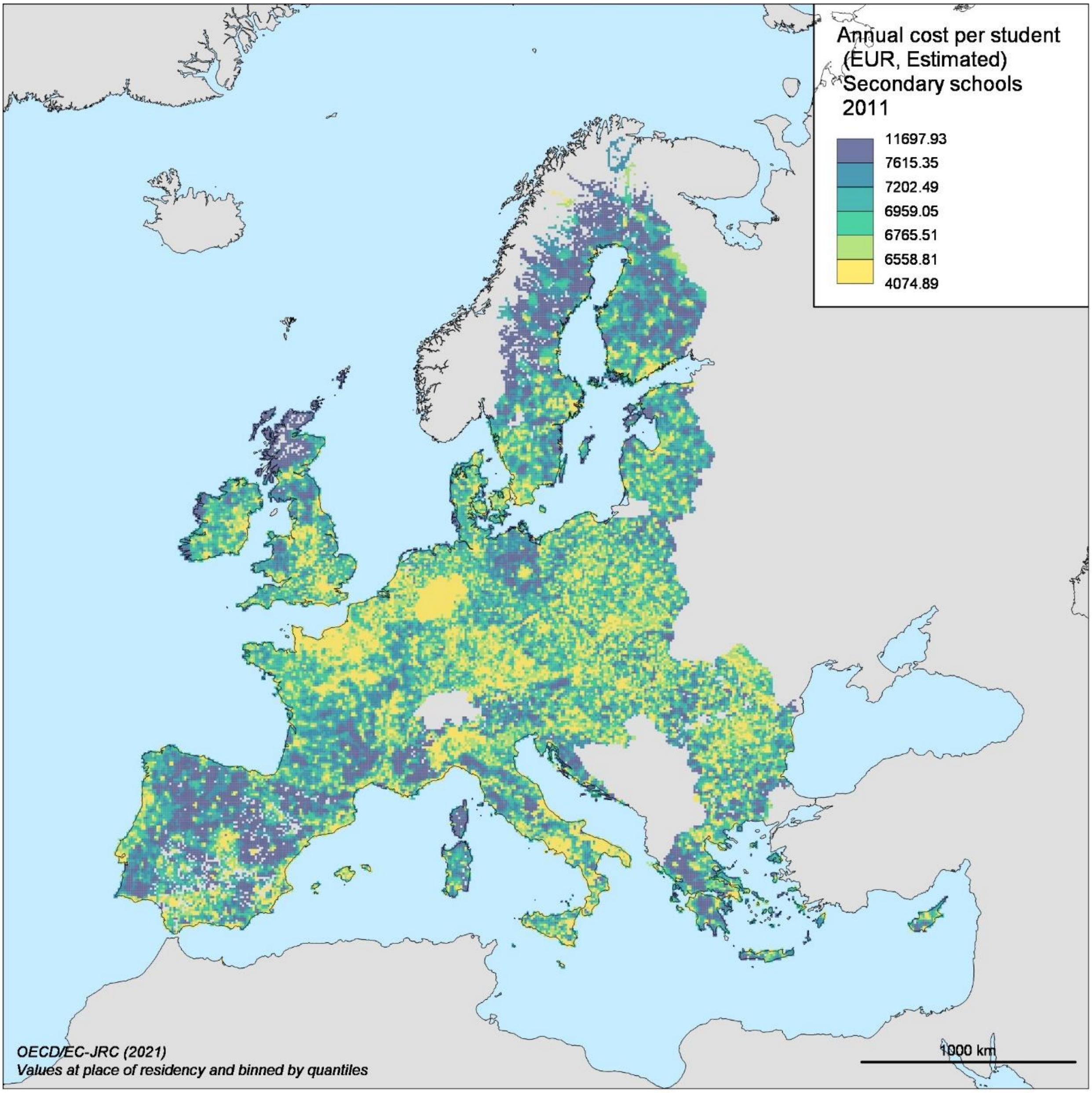
Figure 3.8. Annual costs per primary school student (estimated), EU27+UK



Source: Authors' elaboration based on (Goujon et al., 2021[2]; Jacobs-Crisioni et al., n.d.[3]).

Figure 3.9. Annual costs per secondary school student (estimated), EU27+UK

2011



Source: Authors' elaboration based on (Goujon et al., 2021[2]; Jacobs-Crisioni et al., n.d.[3]).

Present school costs across regions

Aggregating the results by TL3 region gives a first impression of how much geography affects the costs of provision. For the average of TL3 regions, annual costs per student in primary schools is EUR 4 034, with a minimum of EUR 3 242 (Paris) and a maximum of EUR 6 544 (Evrytania, Greece). The next regions with the lowest values are Hackney & Newham (United Kingdom) and Hauts-de-Seine (France) that like Paris are highly dense regions with a relatively high share of student-age population. Following Evrytania with high-cost values are Lozère (France) and Lochaber, Skye & Lochalsh, Arran & Cumbrae and Argyll & Bute

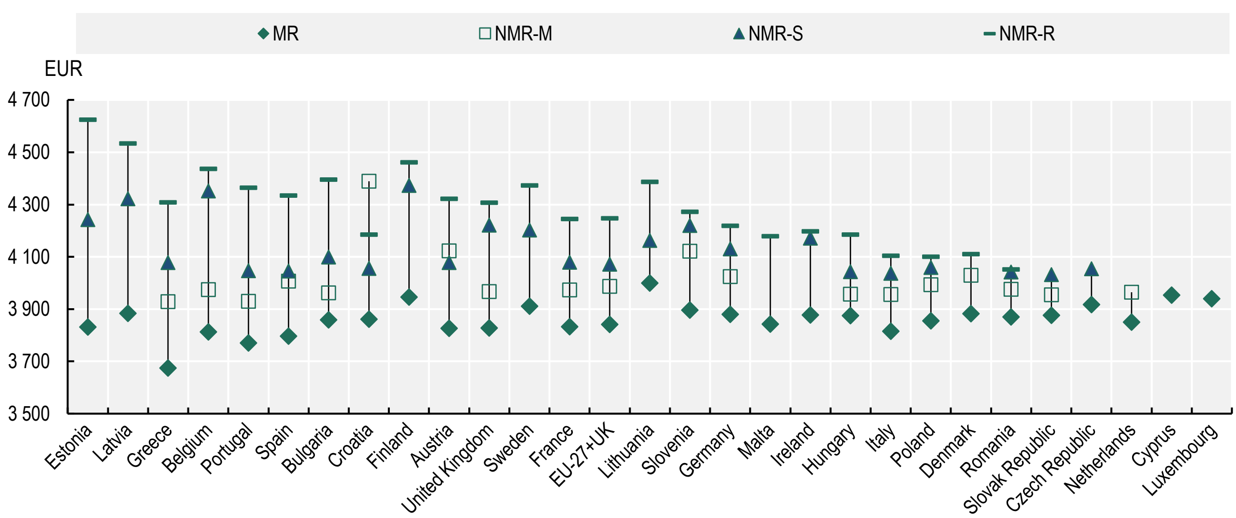
(United Kingdom) that as Evrytania are all remote and mountainous regions with a low share of primary-age school students.

The average annual cost by secondary school student across EU27+UK regions is EUR 6 571, and there is a difference of EUR 2 495 between Heinsberg (Germany) and Na h-Eileanan Siar (Western Isles) (United Kingdom). The results for secondary schools follow a similar geographical pattern compared to primary schools because they reflect geographical differences in density and demand. Variations between the two cases are driven by two factors: first, the different shares of secondary age school students (compared to primary school age shares); and second, the longer maximum travel distance allowed for secondary school students (see Chapter 2 for more details).

When aggregated by type of TL3 regions, for all countries with remote regions except Croatia,[4] costs per primary school student are lowest in metropolitan regions and highest in remote regions (Figure 3.10). The same holds for secondary school student costs except in Belgium (where per head costs in remote regions are as large as costs per head in regions close to a small city) and in Slovenia (Figure 3.11). Regional type differences in primary school costs per student are highest in Estonia, Latvia, and Greece and lowest in the Netherlands, Czech Republic, and Slovak Republic. For secondary schools, they are highest in Belgium, Greece and the United Kingdom, and lowest in the same countries as for primary schools.

Figure 3.10. Annual cost per primary school student (estimated) by country and type of TL3 region, EU27+UK

2011



Note: MR=Metropolitan Region; NMR-M=Non-Metropolitan Region Close to Metropolitan; NMR-S=Non-Metropolitan Region Close to Small Metropolitan; NMR-R=Non-Metropolitan Region Remote.
Source: Authors' elaboration based on (Goujon et al., 2021[2]; Jacobs-Crisioni et al., n.d.[3]).

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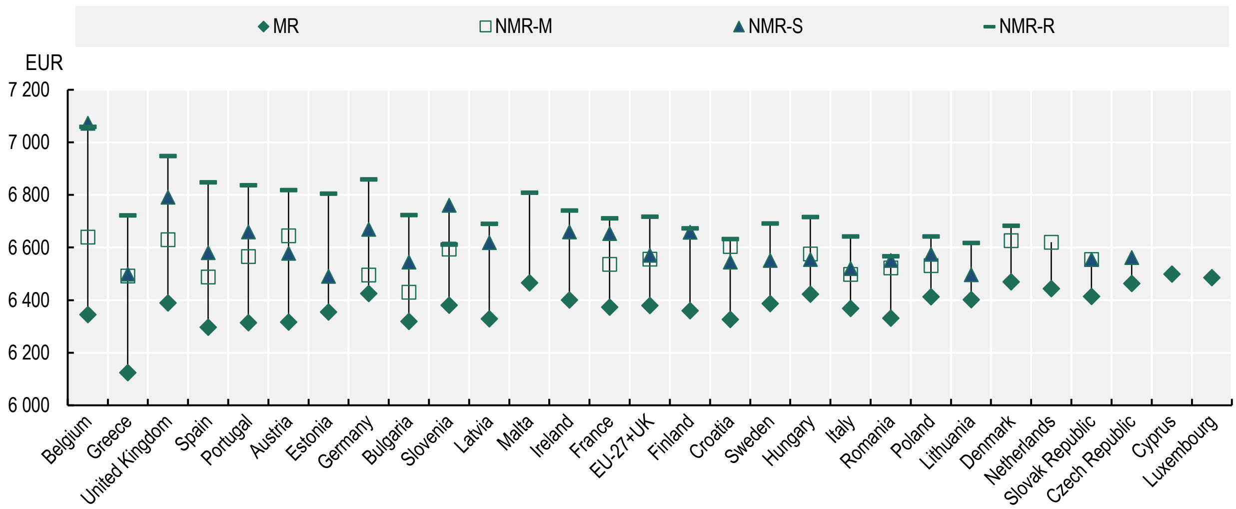
Figure 3.11. Annual cost per secondary school student (estimated) by country and type of TL3 region, EU27+UK

2011



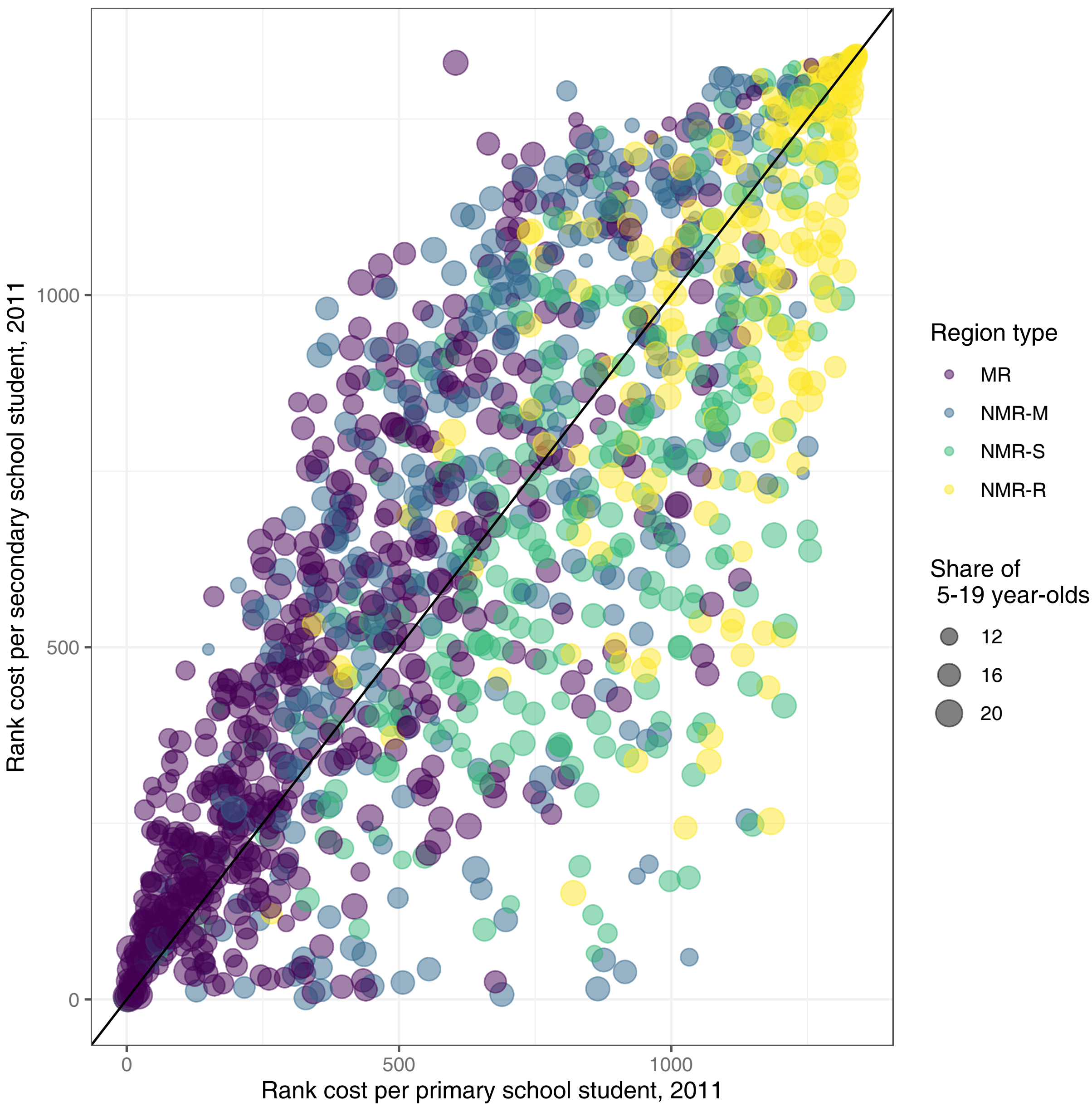
Note: MR=Metropolitan Region; NMR-M=Non-Metropolitan Region Close to Metropolitan; NMR-S=Non-Metropolitan Region Close to Small Metropolitan; NMR-R=Non-Metropolitan Region Remote.
Source: Authors' elaboration based on (Goujon et al., 2021[2]; Jacobs-Crisioni et al., n.d.[3]).

StatLink https://doi.org/10.1787/888934246108

Figure 3.12 plots the rank of cost per student (from lowest to largest) in primary versus secondary schools across 1 341 TL3 regions, with colours indicating the type of TL3 region. Proximity to the diagonal line in this plot - more recurrent at the top and bottom of the rank- indicates that a region with relatively high (low) primary school costs is likely to also have relatively high (low) secondary school costs. Although as expected metropolitan regions are more present closer to the axis, some metropolitan regions are among the regions with the highest costs per student in both primary and secondary schools. The top 10 metropolitan regions with the highest expenditure in primary schools are seven German regions, two Austrian regions and one Bulgarian region (Sofia) all with a relatively low share of people of school age.

Figure 3.12. Rank of (estimated) annual cost per primary vs secondary school students by type of TL3 region, EU27+UK

2011



Note: MR=Metropolitan Region; NMR-M=Non-Metropolitan Region Close to Metropolitan; NMR-S=Non-Metropolitan Region Close to Small Metropolitan; NMR-R=Non-Metropolitan Region Remote.
Source: Authors' elaboration based on (Goujon et al., 2021[2]; Jacobs-Crisioni et al., n.d.[3]).

The provision of primary education and the municipal level

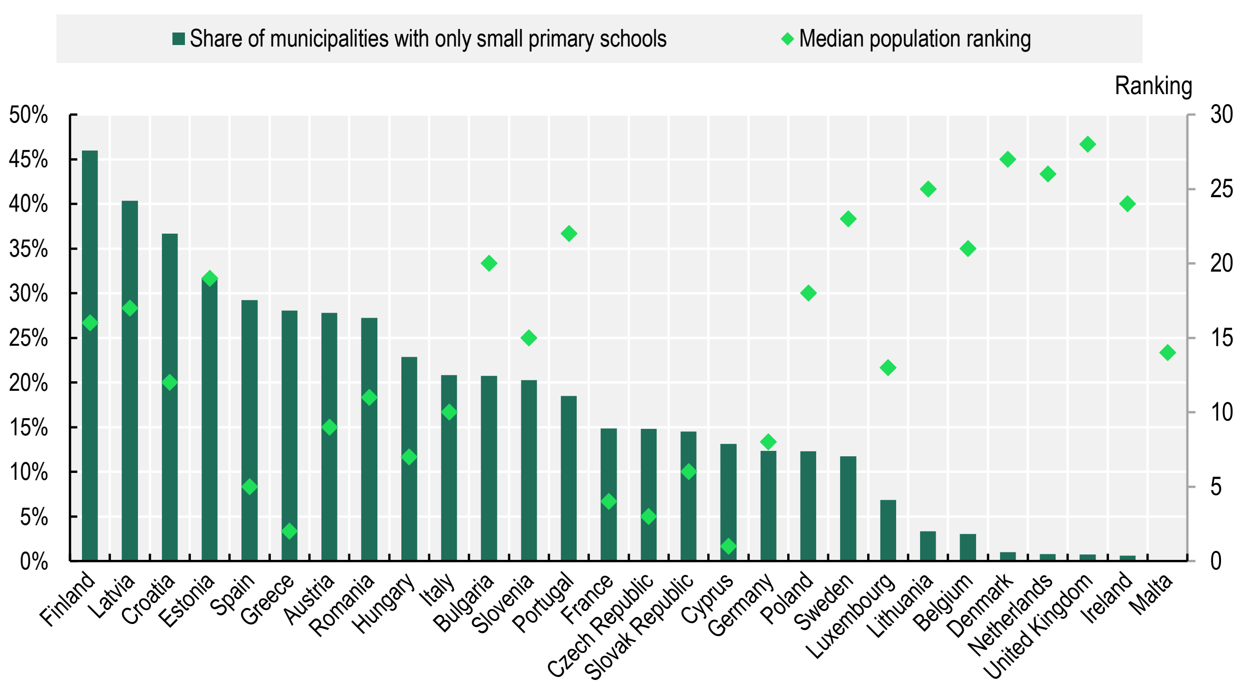
Across European countries, municipalities have an important role to play in the provision of primary education. In many countries, local governments have significant responsibilities with respect to the provision of primary education, sometimes including even its funding, for example in Sweden. Countries, however, have widely diverging arrangements with respect to the number and average size of municipalities: the median population per municipality varies from 222 people in Cyprus to 130 633 people in the United Kingdom.

Countries with strong municipal consolidation and, consequently, relatively large median municipal populations include the United Kingdom, Ireland, the Netherlands and Denmark (Figure 3.13). In these countries, the share of municipalities with only small schools is negligible because a larger number of students are hosted in larger municipal borders. At the other extreme, countries with high municipal fragmentation, including Cyprus, Greece, Czech Republic, France and Spain, have a relatively large share of municipalities with no schools or only small schools. In Spain, for instance, out of 8 124 municipalities, 45% do not have any school, 36% have only one school and 29% have only small schools. In countries with high municipal fragmentation, most municipalities that have only small schools have in fact only one school. This is the case in Spain (29% of municipalities with small schools versus 26% with only one small school), Greece (28% versus 27%) and France (15% versus 14%).

In large sparsely populated countries and small countries experiencing depopulation including Finland, Latvia, Estonia and Bulgaria, relatively high municipal consolidation for European standards is still associated with a relatively large share of municipalities with only small schools. In these countries, municipalities host more than one small school. For instance, in Finland, 46% of municipalities have only small schools, but only 5% have only one small school (Figure 3.13). There is a similar discrepancy between the share of small schools and the share of only one small school in other relatively consolidated countries including Latvia (40% versus 3%) and Estonia (32% versus 4%).

Figure 3.13. Share of municipalities with only small primary schools vs. median municipality size ranking by country, EU27+UK

2018 LAU2 boundaries and population; 2011 school data



Source: Authors' elaboration based on (Goujon et al., 2021[2]; Jacobs-Crisioni et al., n.d.[3]).

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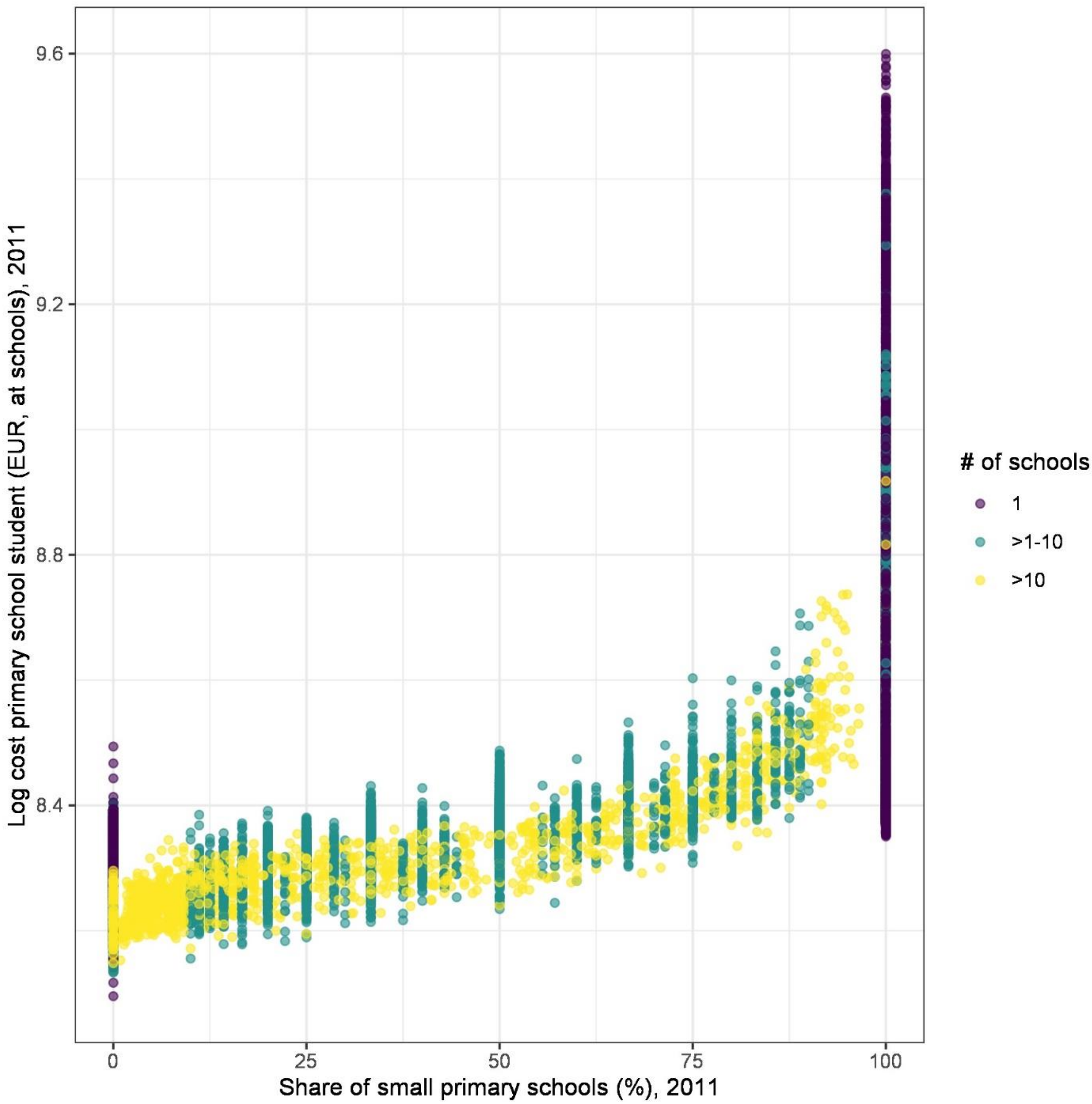
A higher share of small schools in a municipality drives up the costs measured at primary schools (instead of the place of residency of students). As Figure 3.14 illustrates, school-based costs per primary school student by municipality increase when at least half of the municipality schools are small. Extreme cases - with costs over four times the average expenditure - all occur in municipalities with one small school. The top three extreme cases are all municipalities with less than 200 inhabitants, and a single small school, each serving less than 8 students.

Figure 3.14. Annual cost per primary school student versus share of small primary schools by municipality, EU27+UK



Source: Authors' elaboration based on (Goujon et al., 2021[2]; Jacobs-Crisioni et al., n.d.[3]).

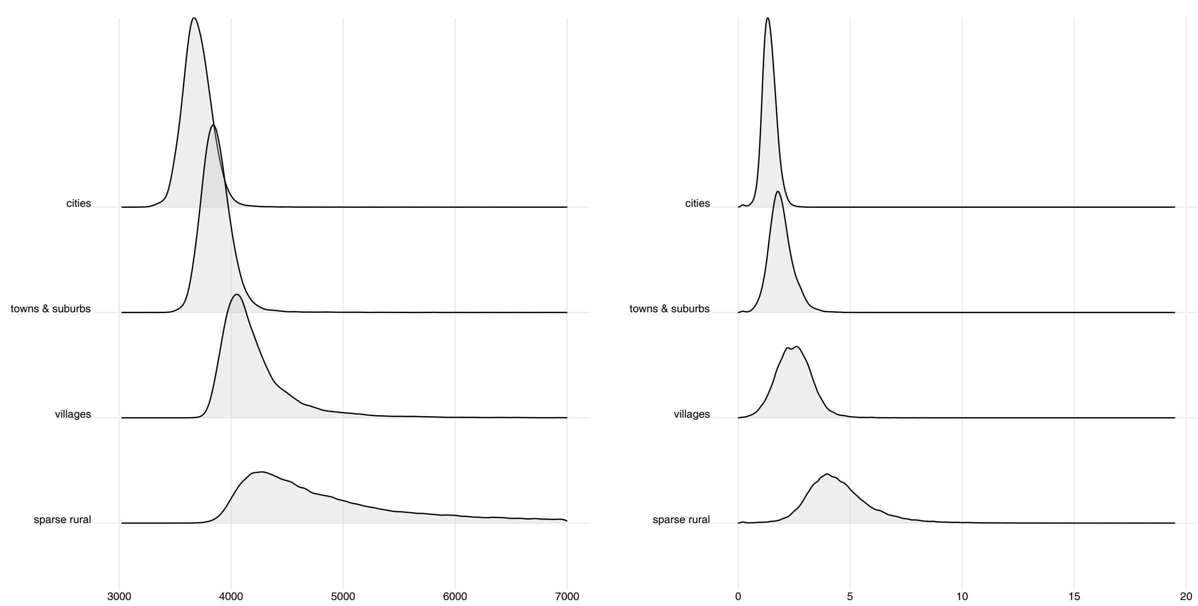
While municipal consolidation can help reduce the number of municipalities operating one small school at high costs, the room for further school consolidation and the consequences for travel will depend on the initial level of municipal fragmentation of the country and its geography. The next section will discuss in more detail the changes in accessibility following changes in the school network.

Present costs and access by degree of urbanisation

To get a sense of the variation of the results across degrees of urbanisation, Figure 3.15 and Figure 3.16 plot the density distribution of cost and distance travelled per student across all simulated schools in Europe. In primary and secondary schools, both the means and the dispersion of costs and distance travelled per student increase with sparsity, with the lowest mean and variation in cities, and the largest in sparse rural areas. The larger dispersion in costs in sparse rural areas and smaller differences in travelled distance between primary and secondary schools happens because secondary school students can travel longer travel distances than primary school students, which decreases the likelihood of very small secondary schools with very high cost per student. In other words, the results reflect the larger geographical concentration of secondary schools compared to primary schools.

Figure 3.15. Distribution of annual cost and distance travelled per primary school student (estimated, at schools) by degree of urbanisation

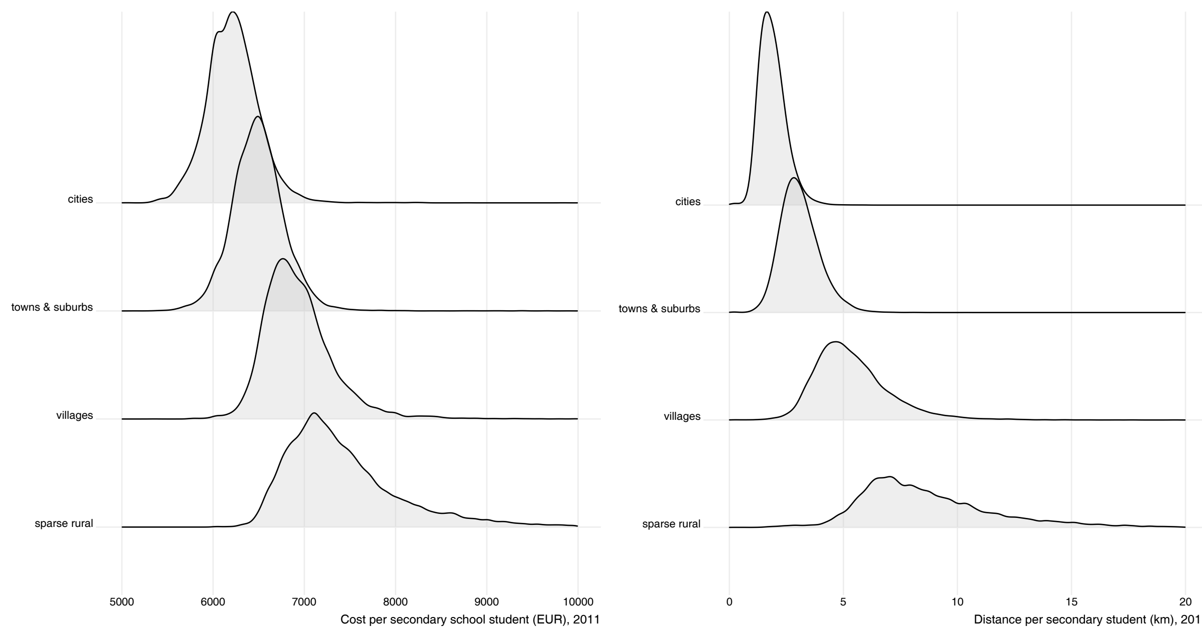
2011



Source: Authors' elaboration based on (Goujon et al., 2021[2]; Jacobs-Crisioni et al., n.d.[3]).

Figure 3.16. Distribution of annual cost and distance travelled per secondary school student (estimated, at schools) by degree of urbanisation

2011



Source: Authors' elaboration based on (Goujon et al., 2021[2]; Jacobs-Crisioni et al., n.d.[3]).

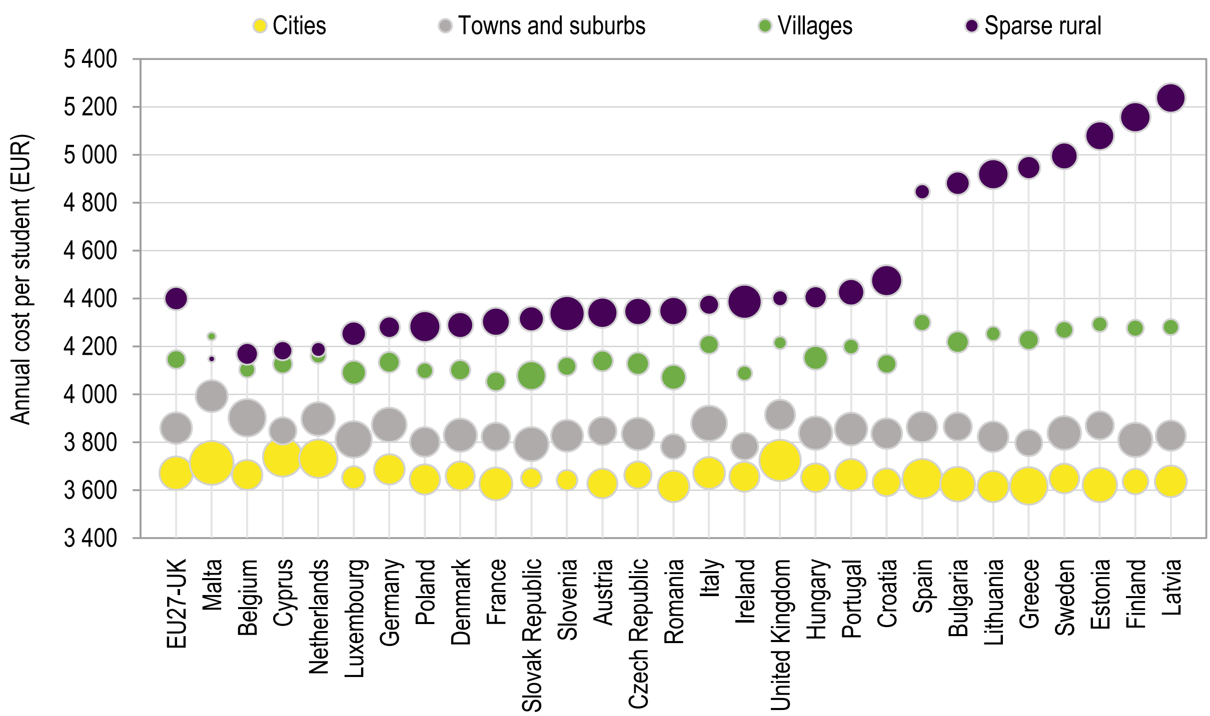
Costs

Figure 3.17 and Figure 3.18 show annual costs per student estimates by degree of urbanisation and by country. For primary schools, costs per student tend to go down as density goes up (Figure 3.17). They are highest in sparse rural areas and lowest in cities. For EU27+UK, the difference in annual cost per student between cities and sparse rural areas is about EUR 650 per student. The cost gap between cities and sparse rural area is EUR 1 000 or more in Spain, Bulgaria, Lithuania, Sweden, Greece, Estonia, Finland, and Latvia. In these countries, the difference in costs per primary student between villages and cities is about half that between sparse rural areas and cities. In the other countries, the costs per head in sparse rural areas are only slightly higher than in villages.

For secondary schools, annual costs per student also decrease with increasing density, with a difference of EUR 681 between cities and sparse rural areas (Figure 3.18). However, the difference between costs in villages and sparse rural areas is smaller than for primary schools. In fact, in Cyprus, Italy, Belgium, the Netherlands, Malta, and the United Kingdom, costs per head are lower in sparse rural areas compared to villages. The cost gap between cities and towns and suburbs are larger in secondary schools than in primary schools. The gap is larger than EUR 400 in Malta, Spain, Belgium, Austria, Slovenia, and the United Kingdom, while they are always below EUR 290 for primary schools. For EU27+UK, the difference in cost per student in secondary schools between cities and sparse rural areas is about EUR 670 per student. The cost gap between cities and sparse rural areas is also quite substantial for the case of secondary schools in many countries including Spain, Greece, Bulgaria, Luxembourg, Sweden and Estonia, although it stays below EUR 1 000.

Figure 3.17. Annual cost per primary school student (estimated) by country and degree of urbanisation, EU27+UK

Bubble areas represent the share of national population, 2011



Note: Costs at place of residency. Bubble areas represent the share of national population.
Source: Authors' elaboration based on (Goujon et al., 2021[2]; Jacobs-Crisioni et al., n.d.[3]).

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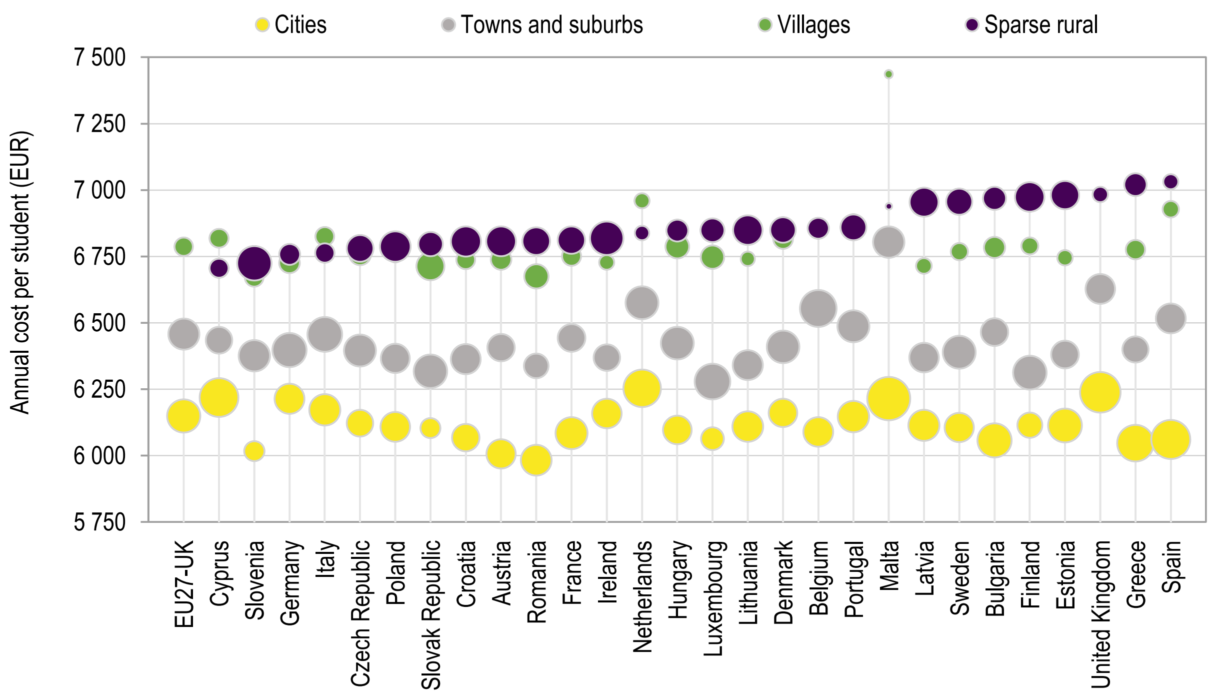
Figure 3.18. Annual cost per secondary school student (estimated) by country and degree of urbanisation, EU27+UK

Bubble areas represent the share of national population, 2011



Note: Costs at place of residency. Bubble areas represent the share of national population.
Source: Authors' elaboration based on (Goujon et al., 2021[2]; Jacobs-Crisioni et al., n.d.[3]).

StatLink https://doi.org/10.1787/888934246165

Access

How far do students have to travel and where do they travel to when attending schools? Box 3.2 explains the measurement and interpretation of travelled distance in this report.

Box 3.2. How are school transport costs measured in this report?

Primary and secondary schools transport costs are expressed using average students' travelled road distance to their schools. The analysis in this chapter uses residence-based, not school-based, travel distances, unless specified.

The reported travel distances do not always reflect the minimum travel distance for each student. This is because in the model, while closer schools have a much larger preference in student's choices, a portion of students would attend farther schools because of the balancing mechanism described in Chapter 2. This means that the reported average travelled distances are typically correlated, but slightly higher than often measured distances to nearest facilities (Milbert et al., 2013[28]) (Papaioannou, 2018[29]).

Calculating travel costs involves monetizing the value of time lost, as well as defining the costs of opportunities missed because of travel. Because of the complexity involved in these calculations, this report uses travelled distance as a limited approximation of travel costs (Jara-Diaz, S., 2020[30]) (Liu, Q., Jiang R., Liu R., Hui Z. and Gao Z., 2020[31]).

Table 3.1 summarises residence-to-school mobility flows across degrees of urbanisation for all students in simulated primary and secondary schools in EU27+UK countries. In both primary and secondary schools, villages have the largest share of students coming from other types of settlements: 39% (54%) of all primary (secondary) students attending school in villages do not come from villages. The large majority of these students actually comes from sparse rural areas. Across countries, the share of students in primary schools in villages coming from another area is highest in Slovenia (54%), Poland (51%), Ireland (49%) and Belgium (48%), and lowest in Spain (26%), Bulgaria (29%), Slovak Republic, and Hungary (both 31%).

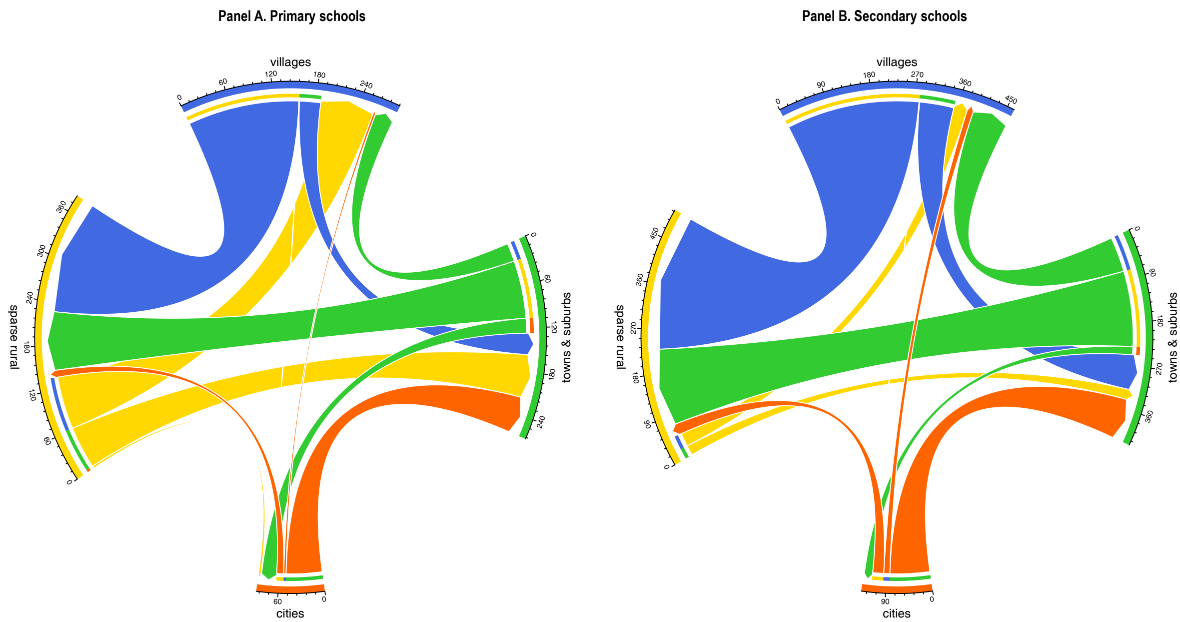
Table 3.1. Primary and secondary student flows shares by degree of urbanisation

Type	Share of students coming from other areas (%)	Share of origin places of students coming from other areas (%)			
		Share from sparse rural	Share from villages	Share from towns and suburbs	Share from cities
Primary schools					
Sparse rural	29%	0%	54%	43%	2%
Villages	39%	84%	0%	16%	0%
Towns and suburbs	13%	64%	20%	0%	16%
Cities	5%	15%	5%	79%	0%
Secondary schools					
Sparse rural	25%	0%	57%	43%	1%
Villages	54%	79%	0%	20%	0%
Towns and suburbs	22%	64%	30%	0%	7%
Cities	9%	19%	11%	70%	0%

Source: Authors' elaboration based on (Goujon et al., 2021[2]; Jacobs-Crisioni et al., n.d.[3]).

Figure 3.19 shows a visualisation of the total outflows and inflows of students per degree of urbanisation. For instance, across EU27+UK countries, the over 1 862 000 students attending primary schools in villages come mostly from sparse rural areas (in the diagram represented by a thin yellow line below the blue line representing the total amount of flows in villages, and the largest blue arrow indicating village students coming from sparse rural areas). A much lower number of students that live in villages go to primary school in sparse rural areas and towns and suburbs, with a similar pattern observed for secondary schools. In this sense, villages act as hubs for schooling. This is to a lesser degree also true for towns and suburbs, which host students coming from all other areas. Cities on the other hand show much more limited inflows and outflows of students, and thus serve mostly students living in cities.

Figure 3.19. Primary and secondary student flows by degree of urbanisation

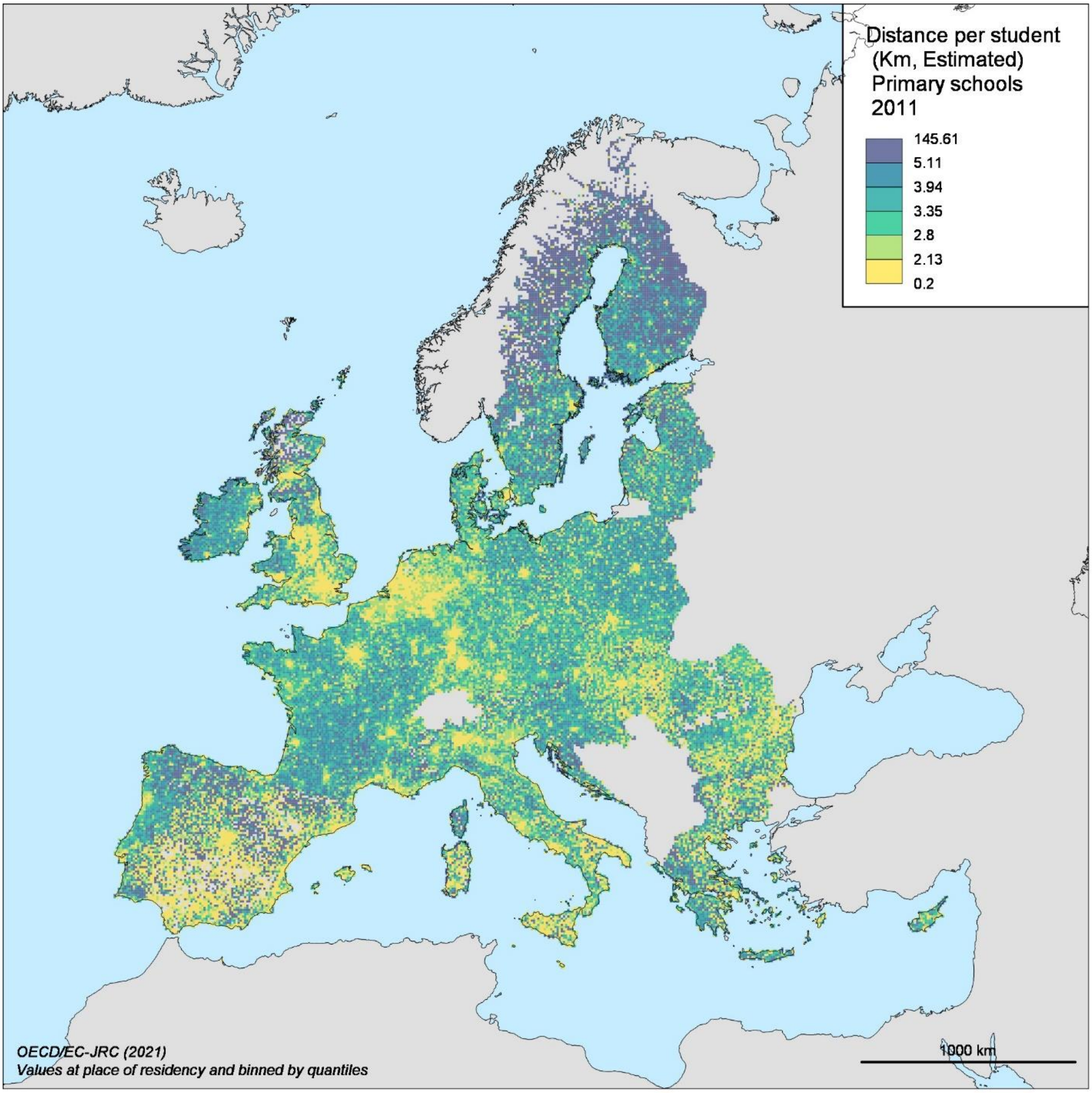


Note: Flows per 10 000 students. Arrows point to the origin of flows, colour coded by destination.
Source: Authors' elaboration based on (Goujon et al., 2021[2]; Jacobs-Crisioni et al., n.d.[3]).

Figure 3.20 and Figure 3.21 show the average distance travelled by students for primary and secondary schools in EU27+UK countries. For both primary and secondary schools, the lowest travelled distances correspond to cities, while the highest distances occur in sparsely populated areas, in particular in the north of Scandinavia. While the median distance for primary schools (3.3 km) is about half that of secondary schools (6.5 km), the overall patterns of school access are similar regardless of school type, with some exceptions including Eastern Bulgaria and Greece, where primary schools are close and secondary schools far. Demographic differences, and in particular the share of students of each type (Figure 3.5 and Figure 3.6), drive these differences.

Figure 3.20. Travelled distance to primary and secondary schools per student (estimated), EU27+UK

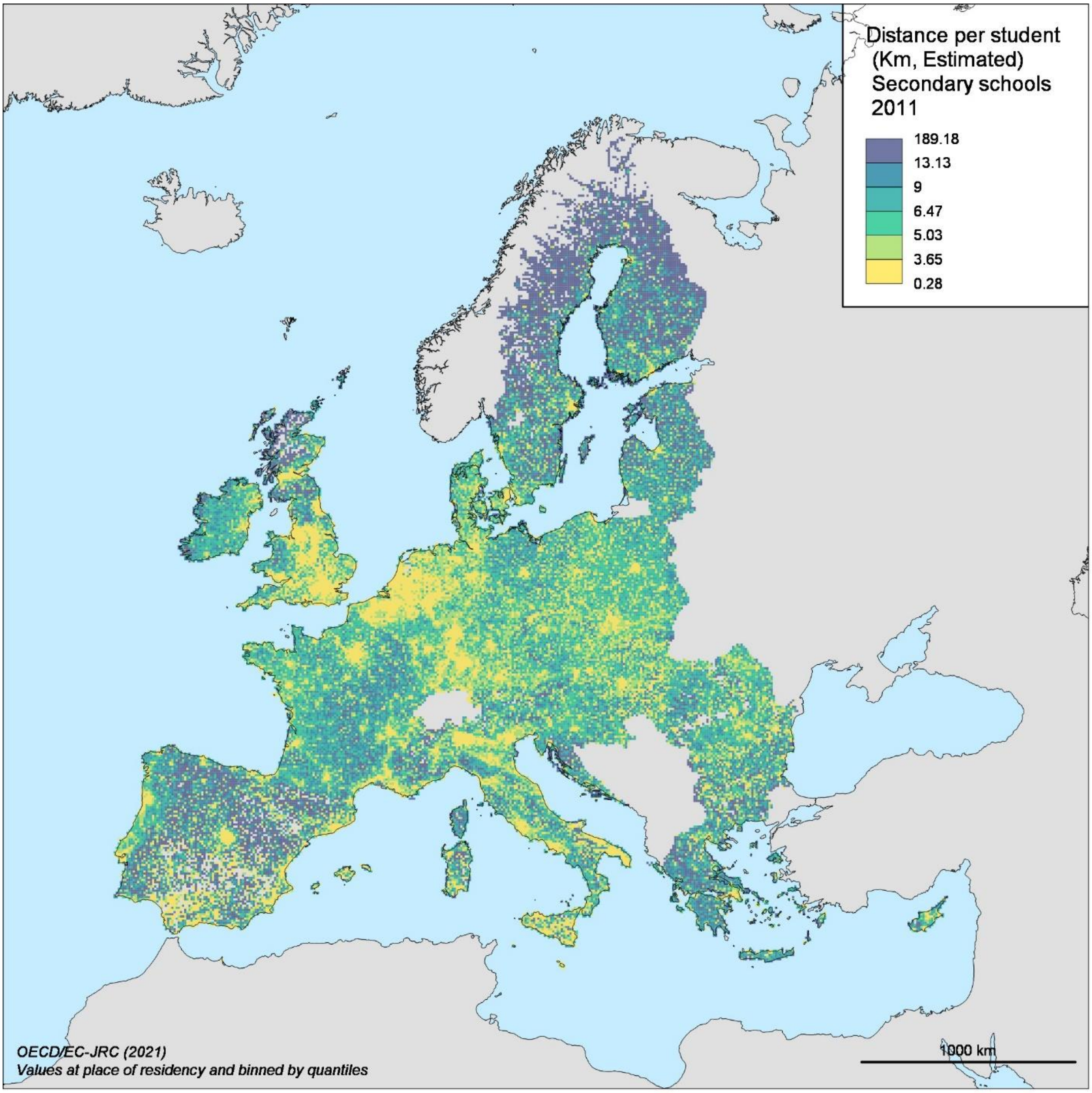
2011



Source: Authors' elaboration based on (Goujon et al., 2021[2]; Jacobs-Crisioni et al., n.d.[3]).

Figure 3.21. Travelled distance to secondary schools per student (estimated), EU27+UK

2011

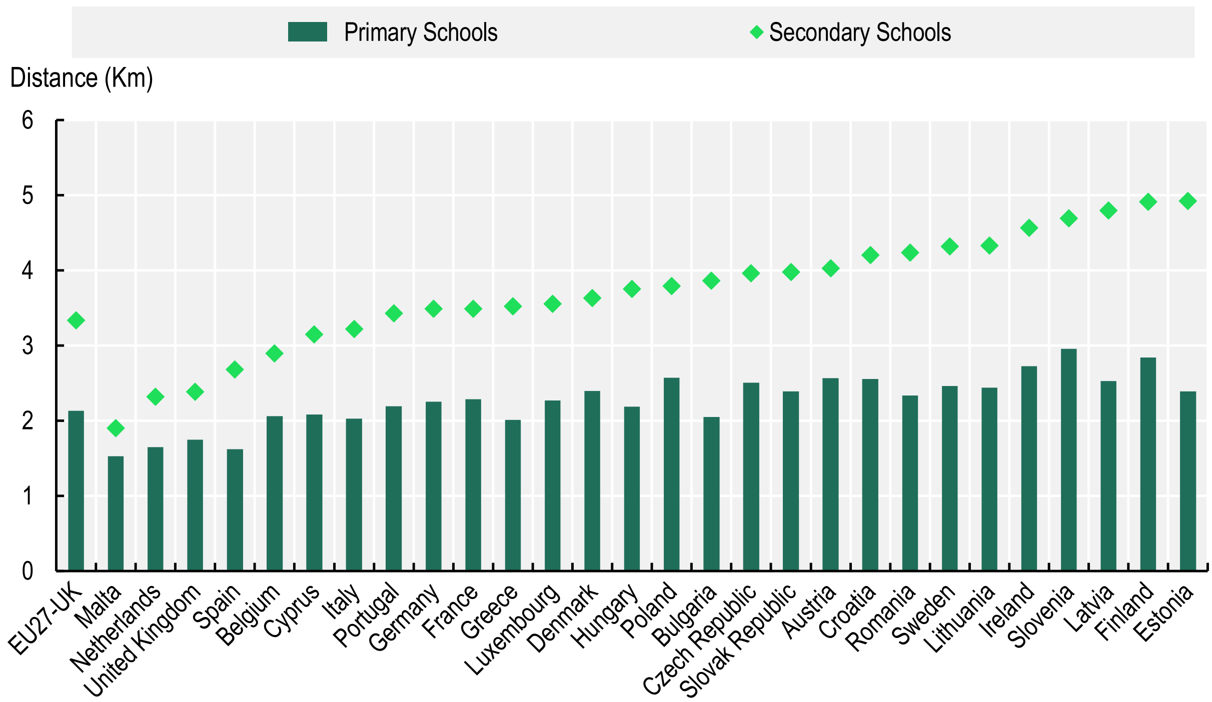


Source: Authors' elaboration based on (Goujon et al., 2021[2]; Jacobs-Crisioni et al., n.d.[3]).

Comparing primary and secondary schools show that for EU27+UK, the average secondary school student needs to travel 1.5 km more, thus a 75% longer distance than the average primary school student (Figure 3.22). These differences are due to less restrictive maximum distances and, consequently, the larger sizes of secondary schools, which increase the geographical concentration of secondary schools. The differences are substantial across countries. In highly urbanised countries including Malta, the Netherlands, the United Kingdom, and Spain, distance to schools is lower than the EU27+UK average. In contrast, in countries such as Ireland, Slovenia, Latvia, Finland and Estonia, distance to schools is larger due to their relatively large share of population in rural and sparsely populated areas. In these countries, the ratios between the primary and secondary schools' distance become even wider, and can be as high as 2-2.5 times.

Figure 3.22. Travelled distance to primary and secondary schools per student (estimated) by country, EU27+UK

2011



Source: Authors' elaboration based on (Goujon et al., 2021[2]; Jacobs-Crisioni et al., n.d.[3]).

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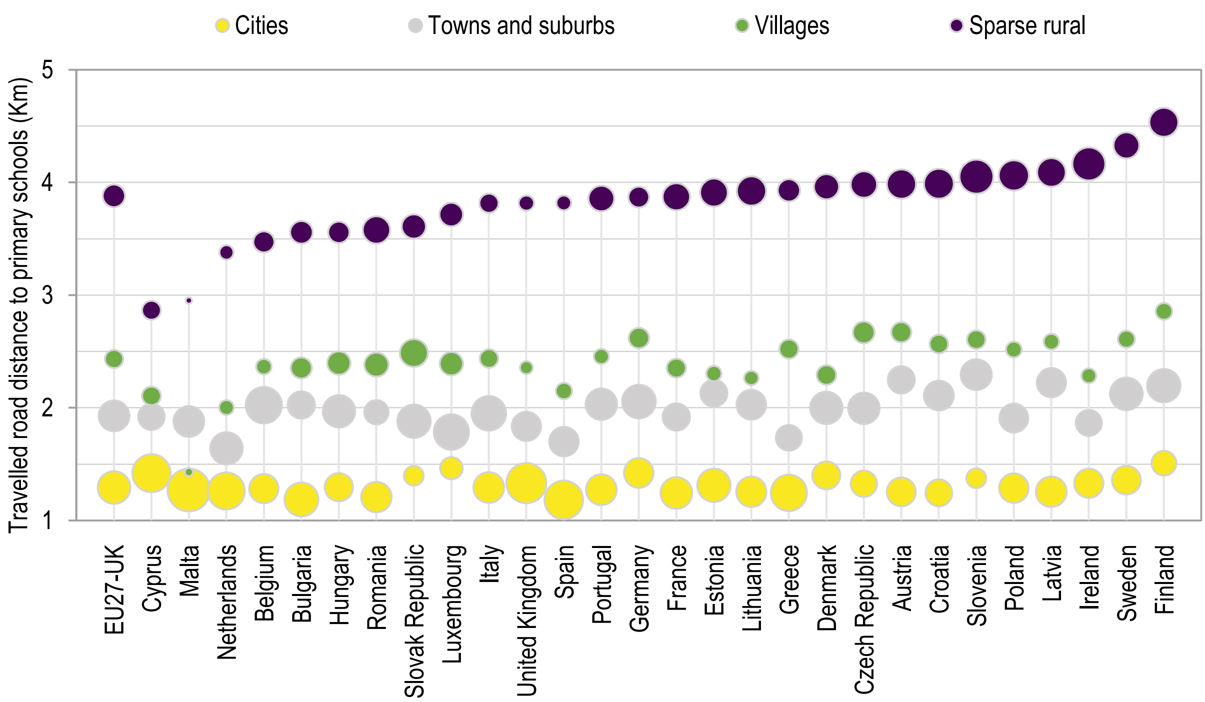
Higher density clearly decreases distance to primary schools, as most students from cities travel less than 2 km to primary and secondary schools, and students from towns and suburbs only slightly more (Figure 3.23). While villages show slightly higher distances, primary school students in sparse rural areas travel on average four to five longer distances than students in cities. These results are in line with recent studies (Kompil et al., 2019[32]); (ESPON, 2018[33]) that show that, in general, cities, towns and suburbs provide better access to public services such as schools.

Average distances across countries are similar in cities, towns and suburbs, and in villages, and these distances are in fact all roughly similar to EU27+UK averages (Figure 3.23). In contrast, distances to primary schools in sparse rural areas display large variation across countries, as expected from the difference in human settlement patterns and in particular the presence of sparsely populated areas (see Chapter 1). For instance, while in Cyprus the distance to primary schools in sparse rural areas is only 2 km longer than in cities, for Finland the difference is double that at 4 km.

Differences in distances to secondary schools across degrees of urbanisation are larger because secondary schools are more concentrated in space, with average distances roughly 7 km higher in sparse rural areas in Finland, Latvia and Estonia, more than four times the distances travelled by students in the cities in those countries (Figure 3.24).

Figure 3.23. Travelled distance to primary schools per student by country and degree of urbanisation (estimated), EU27+UK

2011



Note: Bubble areas represent the share of national population.
Source: Authors' elaboration based on (Goujon et al., 2021[2]; Jacobs-Crisioni et al., n.d.[3]).

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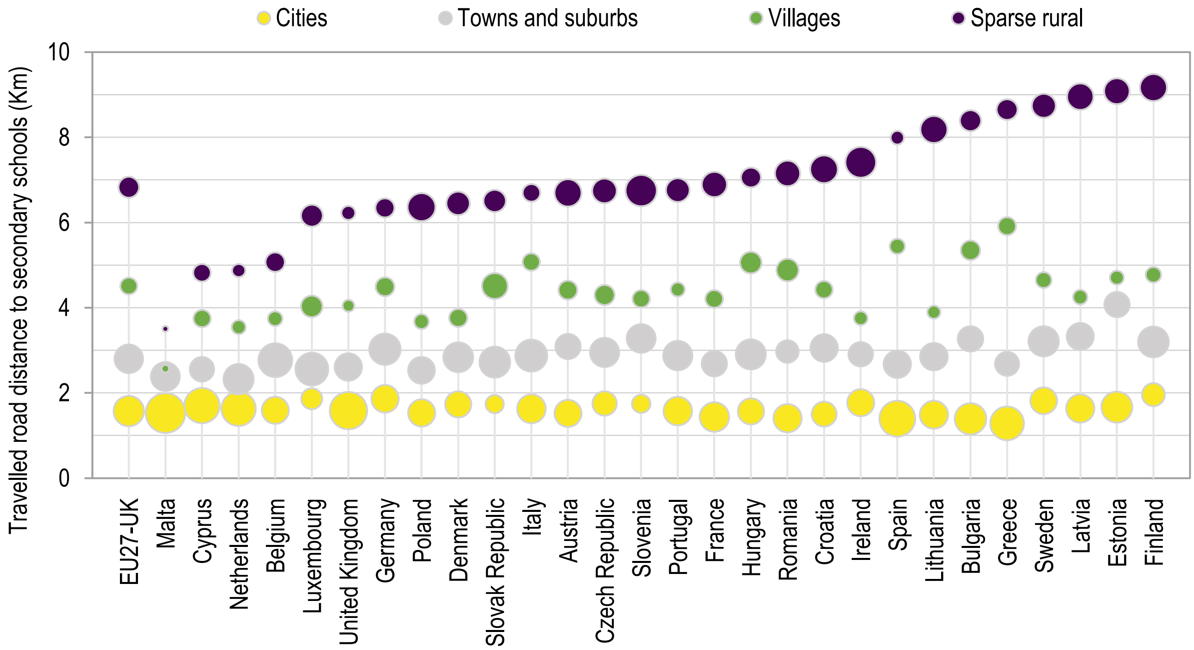
Figure 3.24. Travelled distance to secondary schools per student by country and degree of urbanisation (estimated), EU27+UK

2011



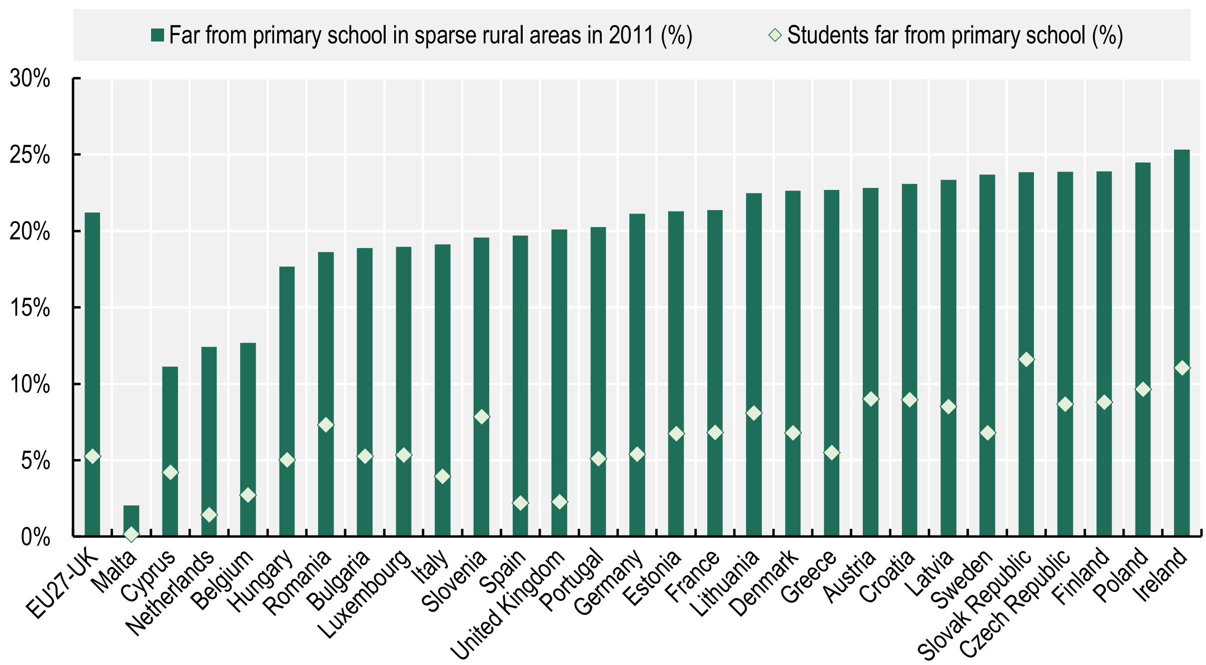
Note: Bubble areas represent the share of national population.
Source: Authors' elaboration based on (Goujon et al., 2021[2]; Jacobs-Crisioni et al., n.d.[3]).

StatLink https://doi.org/10.1787/888934246222

To understand equity impacts of travel distances for students, Figure 3.25 and Figure 3.26 plot the percentage of students in sparse rural areas that are far from a school in each country. Students are considered far from school if their travelled distance is more than twice the distance travelled on average to attend primary or secondary schools, respectively. In the majority of countries, more than half of the primary school student population in sparse rural areas has to travel far to go to school. Although country-wide percentages are much lower, in some countries a considerable share of students needs to travel long distances to go to school. Compared with primary schools, the differences are even larger for secondary schools, and in some countries, over 30% of sparse rural students have to travel long distances.

Figure 3.25. Share of total and sparse rural areas population that travels far to primary schools (esimated) by country, EU27+UK

2011



Source: Authors' elaboration based on (Goujon et al., 2021[2]; Jacobs-Crisioni et al., n.d.[3]).

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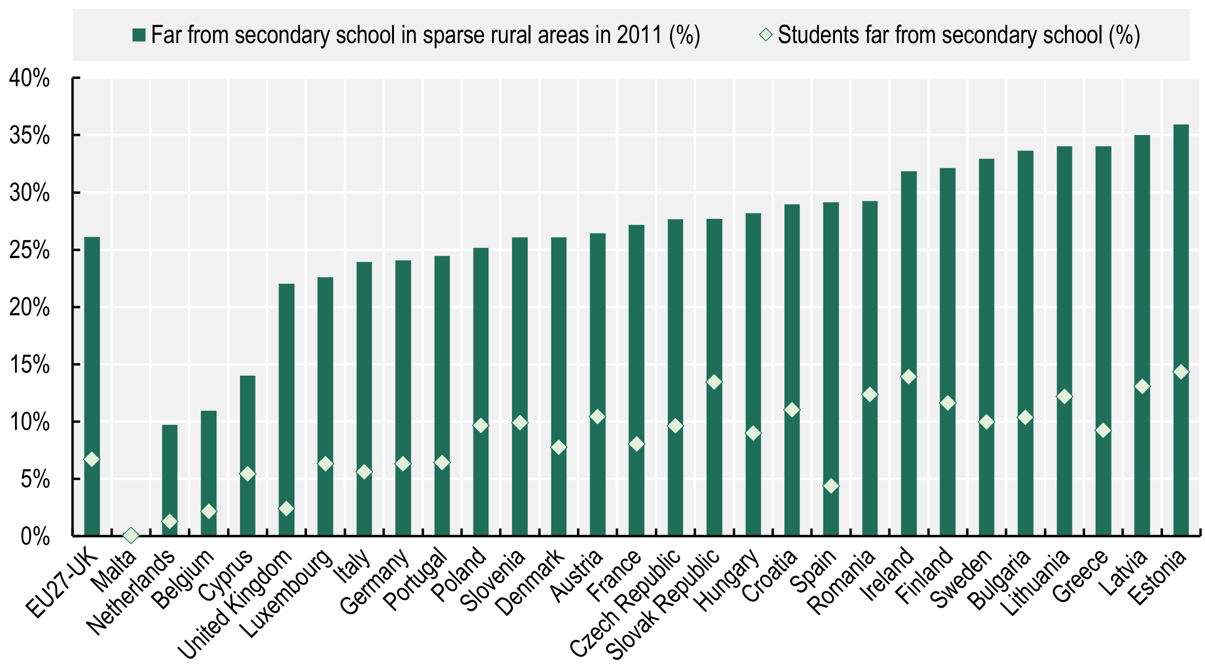
Figure 3.26. Share of total and sparse rural areas population that travels far to secondary schools (esimated) by country, EU27+UK

2011



Source: Authors' elaboration based on (Goujon et al., 2021[2]; Jacobs-Crisioni et al., n.d.[3]).

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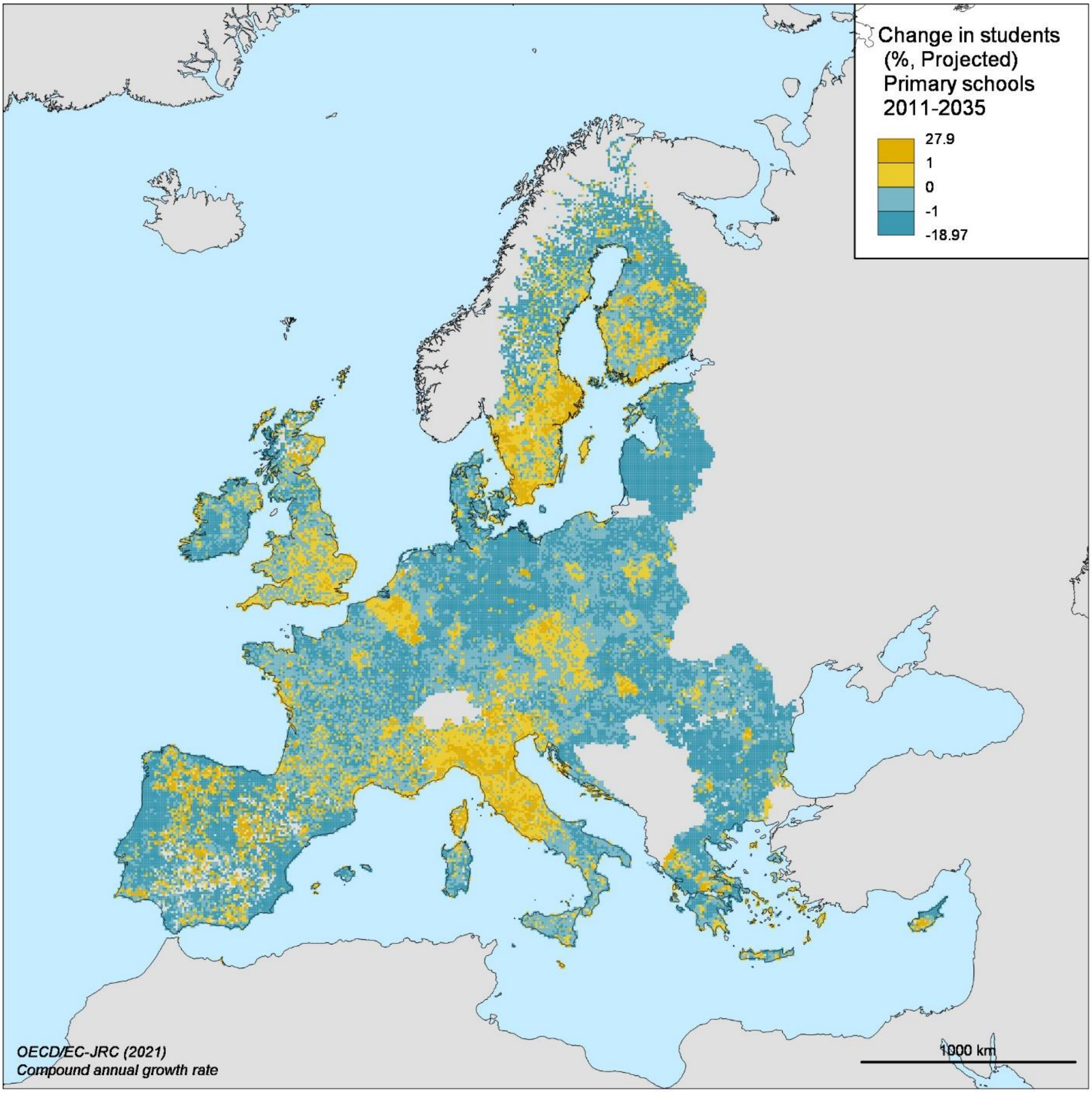
Future school costs and access

Available population projections allow understanding the changes in demand for primary and educational services across EU27+UK countries, that will have an impact not only on the demand for school sites, resources and teachers, but if it affects school supply, also on access to school. According to available projections, parts of Europe and the United Kingdom are projected to become even more sparsely populated (see Chapter 1), with significant variations in the prospective demand for both primary and secondary schooling across countries (Figure 3.27 and Figure 3.29).

Figure 3.27. Projected change in population in primary school age, EU27+UK

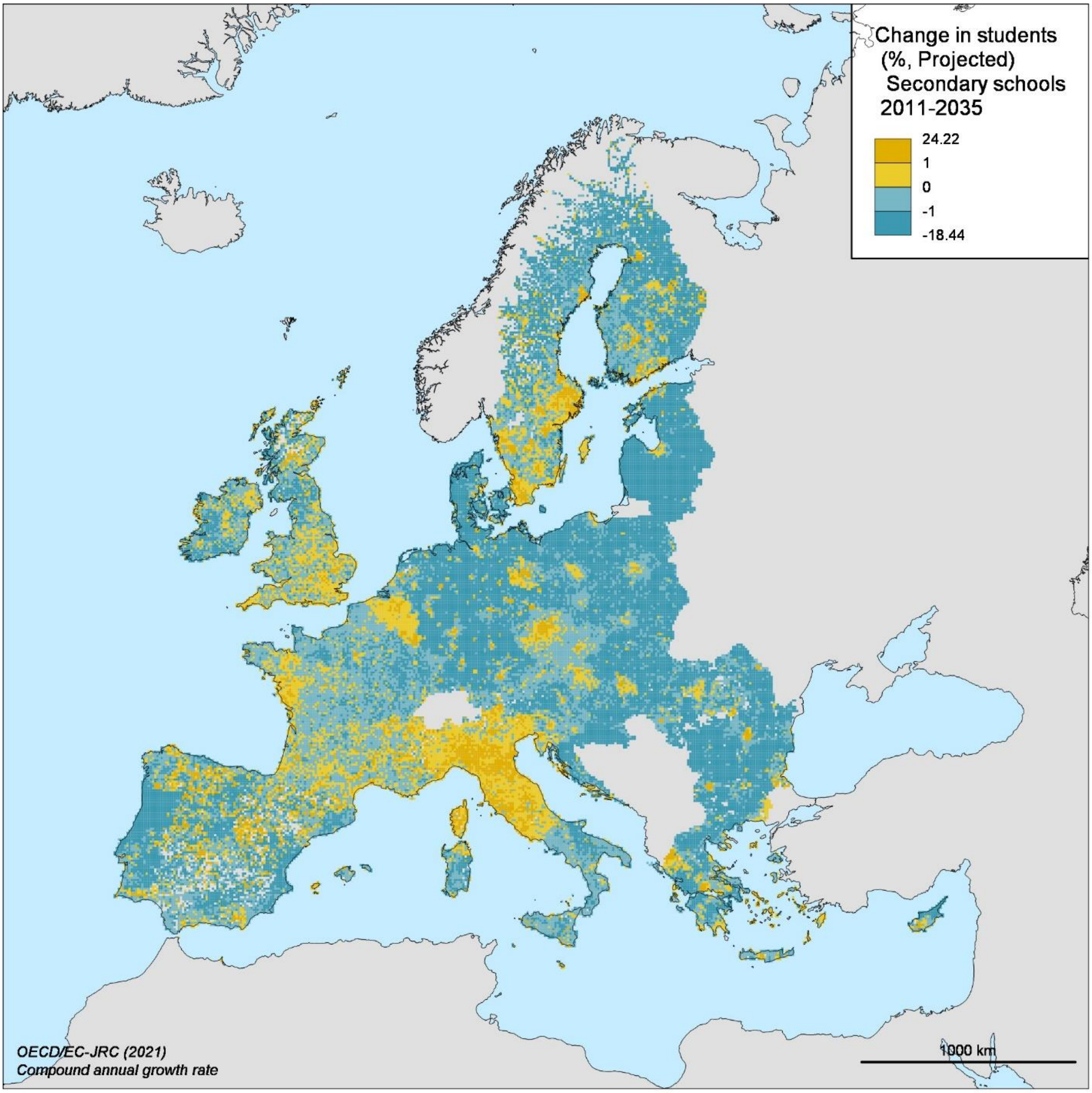
2011-35



Note: Change is calculated as compound annual growth rate in 2011-35.
Source: Authors' elaboration based on (Goujon et al., 2021[2]; Jacobs-Crisioni et al., n.d.[3]).

Figure 3.28. Projected change in population in secondary school age, EU27+UK

2011-35

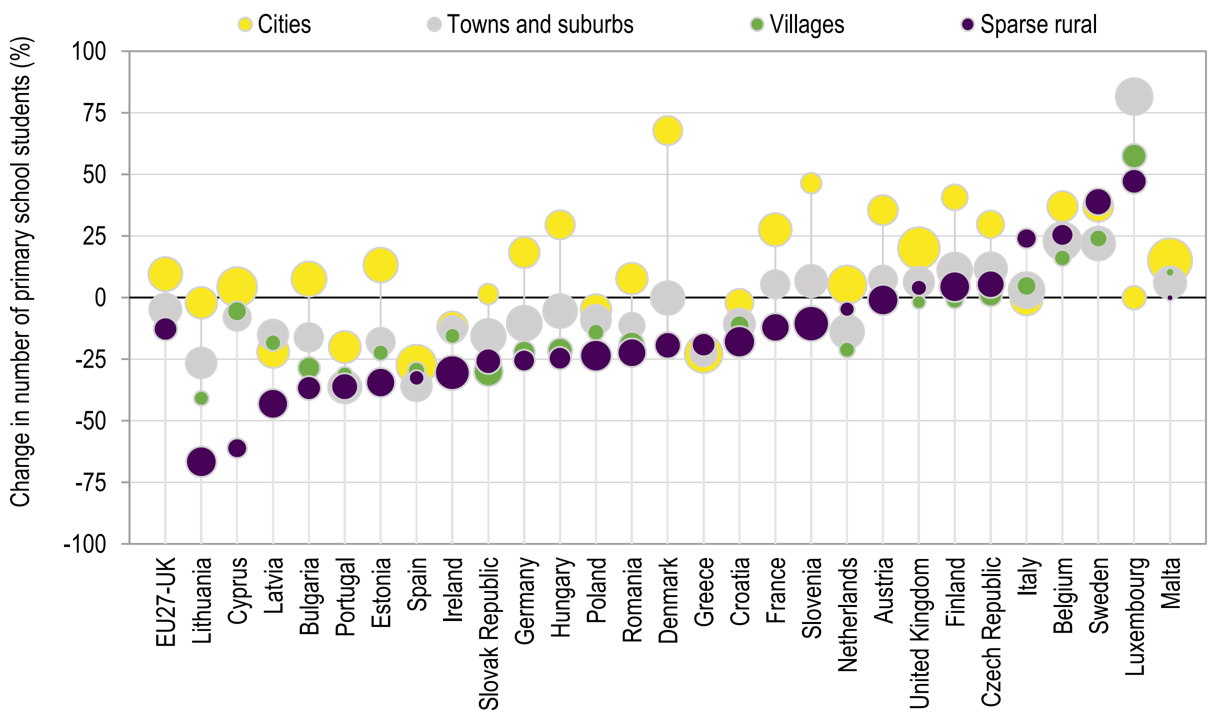


Note: Change is calculated as compound annual growth rate in 2011-35.
Source: Authors' elaboration based on (Goujon et al., 2021[2]; Jacobs-Crisioni et al., n.d.[3]).

The projections for 2035 using the degree of urbanisation for each EU27+UK country (Figure 3.29) show that in general, projected changes in student numbers lead to considerable additional demand for schools in cities, and a demand shift from rural to urban areas, in particular in Eastern, Central and North-western Europe.

Figure 3.29. Change in primary school students by country and degree of urbanisation (estimated), EU27+UK

2011-35



Note: For readability, a few values above 100% are not shown in the graph. Bubble areas represent the share of national population.
Source: Authors' elaboration based on (Goujon et al., 2021[2]; Jacobs-Crisioni et al., n.d.[3]).

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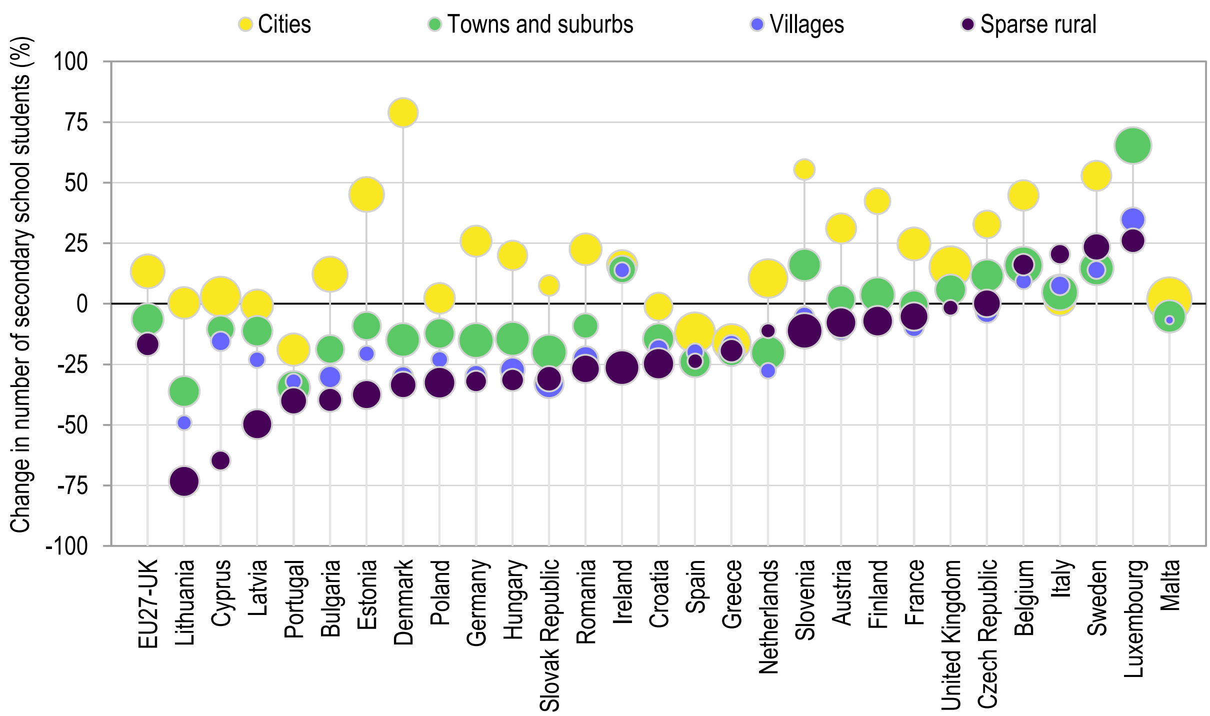
Figure 3.30. Change in secondary school students by country and degree of urbanisation (estimated), EU27+UK

2011-35



Note: For readability, few values above 100% are not shown in the graph. Bubble areas represent the share of national population.
Source: Authors' elaboration based on (Goujon et al., 2021[2]; Jacobs-Crisioni et al., n.d.[3]).

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This section presents cost implications of two future scenarios based on population projections and different school networks for primary and secondary education. The first uses the projected supply of schools, and the second uses current supply of schools. This allows measuring a gap between a forward-looking scenario with one that does not estimate changes in the future supply of schools. The analysis then measures the gap between the two. The two scenarios are as follow:

1. **First scenario based on 2035 school supply and 2035 students**: This scenario replicates the approach used to obtained present costs and distances to schools but using projected demand for primary and secondary education in 2035 (i.e. the projected number of students in each grid-cell in 2035).
2. **Second scenario based on 2011 school supply and 2035 students**: This scenario assumes that the primary and secondary school network remains as in 2011 while it allocates students projected for 2035 (i.e. it assumes all 2011 schools remain in place and open).

First scenario based on 2035 school supply and 2035 students

In this scenario, the school network is reallocated using the projected student population distributions in 2035. Across most EU27+UK countries, projected changes in student population lead to considerable additional demand for schools in cities, and lesser demand in rural areas for both primary and secondary schools (Figure 3.31 and Figure 3.32).

Figure 3.31. Change in primary schools counts (estimated) by country and degree of urbanisation, EU27+UK

2011-35

Country name	Sparse rural	Villages	Towns and suburbs	Cities
EU27-UK	-3925	-1320	-1104	1735
Germany	-884	-417	-530	433
Poland	-688	-88	-149	-65
Spain	-404	-228	-758	-647
France	-396	-293	166	591
Romania	-371	-138	-73	38
Lithuania	-368	-15	-31	-4
Latvia	-222	-5	-11	-17
Ireland	-199	-11	-28	-18
Bulgaria	-187	-44	-37	19
Portugal	-169	-35	-243	-91
Finland	-153	-9	52	58
Greece	-147	-27	-85	-107
Hungary	-137	-35	-36	59
Slovak Republic	-81	-50	-40	3
Denmark	-79	-33	-19	105
Estonia	-76	-4	-11	7
Austria	-72	4	43	64
Cyprus	-62	-1	-3	4
Croatia	-52	-9	-18	-4
Slovenia	-18	2	16	10
Netherlands	-4	-71	-146	79
Malta	4	0	1	4
Luxembourg	5	15	29	12
United Kingdom	13	12	219	904
Czech Republic	41	2	39	56
Belgium	59	38	238	108
Sweden	229	33	129	115
Italy	493	87	182	19

Source: Authors' elaboration based on (Goujon et al., 2021[2]; Jacobs-Crisioni et al., n.d.[3]).

StatLink https://doi.org/10.1787/888934246317

Figure 3.32. Change in secondary schools counts (estimated) by country and degree of urbanisation, EU27+UK

2011-35

Country name	Sparse rural	Villages	Towns and suburbs	Cities
EU27-UK	-1473	-2194	-1081	1574
Poland	-439	-335	-219	-19
Romania	-128	-239	-53	53
United Kingdom	-99	-23	106	501
Lithuania	-98	-35	-49	-4
Bulgaria	-82	-76	-27	16
Germany	-71	-748	-304	518
Spain	-71	-154	-348	-192
Ireland	-71	-5	19	8
Latvia	-59	0	-13	-2
Portugal	-59	-79	-164	-65
Greece	-44	-35	-44	-48
Croatia	-42	-29	-23	-4
Cyprus	-37	-6	-2	-1
Denmark	-37	-84	-42	50
Finland	-35	-15	6	45
Slovak Republic	-31	-99	-45	2
Austria	-28	-28	-2	38
France	-27	-147	22	255
Hungary	-20	-116	-69	32
Estonia	-18	-9	3	11
Slovenia	-15	-6	13	11
Czech Republic	-7	-10	44	55
Netherlands	-7	-80	-165	29
Luxembourg	-1	5	22	10
Italy	1	113	65	71
Malta	1	0	-1	1
Belgium	3	29	113	84
Sweden	48	17	76	119

Source: Authors' elaboration based on (Goujon et al., 2021[2]; Jacobs-Crisioni et al., n.d.[3]).

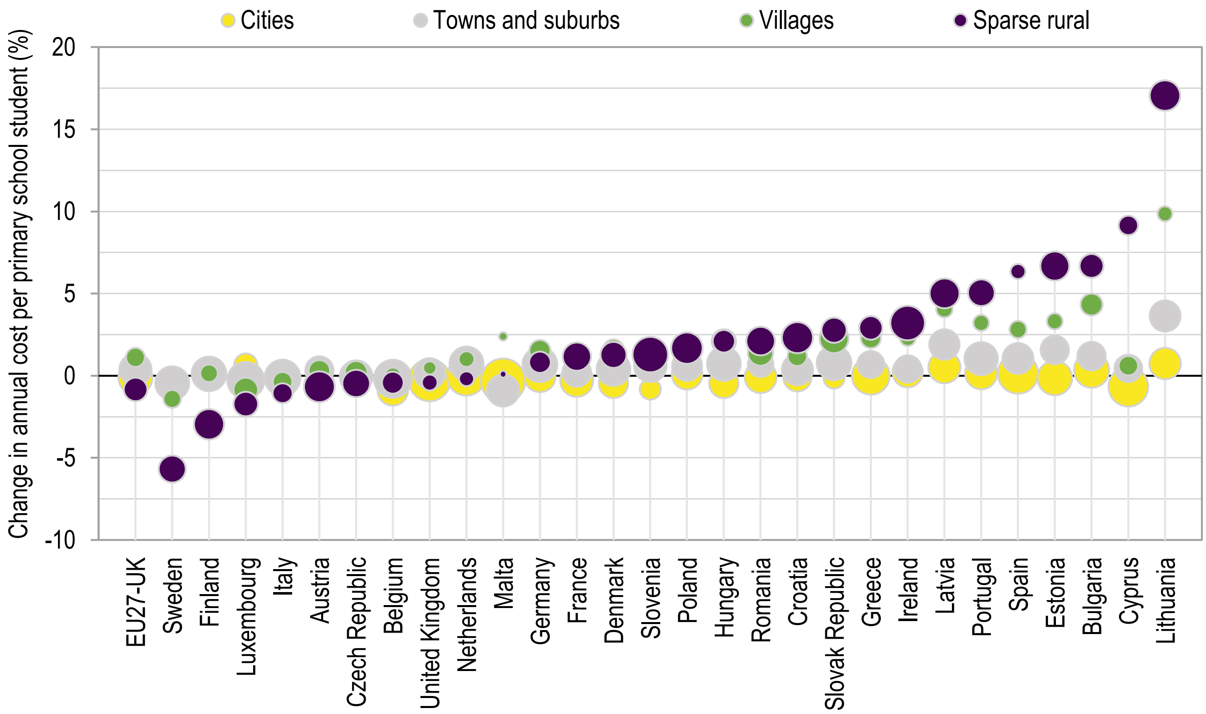
StatLink https://doi.org/10.1787/888934246336

Figure 3.33 and Figure 3.34 show the projected changes in cost per student due to changes in the demand for schooling, as well as the geographical distribution of students, by country and degree of urbanisation. For the average of EU27+UK countries, changes for primary schools are close to zero in all areas except sparse rural areas, where costs per primary school student are expected to increase by 2.6% (Figure 3.33). Costs per primary school student are expected to increase in the sparse rural areas of all countries except in Malta, Sweden, Luxembourg and Belgium, where they are expected to decrease following an increase in the number of students in sparse rural areas in those countries (Figure 3.29). The expected increase in costs in sparse rural areas is considerably larger in countries with considerable sparsity that are also expecting a drop in demand for primary education, including Lithuania, Estonia, Bulgaria, Spain and Latvia. Unlike sparse rural areas, the expected changes in costs per primary school student in villages are not so pronounced and do not vary so much across countries, with the exception of relatively large expected decreases in Finland and Sweden.

The results for secondary schools follow a similar pattern with less pronounced variations across countries in expected cost per student increases in sparse rural areas, and more variation in cities and towns and suburbs (Figure 3.34). In countries such as France and Denmark that expect a substantial increase in secondary school demand in rural areas, accompanied by an increase in cities (Figure 3.29), costs per secondary school student in cities are expected to decrease while at the same time they are expected to increase in sparse rural areas.

Figure 3.33. Change in annual cost per primary school student (estimated) by country and degree of urbanisation, EU27+UK

2011-35

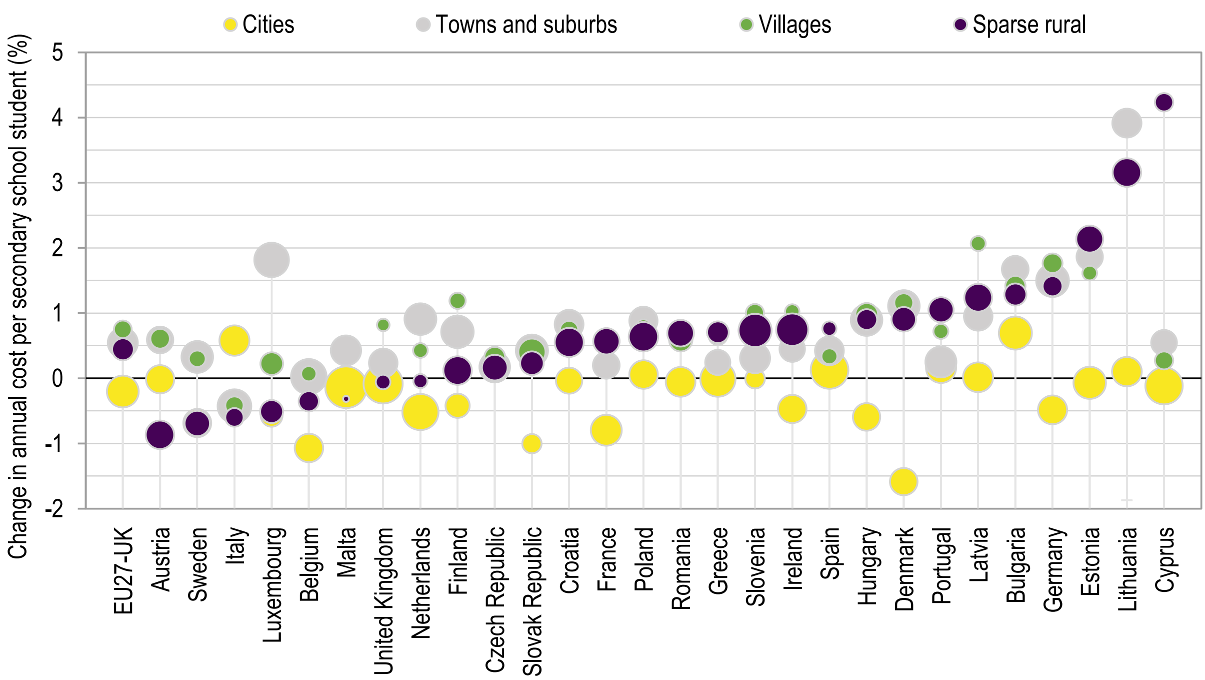


Note: Bubble areas represent the share of national population.
Source: Authors' elaboration based on (Goujon et al., 2021[2]; Jacobs-Crisioni et al., n.d.[3]).

StatLink https://doi.org/10.1787/888934246355

Figure 3.34. Change in annual cost per secondary school student (estimated) by country and degree of urbanisation, EU27+UK

2011-35



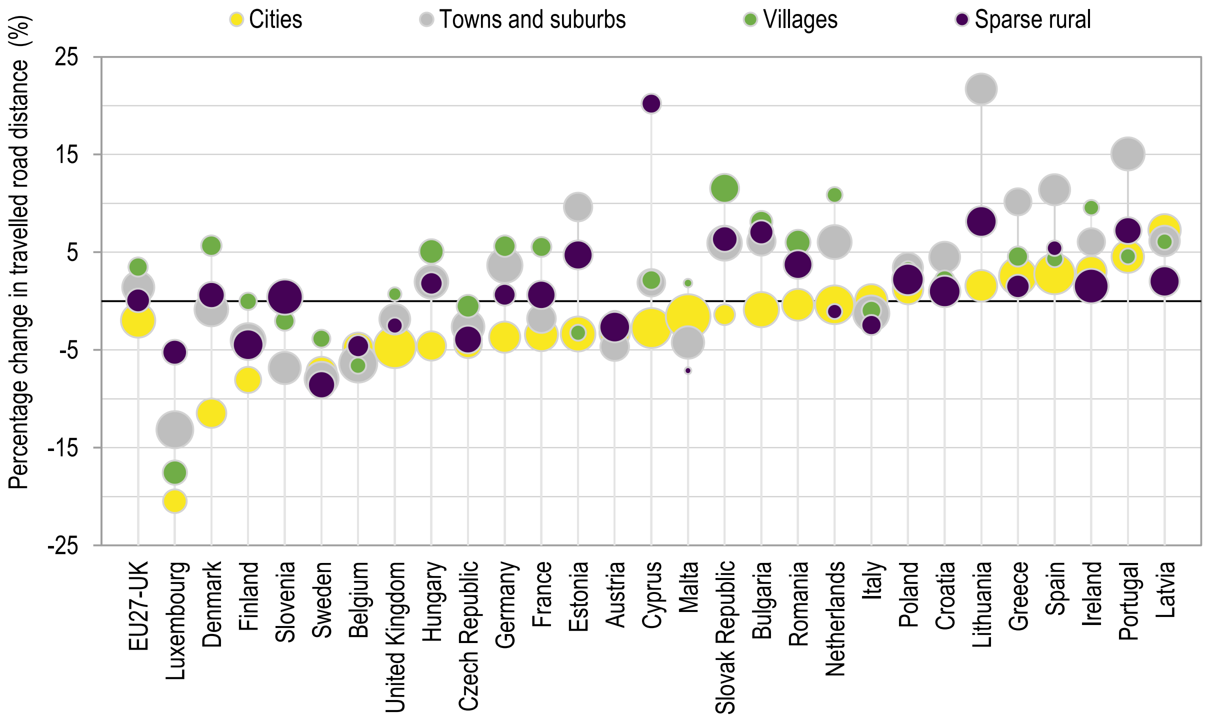
Note: Bubble areas represent the share of national population.
Source: Authors' elaboration based on (Goujon et al., 2021[2]; Jacobs-Crisioni et al., n.d.[3]).

StatLink https://doi.org/10.1787/888934246374

Changes in demand affect school access and travelled distances considerably. Figure 3.35 and Figure 3.36 show changes in travelled road distance to primary and secondary schools between 2011 and 2035. Average distance to primary and secondary schools in 2035 increases in sparse rural areas (primary 0.2% versus secondary 2%), villages (4.8% versus 9.3%), and towns and suburbs (1.9% versus 2.1%) and decreases in cities (2.6%) compared to 2011 (Figure 3.35). Countrywide distances to primary schools increase in Spain, Ireland, Portugal and Latvia, while Lithuania, Cyprus, Portugal and Latvia face increases in average distance to secondary schools, in particular for sparse rural areas (Figure 3.36). Cities in Luxembourg, Denmark, Finland, and Sweden record the highest decreases in average distance to both primary and secondary schools.

Figure 3.35. Change in travelled distance to primary schools per student (estimated) by country and degree of urbanisation, EU27+UK

2011-35

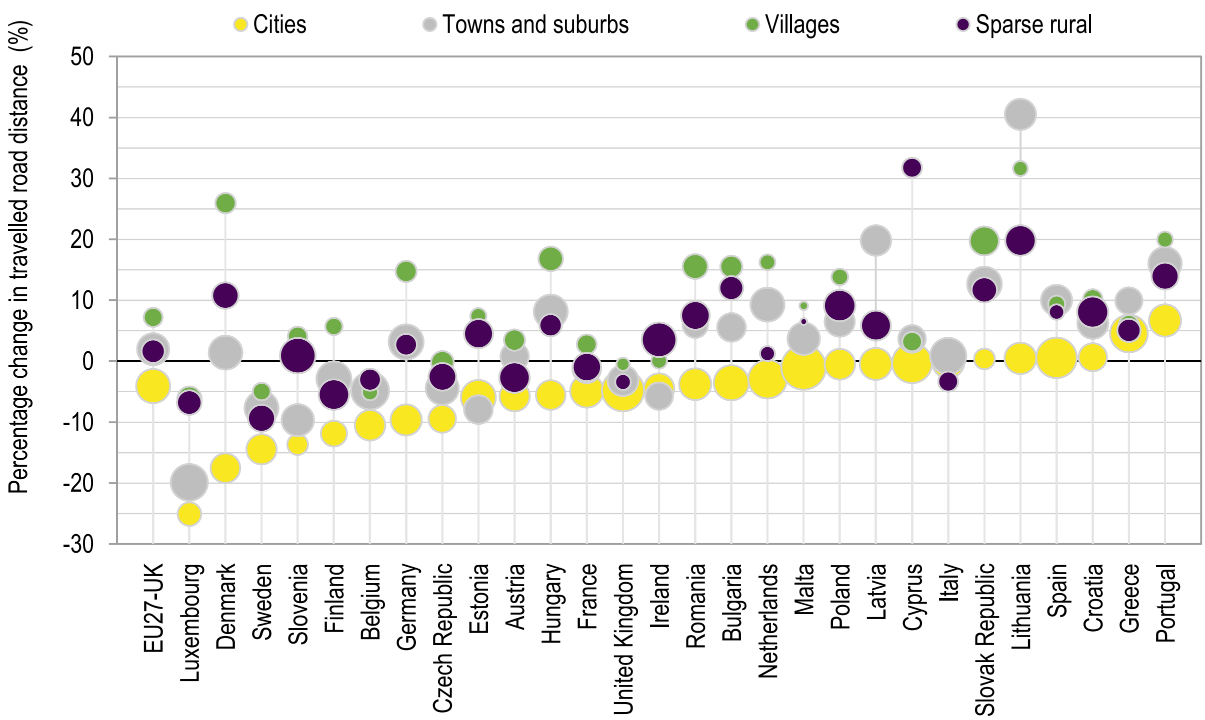


Note: Bubble areas represent the share of national population.
Source: Authors' elaboration based on (Goujon et al., 2021[2]; Jacobs-Crisioni et al., n.d.[3]).

StatLink https://doi.org/10.1787/888934246393

Figure 3.36. Change in travelled distance to secondary schools per student (estimated) by country and degree of urbanisation, EU27+UK

2011-35



Note: Bubble areas represent the share of national population.
Source: Authors' elaboration based on (Goujon et al., 2021[2]; Jacobs-Crisioni et al., n.d.[3]).

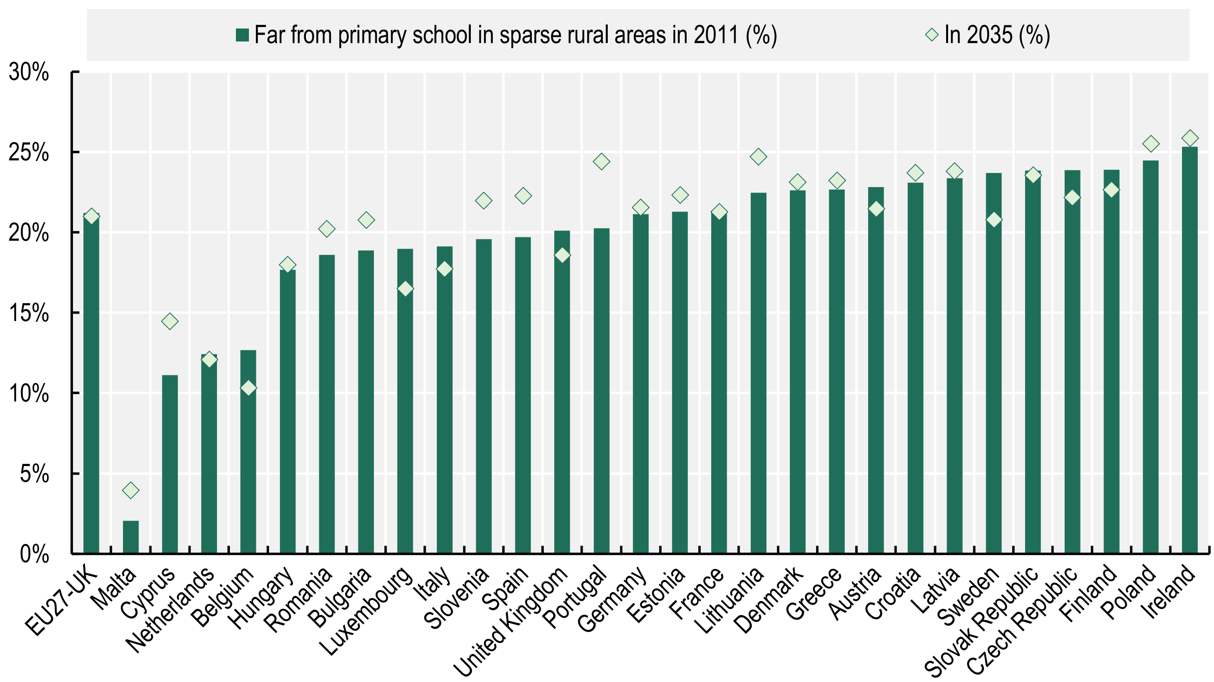
StatLink https://doi.org/10.1787/888934246412

In countries where an increase in student populations is foreseen including Belgium, Luxembourg and Sweden, the share of primary school students in sparse rural areas that have to travel far is expected to decrease slightly (Figure 3.37). In contrast, in countries such as Cyprus, Slovak Republic, and Portugal, the share of the sparse rural student population is expected to increase, in some cases quite considerably. In some countries expected to face depopulation, including Estonia and Latvia, the percentage of sparse rural population that needs to travel far is not expected to change. In these countries, it is possible that travel distances to schools are already large to start with, so the adjustment happens through reduced school size, as evidenced by their larger expected increases in expenditure per student.

Compared with the results for primary schools, the effects of school redistribution are even more marked for secondary schools, with growing number of students travelling far in the vast majority of countries (Figure 3.38). As is the case with primary schools, the dominant increase in far-travelling sparse rural students is in line with expected student population decline in those sparse rural areas.

Figure 3.37. Share of primary school students that have to travel far to school (estimated) by country, EU27+UK

2011-35

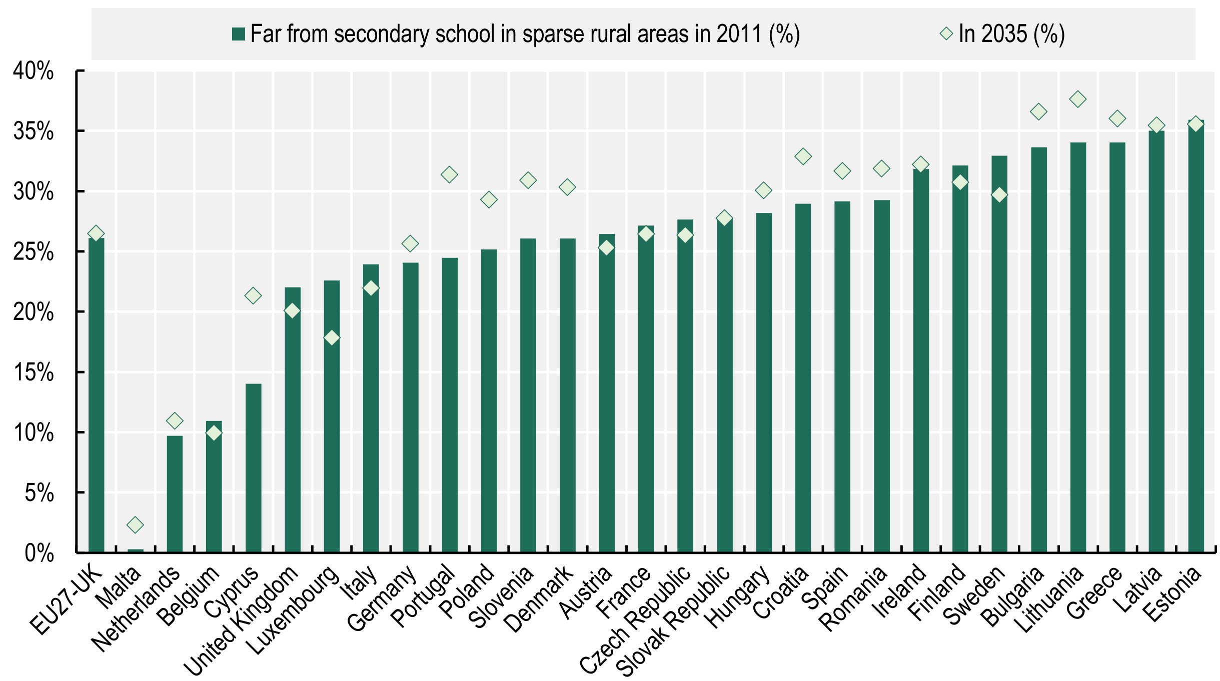


Source: Authors' elaboration based on (Goujon et al., 2021[2]; Jacobs-Crisioni et al., n.d.[3]).

StatLink https://doi.org/10.1787/888934246431

Figure 3.38. Share of secondary school students that have to travel far to school (estimated) by country, EU27+UK

2011-35



Source: Authors' elaboration based on (Goujon et al., 2021[2]; Jacobs-Crisioni et al., n.d.[3]).

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Second scenario based on 2011 school demand and 2035 students and gaps

Figure 3.39 shows a comparison per degree of urbanisation and country of the expected changes in costs per primary and secondary school student under the 2035 schools – 2035 students and the 2011 school and 2035 student scenarios. The results show the additional costs brought by keeping the 2011 school network the same in the future, even though it may not be the most efficient network for the future volume and distribution of students.

The results for primary schools indicate that keeping the 2011 primary school network in 2035 instead of having a new network allocated to provide for the future number of students implies for the average of EU27+UK countries:

- Additional costs of about EUR 36 per student in sparse rural areas (with allocating a new network, costs increase with EUR 37, when keeping the 2011 school network, costs increase with EUR 73), EUR 31 in villages (increase of EUR 46 versus increase of EUR 77).
- A small decrease in towns and suburbs (EUR 0.6) and cities (EUR 21), potentially signalling crowding issues in the 2011 network.

Across countries, the additional costs of maintaining the 2011 school network into the future are more substantial in:

- Sparse rural areas of Lithuania (EUR 1 243 per student), Latvia (EUR 741), Cyprus (EUR 431), Estonia (EUR 330) and Bulgaria (EUR 285), all countries with the largest changes under the 2035 students – 2035 school scenario.
- In villages in the same group of countries, although for villages the differences are smaller in magnitude.

- Towns and suburbs of, Lithuania, Portugal, and Spain.

For secondary schools, keeping the 2011 primary school network implies for the average for EU27+UK countries:

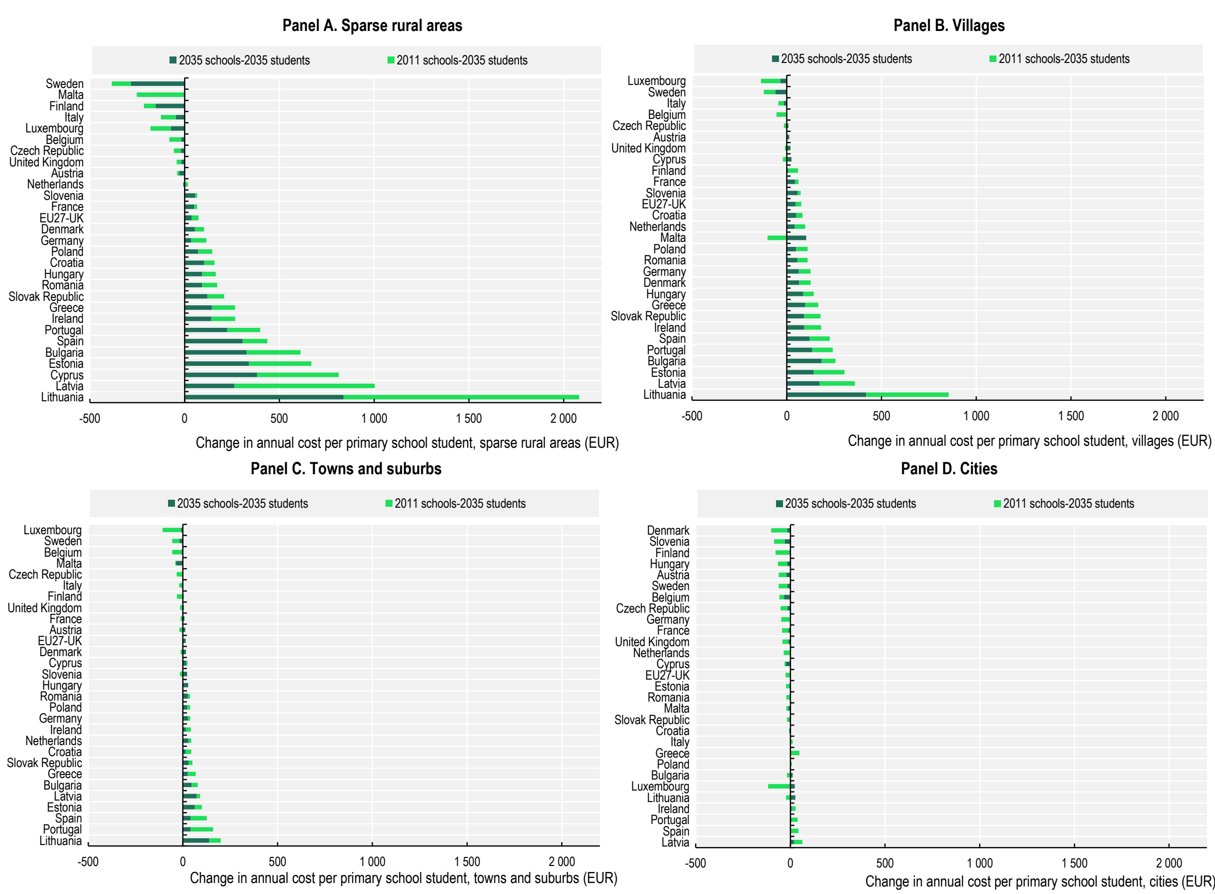
- Small additional costs of about EUR 6 per student in sparse rural areas (from EUR 31 increase to EUR 37 increase), EUR 12 in villages (from EUR 51 increase to EUR 63 increase).
- In towns and suburbs it implies an increase of EUR 3 (from EUR 35 increase to EUR 32 increase) and in cities, it implies an increase of EUR 52 (from EUR 12 decrease to EUR 64 decrease).

Across countries, keeping the 2011 school network to serve 2035 students implies the largest additional costs increases on costs per students in:

- Sparse rural areas of Lithuania (EUR 546), Cyprus, (EUR 297), Latvia (EUR 255) and Bulgaria (EUR 161).
- Villages of Lithuania (EUR 312), Slovak Republic (EUR 129) and the Netherlands (EUR 102).
- Towns and suburbs of Portugal (EUR 145), Lithuania (EUR 70), and Slovak Republic (EUR 55).

Figure 3.39. Comparison of changes in annual cost per primary school student under two scenarios (estimated) by country and degree of urbanisation, EU27+UK

2011-35

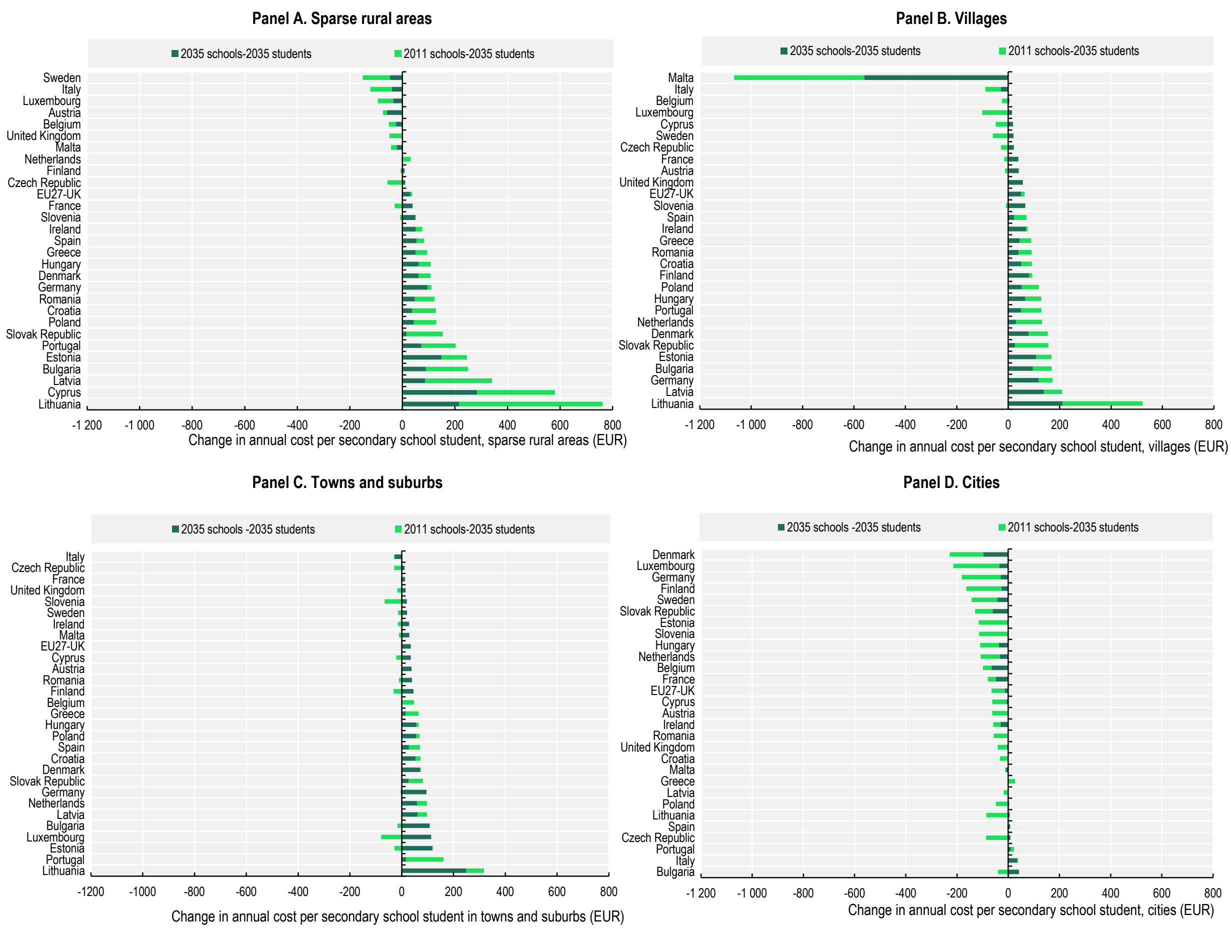


Source: Authors' elaboration based on (Goujon et al., 2021[2]; Jacobs-Crisioni et al., n.d.[3]).

StatLink https://doi.org/10.1787/888934246469

Figure 3.40. Comparison of changes in annual cost per secondary school student under two scenarios (estimated) by country and degree of urbanisation, EU27+UK

2011-35



Source: Authors' elaboration based on (Goujon et al., 2021[2]; Jacobs-Crisioni et al., n.d.[3]).

StatLink https://doi.org/10.1787/888934246488

Conclusions

This chapter shows how the spatial and demographic differences between countries could impact the distance travelled to school and the costs of providing education. The method used in this chapter to locate schools and attribute students to these schools does not require students to go to the closest school or the school in the same municipality. Students have some freedom to choose a school taking into account distance and the number of students attending nearby schools. Next, each school's current expenditure is estimated taking into account their number of students.

The analysis shows that costs per student tend to go up as density goes down. In most countries, costs are highest in sparse rural areas, and lowest in cities. On average in the EU27+UK, the cost per student in sparse rural areas is EUR 650 higher than in cities. In some more sparsely populated countries, this difference can be as high as EUR 1 000. For primary schools, costs are similar between cities and towns and suburbs. As secondary schools are larger, cities have a bigger cost advantage as compared to towns and suburbs.

A striking result is that villages can play a vital role in the provision of primary level schooling. The distance to these schools is only slightly higher than cities and half the distance in sparse rural areas. For secondary schools, towns and suburbs may be a key area of interest as they serve a mix of students from all areas, including cities, and are located closer to the students.

This analysis goes beyond the bulk of current literature by linking demography projections with school provision and costs. The projections for 2035 show that changes in student numbers will lead to considerable additional demand for schools in cities, and in some countries, a reduction in demand in rural areas. In the 2035 scenario with future school placements, changes for primary schools are close to zero in all areas except sparse rural areas, where costs per primary school student are expected to increase by 2.6% on average for EU27+UK countries, while distances are expected to increase in all areas except cities, and distances are expected to increase the most in villages. The results for secondary schools follow a similar pattern with lower increases in expected cost increases, but higher distance increases. The results also show that keeping the 2011 primary school network – and consequently maintaining distances to schools similar to the present scenario - implies even larger average cost increases for EU27+UK countries, of about EUR 36 per student in sparse rural areas and EUR 21 in villages, with substantial variations across countries depending on their expected change in future demand.

This chapter acknowledges that school closures may also have a broader impact on communities that are already in decline. It consequently seeks to identify, besides the average effect of demographic change on costs and access, the areas that are at high risk of having both very high distances and costs per student due to their low density of demand for education services. In this chapter, the results by municipality already showed that countries with high fragmentation have many municipalities without schools, and many more with only small schools that are likely to experience high unavoidable costs of smallness. In these cases, policy strategies can focus on increasing scale and capacity, for instance through school clusters or municipal consolidation, while reconciling the service needs of small rural communities.

Finally, while the estimations in this chapter concern EU27+UK countries, the method and analysis can be applied to any country with available population grids by age classes.

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Notes

[1] School competition is a multi-faceted concept, affected by such factors as local school markets, school performance, affordability or teaching model. Regarding differences in how parents choose schools for their children, a safe school environment or school’s good reputation are the most important criteria when choosing a school for their child, even more than the criterion “high academic achievement of students in the school”. Increases in school choice may exacerbate segregation and territorial disparities through self-selection mechanisms (Fjellman, Yang Hansen and Beach, 2018[36]). This report does not develop these aspects of school choice.

[2] This results from the so-called Modifiable Areal Unit Problem (Mobley, Kuo and Andrews, 2007[34]); (Stępniak and Jacobs-Crisioni, 2017[35]).

[3] The consideration of local communities is in line with literature suggesting that local communities have a stake in obtaining and maintaining a school when taking into account access, expected population consequences and broader social benefits (Barakat, 2014[22]) (Elshof, van Wissen and Mulder, 2014[23]) (Salant, P. and Waller, A., 1998[25]) (Lyson, Thomas A., 2002[24]).

[4] Costs are highest in the region County of Karlovac, the only NMR-M region in Croatia.

4 A method to estimate health care services access and costs

This chapter estimates health service location demand and costs using a method based on data for England. After reviewing the determinants of health care demand, it describes the method to estimate health services potential demand and access. The chapter then highlights the difficulties of predicting health care costs and examines preliminary evidence on health care costs for England. Finally, the chapter presents the method estimating differences in cardiology and maternity and obstetrics (M&O) services costs and access across geographical areas.

Main takeaways

- Due to data limitations, the analysis distinguishes between locations offering a given service but not among different facilities offering a service in the same location, or facilities offering multiple services, and focuses on cardiology and maternity and obstetrics (M&O) services.
- Evidence on "compression of morbidity" shows that individuals increasingly compress ill-health into the final years of life and that chronic diseases begin to present later in life at a rate faster than increases in life expectancy. Consequently, measures of expected future morbidity or time-to-death are of more use than age in predicting present and future health demand and costs.
- The simulation of health service location uses expected local deaths to approximate demand for cardiology and local birth rates to approximate demand for obstetrics and gynaecology services. It estimates demand at each location, the origin and destination of health service trips and the distances that users travel to reach a location.
- Data for England shows that users in sparse rural areas travel on average 10 km more than users in cities to access cardiology services and about 14 km more to M&O services.
- As most health service locations serve a largely diverse population in terms of geographical origin, comparing geographical cost differences should be based on the place of residency of users instead of the precise location of service location.
- Although there are many factors that can involve the costs of providing health services, this chapter considers only cost differences due to varying scales of operation of health service locations.
- The estimations show a negative and significant coefficient of population in catchment areas for both services and indicate reduced costs with increasing demand: for cardiology, a 1% increase in population in the catchment area of the average service location is associated with reducing costs per head in that service location by 0.57%.

Introduction

This chapter presents a method to estimate a selected number of health service costs from underlying catchment area population characteristics. Due to data limitations, the analysis focuses on health service locations in England, using estimates of individual service cost and location. The benchmark predicts costs of specific health services that are then aggregated at different geographical levels. This allows estimating present and future population values. Chapter 5 further examines the results of these estimates.

This chapter focuses on two specific services: cardiology and maternity and obstetrics (M&O). The proposed method allocates service locations based on local demand, approximated local death rates for the case of cardiology and birth rates for the case of M&O services. From local demand, the method estimates users in each location catchment area. Finally, the cost estimation aims to capture differences in costs per user purely driven by the size and composition of the service location catchment areas. This means that the costs estimated in this chapter do not aim to capture cost efficiencies arising from either economies of scale in facilities or scope across proximate facilities (Lorenzoni and Marino, 2017[1]).

The chapter first sets the scene in terms of the constraints within which the proposed method has been developed. It then presents a literature review on the determinants of health care demand and the chosen method of measuring demand. Subsequently, a literature review describes the measurement of accessibility and utilisation of health services that support the method choices used to predict health care supply and accessibility. A method to estimate variation in health care costs due to differences in numbers of users is presented together with a reflection on the limitations of the method. Finally, the last section concludes and the annexes provide additional technical details.

Estimating health services demand and access

Where are health services offered and how many people use them? This section tackles this question from an empirical point of view using actual health care data for England (see Annex 4.A for details on the data). The question of supply and demand of services can be seen from two different perspectives. The first is the perspective of health facilities that can vary in size and level of complexity in the services they offer. The offering of, for instance, cardiology services, can happen in both large hospitals or primary care facilities depending on patient needs and the organisation of the health care system.

A proper estimation of supply and demand in such a setting would require the availability of the volume of services offered in each facility linked to the usage of the service (e.g. as measured by admissions or visits). The next question on estimating demand would be what the relationship between facility choice and user characteristics is– in particular, how much distance determines the choice for a facility from the point of view of users.

Unfortunately, such level of detail is not available in the observed data, so the analysis in this chapter has to make a number of simplifications that limit the scope of the estimations. The first simplification is that the analysis distinguishes between locations offering a given service, but not among different facilities offering a service in the same location, or facilities offering multiple services. In this sense, the approach proposed here does not aim to capture the role of facility-specific determinants of supply and efficiency of service provision (Lorenzoni and Marino, 2017[1]) or the role of competition or complementarity between proximate locations in the offering of a service.

The second simplification is that the analysis focuses only on cardiology and maternity and obstetrics (M&O) services because these services have available data for relatively many locations, giving enough geographical variation for the analysis. Specifically, the analysis considers data for England for cardiology services in 188 facilities offering Cardiac Surgery Service (NHS specialty code 172), Paediatric Cardiac Surgery Service (code 221), Cardiology Service (code 320), Paediatric Cardiology Service (code 321), and

Congenital Heart Disease Service (code 331); and maternity and obstetrics (M&O) services in 219 facilities offering Obstetrics and Gynaecology (code 500), Obstetrics (code 501) and Midwifery Service (560).

This section starts with a review of the literature on measuring health services demand, access and costs. It then outlines an approach to estimate potential demand at every service location.

What determines health care demand?

A substantial body of literature has been dedicated to the accurate estimation of health care demand using both individual and population-level characteristics. This has most importantly incorporated a focus on the merits or otherwise of age and life expectancy, or remaining lifetime (often termed “time-to-death”) in explaining demand.

Formal interest in such predictions, and increasing concern about the potential role of demographic factors in future changes in health care demand and expenditures, can be traced back to at least (Heller et al., 1986[2]), an International Monetary Fund report pointing to cross-sectional relationships between age and health care expenditures. Importantly, however, these relationships were not estimated longitudinally, nor did they attempt to control for morbidity. Even as late as 2000, the OECD report *Fiscal Implications of Ageing* expressed concerns that demographic changes would lead to expenditures on age-related social expenditures such as those on health care to rise by over a third as a percentage of GDP by 2050 (Dang, Antolin and Oxley, 2001[3]).

Uncertainty around such predictions, and the unsatisfactory nature of modelling such relationships in the cross-section, has given rise to a strand of academic literature arguing that age is a “red herring” in explaining health care demand and expenditures. Beginning with (Zweifel, Felder and Meiers, 1999[4]), successive papers have argued that while age is undoubtedly correlated with health care costs in the cross-section, such a relationship does not explain the true data-generating process – i.e. that age itself is an unsatisfactory explanatory cause of health care costs. Much of this literature (Werblow, Felder and Zweifel, 2007[5]; Zweifel, Felder and Werblow, 2004[6]; Zweifel, Felder and Meiers, 1999[4]) has focused on replacing, or augmenting, use of age as an explanatory factor with time-to-death, and finding that doing so removes the vast majority of explanatory power of ageing. Reviewing OECD projections for 2050 in the light of early such publications, (Gray, 2004[7]) remarks that age “is not a particularly good predictor of health expenditure, and simple projections based on age-specific health expenditure will therefore be misleading.”

While more recent research has argued that time-to-death is itself a red herring in explaining health care costs (Howdon and Rice, 2018[8]), being itself a proxy for morbidity, it is generally accepted that time-to-death provides greater explanatory power than age. This has substantial implications for the prediction of future health care costs: the use of parameter estimates associated with age in *ceteris paribus* predictions of future health care demand and costs is likely to be inappropriate, and the use of measures of expected future morbidity or time-to-death would be of more use. Indeed, this has been repeatedly evidenced theoretically and empirically in a “compression of morbidity” strand of literature beginning with (Fries, 1980[9]). This thesis broadly argues that individuals increasingly compress ill-health into the final years of life, rather than having a consistent and immutable decline in overall health over their lifetime, and that chronic diseases begin to present later in life at a rate faster than increases in life expectancy.

What determines health service accessibility and utilisation?

The number of health accessibility studies has recently increased due to both the wider use of geographic information systems (GIS) and availability of spatially disaggregated data, and the growing importance of adequate and equitable accessibility concerns among policy makers (Neutens, 2015[10]). The literature spans several subjects: accessibility to emergency medical services (Shin and Lee, 2018[11]), accessibility to heart-related hospital services (Hare and Barcus, 2007[12]), accessibility to primary health care (McGrail and Humphreys, 2014[13]; Guagliardo, 2004[14]), accessibility, equality and health care (Goddard and Smith, 2001[15]), impacts of hospital closures in rural areas (Vaughan and Edwards, 2020[16]) and change in hospital accessibility inequalities over time. These various strands have provided convincing evidence that spatial barriers between service provider and user contribute to lower health care utilisation and decreased uptake of preventive services.

Access to a particular location does not guarantee utilisation (Hare and Barcus, 2007[12]) because there can be individual socio-economic characteristics and preferences, and consumer’s ability to pay for services plays an important role in health service utilisation. Still, proximity to appropriate services is considered as the main determinant of health service utilisation, particularly in rural areas (Cromley and McLafferty, 2002[17]; Meade and Earickson, 2000[18]).

Health service accessibility is usually modelled based on the catchment areas where health care service utilisation is realised. Two factors to consider in the modelling catchment areas are the type of health service delivered and how far users are prepared to travel. Travel distance becomes particularly important for primary health care services, where most residents prefer to stay within their immediate neighbourhood (McGrail and Humphreys, 2014[13]).

Measuring health service accessibility has been done in several ways:

- Using travel distance or time to the nearest facility or to a certain number of closest facilities (see for example (Pilkington et al., 2017[19]) and (Lovett et al., 2002[20]). However, such a measurement does not consider capacity of the service provider or size of the population.
- Gravity models provide an alternative to include also population, where both accessibility and availability (i.e. capacity) are considered and attractiveness of a service diminishes with increasing distance (Guagliardo, 2004[14]).
- Population-to-provider ratios give a picture of both supply and demand for health care services. However, they usually do not use any spatial movement or separation (McGrail and Humphreys, 2014[13]).

Among various methods, the two-step floating catchment area (2SFCA) method proposed by (Luo and Qi, 2009[21]) and (Wang, 2012[22]) is one of the most widely used methods in measuring health service accessibility. It is a special form of gravity model combined with population-to-provider ratios. In the first step of the 2SFCA method, a physician-to-population ratio is calculated for each service within a floating catchment area or a window, in a second step, all the physician-to-population ratios are summed up for each location within the catchment area and used as the accessibility of that location. In each step, a distance or travel time threshold is used to define the catchment area (Pan et al., 2018[23]). The 2SFCA method, considers not only the distance decay (transferability) but also the interactions between supply and demand (complementarity) which overcomes the limitations of traditional place-based accessibility measures where the demand for service is largely overlooked (Chen and Jia, 2019[24]).[1]

A method to estimate health service demand and access

As in the school allocation procedures, this chapter measures demand for local communities that are defined as regularly latticed 1 km^2 node in a network. In the school simulations, educational demand per community is estimated through local student populations, which are straightforward to define for schools using age groups. Estimating current and future demand for health services based on age distributions is not as straightforward. As explained before, time-to-death, rather than age, is the most accurate predictor of demand for many health services. For the case of maternity and obstetrics, the number of births could serve as a reasonable approximation for demand for this type of services. Consequently, uses expected local deaths to approximate demand for cardiology and local birth rates to approximate demand for obstetrics and gynaecology services. Box 4.1 provides detail on the estimation of these rates at the local level.

Box 4.1. Estimating local mortality and birth rates

Estimating local expected deaths

Local-level estimates or proxies of morbidity are usually not available and they need to be estimated. Small area level estimates or proxies of morbidity – such as life expectancy – were not available on a consistently estimated basis at the level of the hospital's catchment area as in the approach of (Howdon and Rice, 2018[8]) who use local estimates of mortality patterns as instrumental variables for time-to-death on an individual basis.

The construction of a local-expected mortality involves the combination of the age distribution of the hospital's likely catchment population by five year age grouping[2] and actuarial tables by age in years at TL2-level as of 2020. This requires assumptions regarding the construction of each age group. It is clearly incorrect to assume that each five-year age group has the same weight in terms of sex: for instance, the age group 80-84 is composed of 56% women and 44% men, with a distribution that due to mortality skews towards lower ages within this group Office for National Statistics (2020[25]; 2019[26]). A more suitable approach is to assume that each age group is composed of proportions reflecting the national age distribution, so that a weighted average according to the population distribution within our age groups can be applied to the estimated mortality risk arising in the next year for individuals of each age.

Estimating local expected births

For each age, births are estimated as the weighted average of the sum of year fertility rates according to the female population distribution within age groups. As with mortality-related measures, local births are estimated as the sum of this for all age groups in the estimated hospital catchment population. This measure gives the total estimated number of expected births within the hospital's catchment area for the forthcoming year. As with mortality-related measures, the extent to which this proxies for actual births is limited by the need to impose TL2-level fertility estimates by age for each hospital's catchment area. Despite this, however, fertility rates on a local basis are likely to differ substantially less than those related to mortality.

To estimate health service locations, the chapter adopts the location-allocation simulation used for schools, as outlined in Chapter 2. Under this approach, health service locations are simulated based on local demand and travel distances. The potential users of a health service location are estimated using so-called floating catchments (Pereira et al., 2021[27]), in which the size of a location's catchment area depends on simulated choice behaviour and the sum of all allocated location users equals the sum of the total population. The method aims to:

- estimate absolute location utilisation, rather than a relative burden on service locations
- estimate the distances that users travel to reach a location, rather than a relative service accessibility indicator.

In addition, the method assumes that simulated health service locations have practically boundless capacity because expected location capacities are, contrary to the case of schools in Chapter 3, unknown for health service locations. As a consequence, in the method the difference in distances to locations is the only determinant of user allocation. This implies that, if a community has for instance a choice set of five service locations at equal distance, all locations obtain equal users from that community.

As is done for schools, the simulation of health service locations across the EU27+UK relies on grid search values. Grid searches allow obtaining the set of thresholds that best describe the geographical distribution of cardiology and maternity and obstetrics services in England[3] (see Annex 4.B). The obtained thresholds represent a societally acceptable balance between service access and service efficiency. The results show that health service locations have a much larger geographical scale than primary or secondary schools. As the thresholds are similar for both services, both cardiology and M&O services are of a similar geographical scale.

For England, catchment areas for cardiology services vary from 0.04% to 2.1% of the total population, with a mean of 0.42%, and for M&O services they vary from 0.04% to 3% with a mean of 0.38%. Table 4.1 summarises the travel distance for cardiology and M&O service users in the actual and modelled health service locations. In both cases, the modelled results capture differences across degree of urbanisation levels for both services. According to the results, users in sparse rural areas travel on average 10 km more than users in cities for cardiology services and about 14 km more in M&O services.

Table 4.1. Comparison of travelled distance per cardiology and maternity and obstetrics user in actual and modelled locations by degree of urbanisation, England

Degree of urbanisation (source locations)	Travelled distance per user (km) Observed	Modelled/modelled
Cardiology		
Sparse rural	17.2	18.1
Villages	17.3	16.6
Towns and suburbs	12.2	10.0
Cities	7.4	5.9
Maternity and obstetrics		
Sparse rural	28.6	18.7
Villages	24.7	16.7
Towns and suburbs	15.8	10.3
Cities	4.3	4.3

Note: Modelled facilities are UK-wide results; observed facilities are England only.
Source: Authors' estimations based on (Goujon et al., 2021[28]; NHS Digital, 2020[29]; NHS England, 2020[30]; NHS Improvement, 2020[31]; Jacobs-Crisioni et al., n.d.[32]).

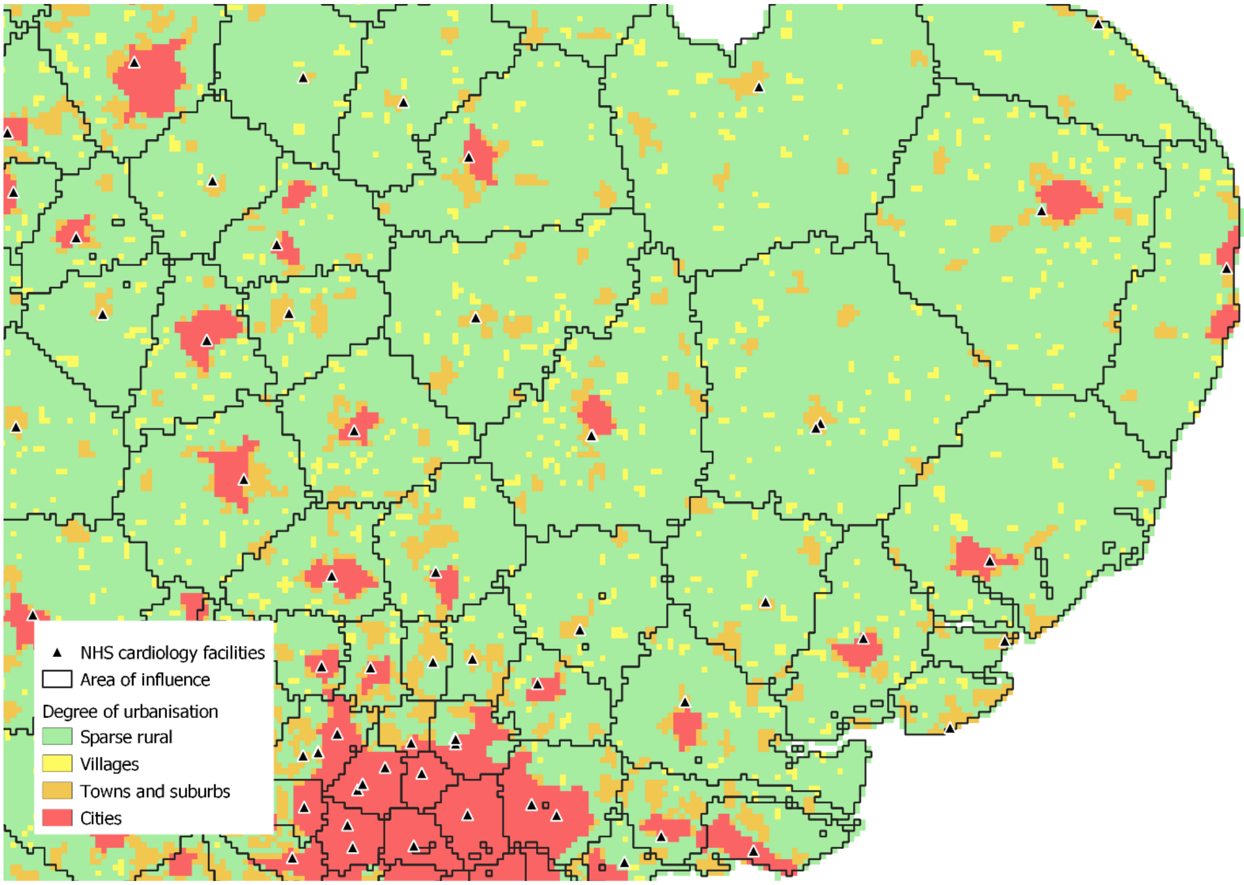
Results from the potential user simulation are subsequently used to assess:

1. total population in the catchment area of health service locations
2. average distances travelled by each community in order to reach these locations
3. retrieving which communities use which location, which in turn is relevant for the geographic distribution of where health care costs are borne.

Average travelled distances per community are computed as a usage-weighted average travel distance from the community to all health service locations in the choice set.

Figure 4.1 shows an example of the area covered by catchment areas for actual locations in England offering cardiology services, calculated following the procedure described above. While some service locations located in city catchment areas fall entirely within city areas, this is not the case for the majority of locations. As Table 4.2 shows, for both cardiology and M&O services, health service locations located in different degrees of urbanisation serve a mix of population coming from different areas. Comparing cost differences across degrees of urbanisation based on the precise location of the location would therefore be misleading, as it would hide the fact that most locations serve a largely diverse population in terms of their place of residency.

Figure 4.1. Example of catchment areas around actual hospital locations offering cardiology services, England



Source: Authors' estimations based on (Goujon et al., 2021[28]; NHS Digital, 2020[29]; NHS England, 2020[30]; Jacobs-Crisioni et al., n.d.[32]).

Table 4.2. Composition of catchment areas of service locations offering cardiology and maternity and obstetrics services by degree of urbanisation

Location by degree of urbanisation	Population in catchment area living in sparse rural areas (%)	Population in catchment area living in villages (%)	Population in catchment area living in towns and suburbs (%)	Population in catchment area living in cities (%)
		Cardiology		
Sparse rural	14.2	12.5	33.3	40.5
Villages	13.6	15.4	31.6	39.4
Towns and suburbs	14.7	11.3	52.3	21.8
Cities	4.3	3.2	18.4	73.8
		Maternity and obstetrics		
Sparse rural	11.4	10.5	30.4	46.3
Villages	24.8	23.3	38.0	34.2
Towns and suburbs	15.5	11.7	53.6	25.3
Cities	3.8	2.9	16.9	73.9

Source: Authors' estimations based on (Goujon et al., 2021[28]; NHS Digital, 2020[29]; NHS England, 2020[30]; Jacobs-Crisioni et al., n.d.[32]).

Estimation of health services costs

Conventional microeconomic theory of the firm suggests that the average cost of production is unlikely to be invariant with the quantity produced (e.g. the number of patients treated). In the case of hospitals, (Giancotti, Guglielmo and Mauro, 2017[33]) in a systematic review indeed find evidence of potential economies and diseconomies of scale. A 2012 review for NHS England looking at evidence for individual services, while reporting "no clear message on economies of scale", found evidence of such scale economies in obstetrics and cardiovascular services, among other services (Monitor, 2012[34]).

Predicting present and future costs and access to health care services in a comprehensive and comparative manner entails a number of added considerations in comparison with predictions on schooling services (see Chapter 3):

- While basic education involves a relatively distinct and uniform set of services, this is not the case for health care provision. Health care costs in hospitals are incurred for a variety of different reasons connected to the provision of a wide set of health services of different levels of complexity.
- While simple demographic characteristics are undoubtedly useful in the prediction of hospital costs, health care use is both more difficult to predict and likely to exhibit within-age group variation in a way that education is not. Unlike the case of education, unobservable characteristics play an important role in determining health care use, implying that, for instance, individuals aged 70 in one area are likely to differ substantially from those aged 70 in another.
- A service like cardiology, just to give one example, can include both highly complex and costly health services such as heart surgery, and simpler procedures that do not require specialised facilities. Moreover, the provision of services of different degrees of complexity can happen both in highly specialised small facilities or in very large hospitals, and salaries can vary widely across staff. In the case of education, while there may be highly specialised (mainly private) schools, the overwhelming majority of schools provide services of similar complexity and intra-school salary disparities are not as wide.

Thus, although there are many factors that can involve the costs of providing health services, this chapter considers only cost differences due to varying scales of operation of health service locations. This section starts with some preliminary evidence for England and an explanation of the method used to estimate the relationship between costs per head and demand for cardiology and M&O services.

Preliminary evidence for England

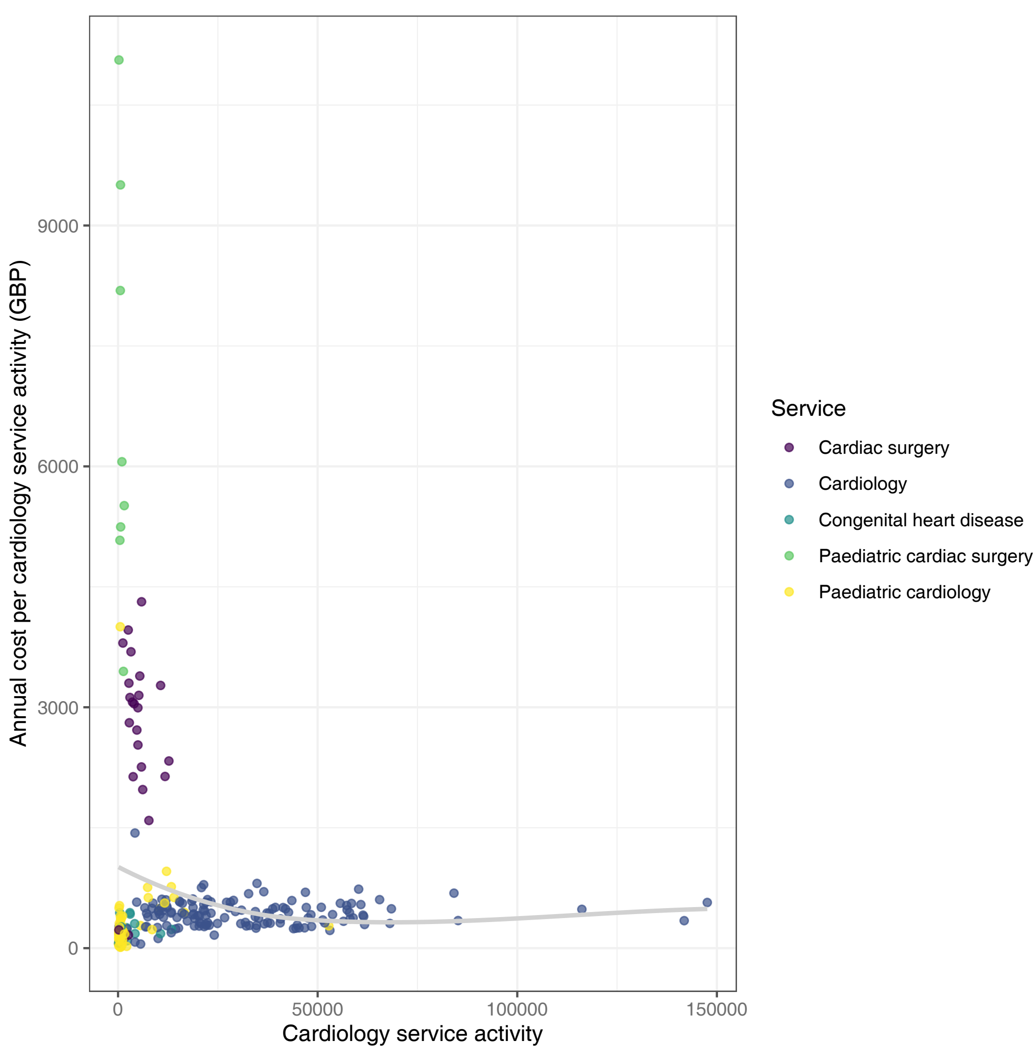
Table 4.3 shows the costs per service activity for each subcategory and the number of trusts offering the service. For cardiology, the annual costs per activity vary from almost GBP 6 000 (around EUR 7 000) for paediatric cardiac surgery to GBP 245 (around EUR 280) for congenital heart disease services. For M&O services, they are around 3 times higher for obstetrics than for relatively less complex midwifery services. As shown in Figure 4.2 and Figure 4.3, the activities with the lowest activity and the highest costs are relatively complex, so that part of the reduction in costs per activity as the number of users increases comes from the larger presence of less complex services.

Table 4.3. Cardiology and maternity and obstetrics services offer and average annual costs, England

Service name	Number of trusts offering the service	Annual costs per service activity (GBP)
Cardiology		
Cardiac surgery services	33	2 693
Cardiology services	142	434
Congenital heart disease services	15	245
Paediatric cardiac surgery services	10	5 923
Paediatric cardiology	92	426
Maternity and obstetrics		
Midwifery service	112	190
Obstetrics	129	552

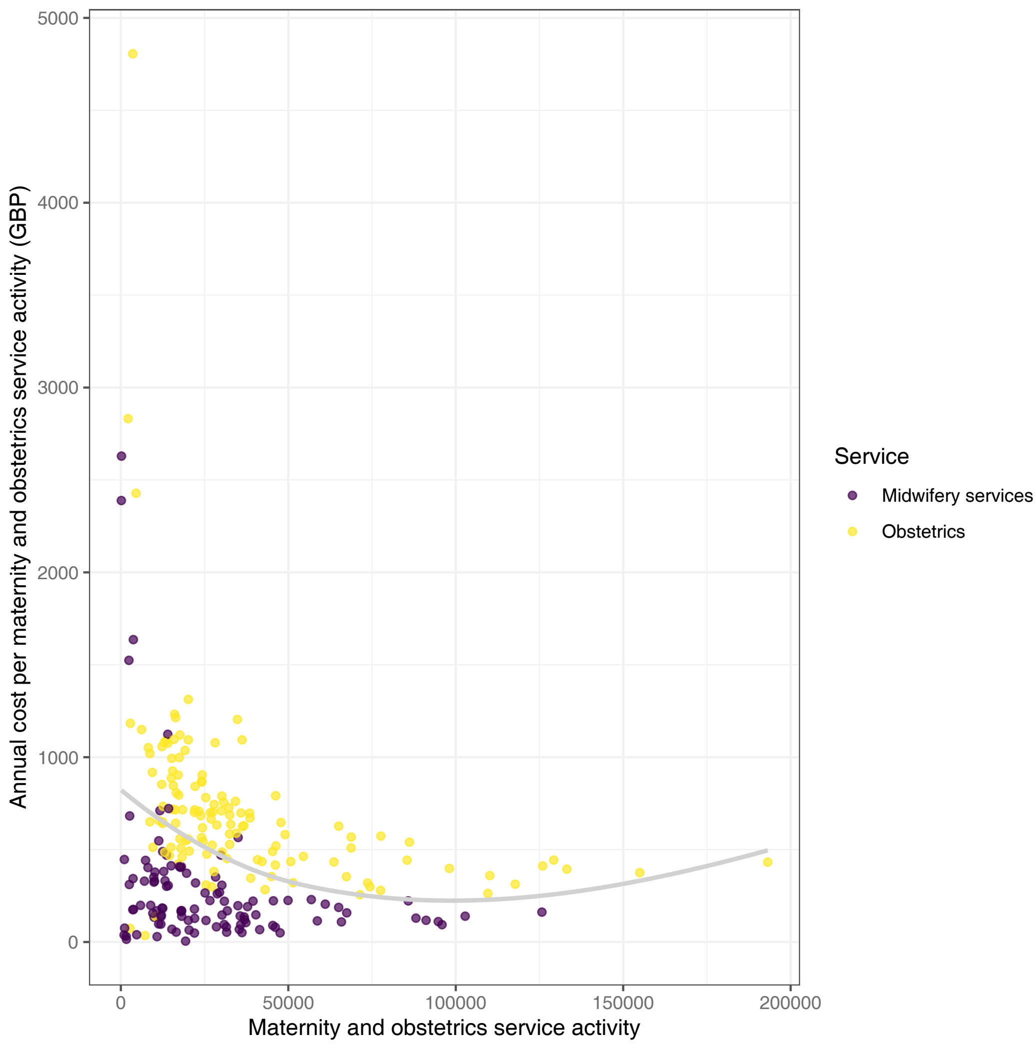
Source: Authors' calculations based on (NHS Digital, 2020[29]; NHS England, 2020[30]).

Figure 4.2. Service activity versus annual cost per activity for cardiology services, England



Source: Authors' elaboration based on (NHS Digital, 2020[29]; NHS England, 2020[30]; NHS Improvement, 2020[31]).

Figure 4.3. Service activity versus annual cost per activity for maternity and obstetrics services, England



Source: Authors' elaboration based on (NHS Digital, 2020[29]; NHS England, 2020[30]; NHS Improvement, 2020[31]).

The information of costs by trust that distinguishes among services at a disaggregated level cannot be readily used for predicting costs at the service location level because there are multiple service locations within most trusts, and many of these locations are not proximate to each other. The analysis first obtains geographical information on service locations, and then it assigns trust-level service costs for the aggregated categories of cardiology and M&O services to each service location. Annex 4.A describes the processing of mapping trust-level estimates to service locations. These location-level measures of costs form the basis of the dependent variable in a regression aiming to predict service costs on the demand for the service estimated via each service location catchment area. The next section describes the estimation of catchment areas.

Proposed cost estimation method

To estimate the cost per head of a given service, the first step is estimating the potential demand for the service, as that a larger candidate population will be strongly associated with the operating scale of the service location. The second step is obtaining an estimate of actual users, to assign the estimated costs to the pool of more likely users instead of the population as a whole. This is useful for both services since the number of admissions of cardiology services increases with age and is higher in males (62% of admissions related to cardiology services in England were males), and those of M&O correspond to women of reproductive age (98% of admissions related to obstetrics and gynaecology services in England were females) (Table 4.4).

Table 4.4. Cardiology and obstetrics admissions by age range, England

2019

Age range	Cardiology admissions by age (%)	Obstetrics and gynaecology admissions by age (%)
0-4	0.05	2.84
5-9	0.02	0.01
10-14	0.03	0.07
15-19	0.46	3.51
20-24	0.84	14.74
25-29	1.01	25.66
30-34	1.23	28.48
35-39	1.66	17.12
40-44	2.33	4.47
45-49	4.36	1.01
50-54	6.61	0.63
55-59	8.70	0.41
60-64	10.15	0.26
65-69	11.51	0.23
70-74	14.47	0.22
75-79	13.49	0.15
80-84	11.89	0.11
85+	11.19	0.07

Source: NHS Digital (2021[35]), "Hospital Episode Statistics for England - Admitted Patient Care statistics, 2018-19", https://digital.nhs.uk/data-and-information/publications/statistical/hospital-admitted-patient-care-activity/2018-19.

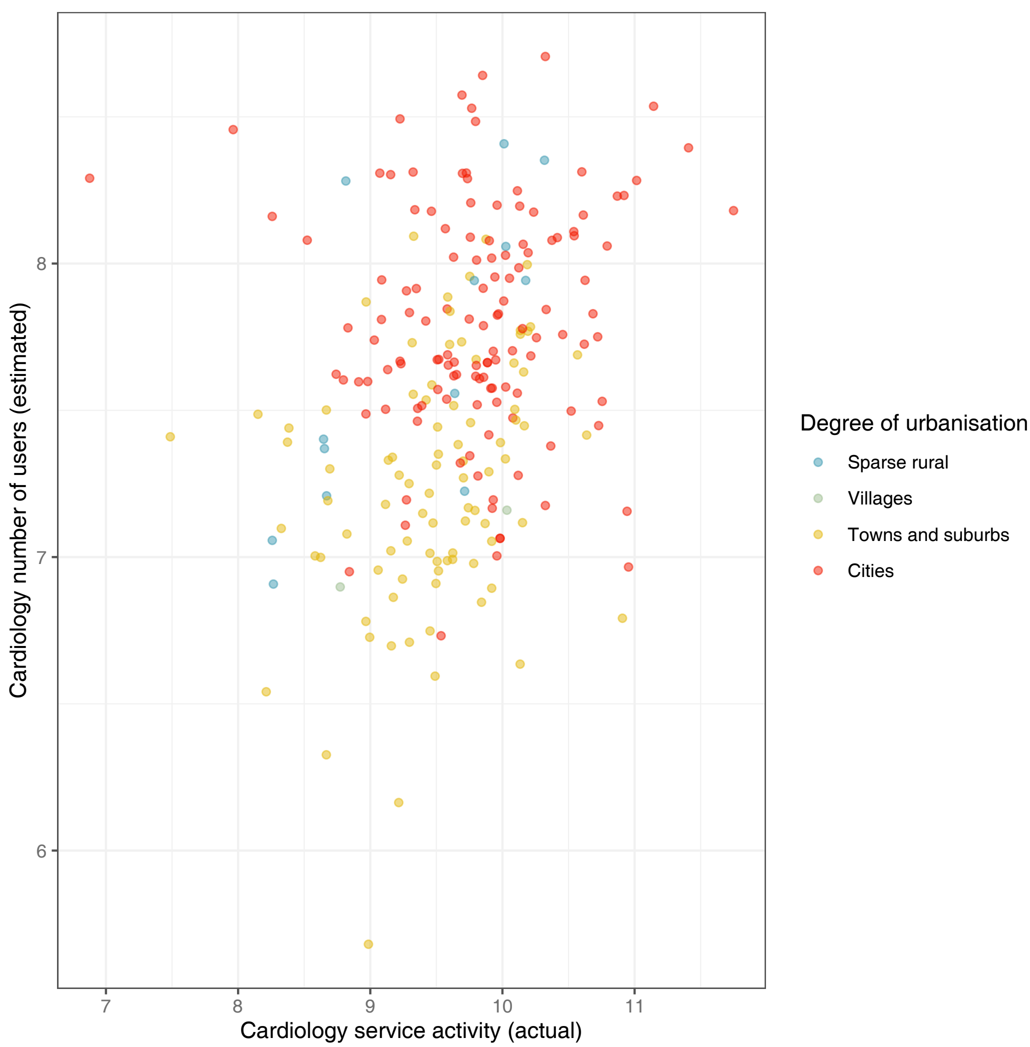
To this end, the approach uses NHS visits statistics for both services, by sex and age group, to estimate usage per catchment area, so that a catchment area with many expected users is allocated a relatively large share of the costs of a service location, compared to catchment area with few expected users.

The comparisons of the estimated annual costs per head per service are done based on costs per user at their place of residency, so when summarising by degree of urbanisation, the average represents the cost for a user living a given degree of urbanisation regardless of where the service location they potentially attend is located. Costs at place of residency are obtained through the process of 'cost porting' described in Box 3.2, Chapter 3. This ensures a consistent comparison of geographical differences in accessibility and costs, as a comparison based on service location would not truthfully capture location-specific scale economies, which likely depend on many other factors besides the scale of the potential user pool. Moreover, these facility-based estimates would give the wrong impression that for instance services located in sparse rural areas serve only users from those areas - in fact, as data for England shows, they serve a balanced mix of users from all areas, including cities.

Figure 4.4 and Figure 4.5 compare for service locations in England the (log) estimated users with (log) service activity, which records all service-related activity for the set of services included in cardiology and M&O services. Generally, the proposed approach to estimate number of users reproduces the scale of operation in service locations in different locations: compared to NHS admissions data by speciality for 2018 (NHS Digital, 2021[35]), the approach predicts 521 764 users in observed Cardiology locations against 450 173 actual cardiology admissions, and 613 707 users of M&O services, close to 720 809 obstetrics admissions.

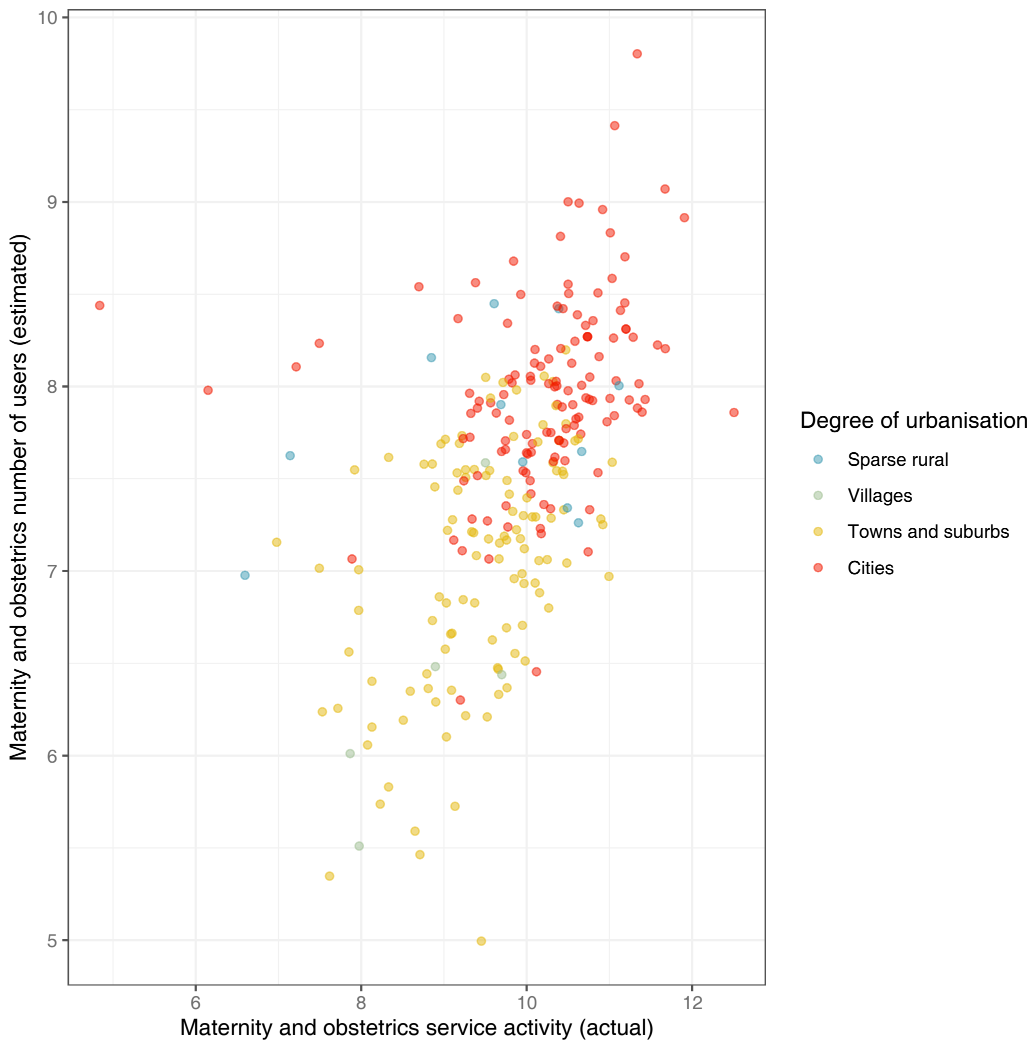
The comparison also confirms that in both actual and simulated data, service locations located in sparse rural areas may have a large scale of activity and services located in towns and suburbs have on average smaller scales. The largest differences between the estimated and actual measures of scale of services are observed for services located in cities and are possibly due to different levels of specialisation in actual urban service locations that cannot be captured with the approach proposed in this analysis.

Figure 4.4. Estimated users versus actual service activity at cardiology service locations, England



Note: Both variables are in logs.
Source: Authors' estimations based on (Goujon et al., 2021[28]; NHS Digital, 2020[29]; NHS England, 2020[30]; NHS Improvement, 2020[31]; Jacobs-Crisioni et al., n.d.[32]).

Figure 4.5. Estimated users versus actual service activity at maternity and obstetrics service locations, England



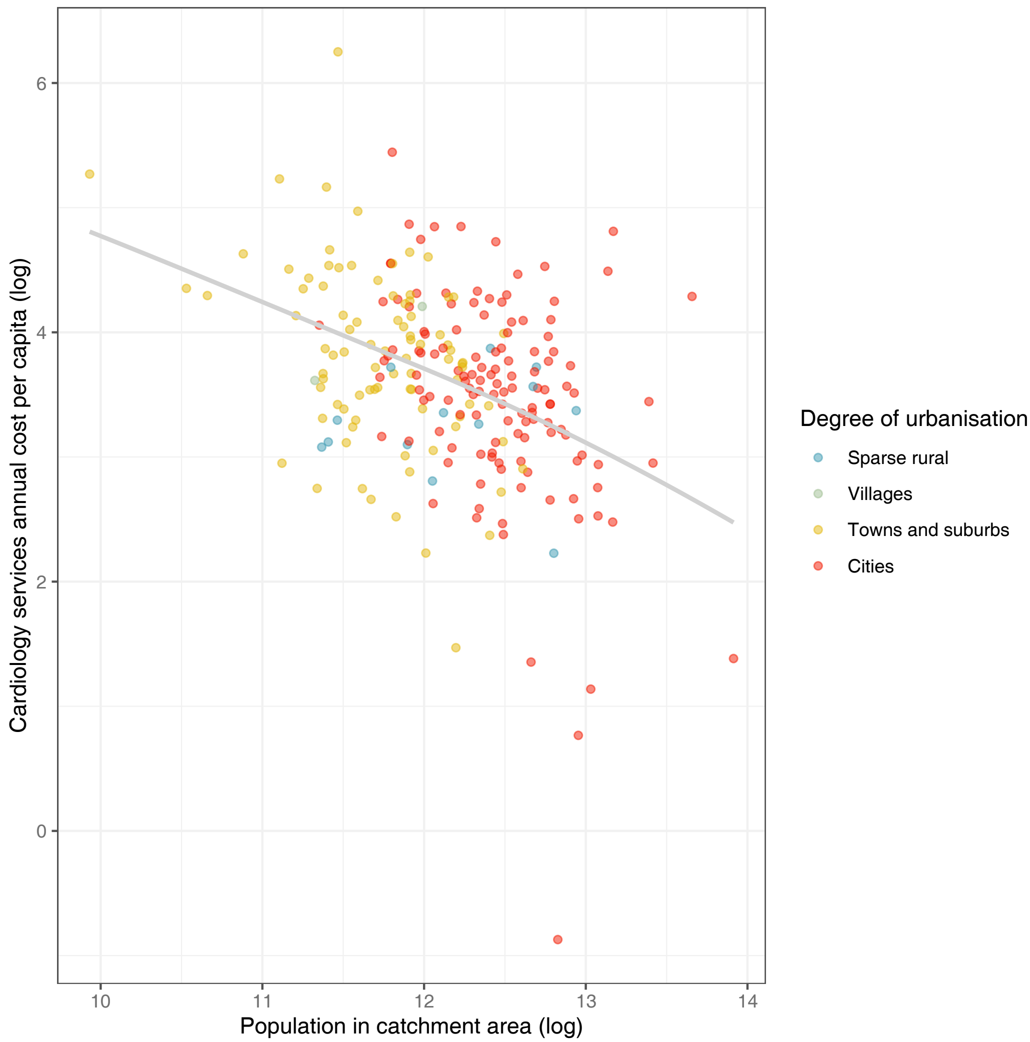
Note: Both variables are in logs.
Source: Authors' estimations based on (Goujon et al., 2021[28]; NHS Digital, 2020[29]; NHS England, 2020[30]; NHS Improvement, 2020[31]; Jacobs-Crisioni et al., n.d.[32]).

For cardiology services, the approach first considers the expected number of deaths in the service location's catchment area for the forthcoming year. However, there is a strong correlation between the number of deaths and population in the catchment area (correlation coefficient = 0.89). Separate regressions of these determinants show that population in the catchment area has higher explanatory power than deaths. Consequently, the approach uses this proxy for local demand in the regression analysis. In alternative regressions considering the effect of average mortality rates together with the effect of population, the effect of average mortality rates turned out to be not statistically significant.

For M&O services, the regression analysis also aims at estimating the effect of potential demand on costs per head, this time approximating demand by the number of expected births in the catchment area (see Box 4.1 for an explanation of how local expected births are obtained). As in the case of cardiology, while there is a strong correlation between births and population (correlation coefficient = 0.89), the regression fit favoured the use of population as a proxy for demand. Figure 4.6 and Figure 4.7 show that (log) population in catchment area has a negative relationship with (log) costs per capita for both services.

Figure 4.6. Population in catchment area versus annual costs per capita for cardiology services (estimated), England

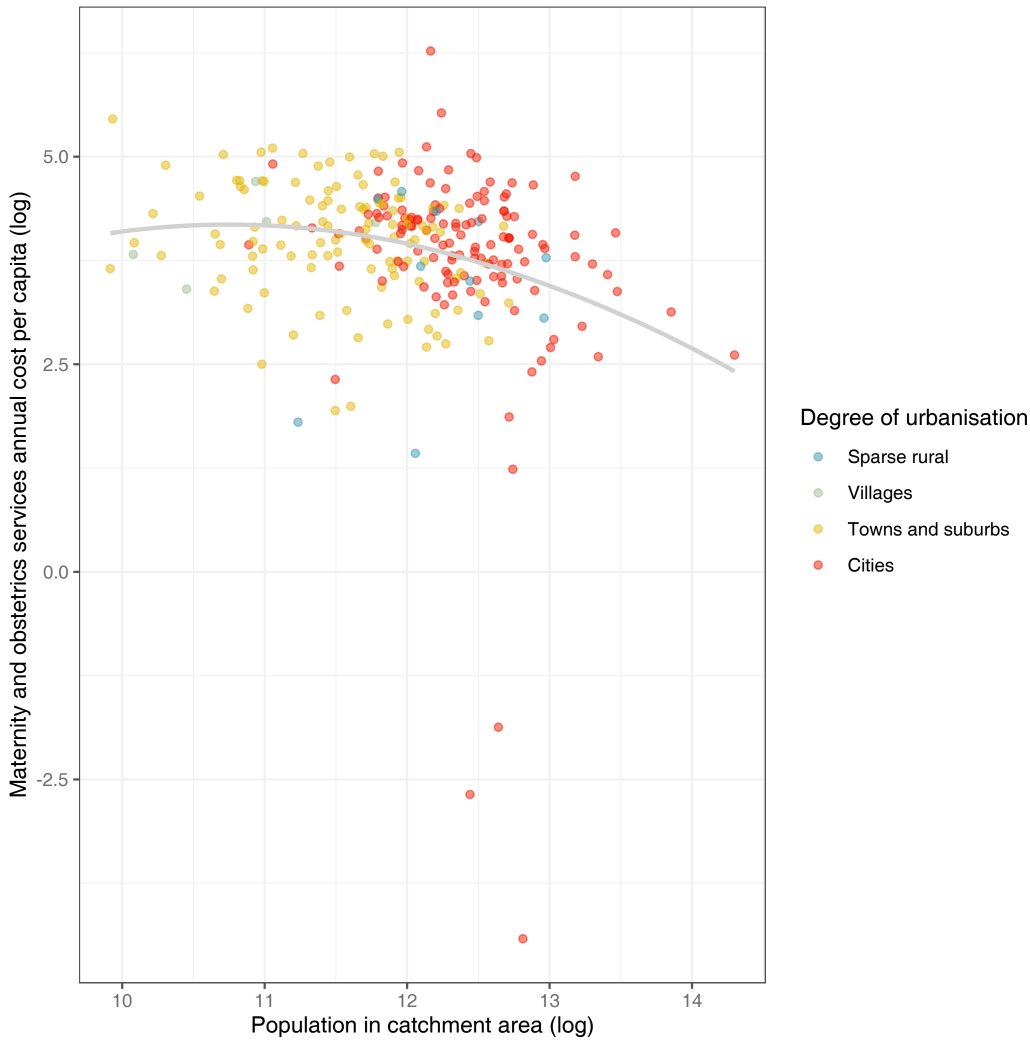
2011



Source: Authors' estimations based on (Goujon et al., 2021[28]; NHS Digital, 2020[29]; NHS England, 2020[30]; NHS Improvement, 2020[31]; Jacobs-Crisioni et al., n.d.[32]).

Figure 4.7. Population in catchment area versus annual costs per capita for maternity and obstetrics services (estimated), England

2011



Source: Authors' estimations based on (Goujon et al., 2021[28]; NHS Digital, 2020[29]; NHS England, 2020[30]; NHS Improvement, 2020[31]; Jacobs-Crisioni et al., n.d.[32]).

Thus, the (log) cost of service per capita for hospitals $i = 1 \ldots n$ as is estimated on the (log) of population of catchment area using linear regression:

$$HCC_i = \beta_0 + \beta_{1is} N_i + \varepsilon_i \quad (1)$$

where HCC_{is} are services costs per capita at hospital i (i.e. total costs of the service in service location i divided by the population in the catchment area of service location i), N_i is the estimated population of catchment area around service location i, and ε_i is an idiosyncratic error term. β_{1i} can be interpreted as an average marginal effect of one percentage point of catchment area population on per capita costs. The same regression is run separately for cardiology and M&O services.

Table 4.5 shows the regression results. According to the estimations, the negative and significant coefficient of population in catchment areas in both regressions indicate reduced costs with increasing demand. For cardiology, a 1% increase in population in the catchment area of the average service location is associated with reducing costs per head in that service location by 0.57%. For M&O services, the elasticity of cost per head to catchment area population is 0.33%.

Table 4.5. Cardiology and maternity and obstetrics service annual costs estimation results

Dependent variable: Annual costs per head (log)

term	estimate	std. error	statistic	p- value
Cardiology (n=233; Adjusted R-square=0.16)				
Intercept	10.482	1.034	10.138	0.000
log(Pop)	-0.565	0.085	-6.657	0.000
Maternity and obstetrics (n=259; Adjusted R-square=0.052)				
(Intercept)	7.775	1.043	7.454	0.000
log(Pop)	-0.325	0.087	-3.745	0.000

Note: Pop=Population in catchment area.
Source: Authors' estimations based on (NHS Digital, 2020[29]; NHS England, 2020[30]; NHS Improvement, 2020[31]).

Table 4.6 shows the results of observed versus modelled annual costs per user at place of residency by degree of urbanisation. When indexing to cities - the degree of urbanisation category with the lowest costs per user - the results for both cardiology and M&O services show that, compared to cities, the modelled costs per user are higher in sparse rural areas and villages and lower in towns and suburbs. The observed costs exhibit a similar pattern, although with larger differences across categories.

Table 4.6. Comparison of actual versus modelled annual cost per user (at place of residency), England

Degree of urbanisation	Annual cost per user (GBP)			Relative costs per user (cities = 100)		
	Observed/ observed	Observed/ modelled	Modelled/ modelled	Observed/ observed	Observed/ modelled	Modelled/ modelled
Cardiology						
Sparse rural	4 257	3 570	4 180	105.2	114.0	116.2
Villages	4 095	3 548	4 182	101.2	113.3	116.3
Towns and suburbs	4 126	3 464	4 016	102.0	110.6	111.7
Cities	4 046	3 131	3 596	100.0	100.0	100.0
Maternity and obstetrics						
Sparse rural	6 102	4 736	4 894	230.3	146.8	124.8
Villages	5 738	4 622	4 975	216.5	143.2	126.9
Towns and suburbs	4 705	4 323	4 754	177.5	134.0	121.2
Cities	2 650	3 227	3 921	100.0	100.0	100.0

Note: Modelled service locations are UK-wide results; observed service locations are England only. All costs are based on porting using expected admissions.
Source: Authors' estimations based on (Goujon et al., 2021[28]; NHS Digital, 2020[29]; NHS England, 2020[30]; NHS Improvement, 2020[31]; Jacobs-Crisioni et al., n.d.[32]).

Conclusions

This chapter has presented a method to estimate service location demand and costs from aggregate data on actual service location costs. Chapter 5 uses these figures to obtain estimations in EU27+UK countries. The method presented in this chapter benchmarks data for England. The benchmarking employs service locations' own estimates of the cost of per capita provision of various healthcare activities, grouped by two service types: cardiology and maternity and obstetrics.

Following the current literature on the topic, the approach uses local death rates, rather than size of age classes, as predictor of demand for cardiology services, and local birth rates as a predictor of demand for maternity and obstetrics services. This demand determines the need for a new service location, so the number of health service locations allocated to a country depends on both the level of demand for the services and its geographical distribution: in sparsely populated areas, service locations are expected to have very large catchment areas, while in cities catchment areas can be relatively small.

To apply the demand and access estimation method presented in this chapter to EU27+UK countries, it is necessary to establish first the possible location of cardiology and maternity and obstetrics services. This chapter explains how the location of actual service locations in England can be used to benchmark the location of service locations elsewhere, using a grid search approach and assuming distances to service locations are the only determinant of user allocation.

The regression analysis used to determine the relationship between costs per head in service locations and demand in their catchment areas finds a negative relationship between the size of the population in the service locations' catchment areas and per capita health care costs for both cardiology and maternity and obstetrics. The results generally suggest the presence of scale returns that imply lower average costs for larger populations in a catchment area.

Annex 4.A. Data processing

Data sources and data processing

This annex describes the process to generate a dataset containing for each relevant health service location: i) estimated catchment areas of the service it provides; and ii) an estimate of the accounted annual costs incurred for health service provision at that facility.

The estimations of costs at location and service level rely on data from NHS England Reference Costs (NHS Improvement, 2020[31]). Reference Costs are published on a yearly basis as an estimate of the actual costs of provision of hospital services in England, with each provider returning an estimate on a full absorption basis (i.e. including a share of any relevant overheads) for services categorised by Healthcare Resource Groups (HRGs), grouping types of hospital activity that are similarly resource-intensive. While the primary aim of the collation of such cost data is to inform the following year's NHS Tariff – the rate at which hospitals are reimbursed for activity – the use of such administrative costs has been common in analysing patterns and changes in hospital activity, with a view to explaining relevant factors in their determination (Aragón, Chalkley and Rice, 2016[36]). While such activity is assigned to an HRG in order to inform reimbursement, it can also be categorised into the broader category service groups, largely at the level of clinical speciality: this is the categorisation employed in this analysis.

In order to map trust cost estimates to service locations, the approach first derives a comprehensive list of data on hospitals in England provided on the NHS website (NHS England, 2020[30]). From this list, data is scraped on the location of the service location (as determined by the midpoint of the location's postcode), as well as a list of all services provided by this service location, usually by clinical specialty. After cleaning for service locations listed as providing no services (from checking a sample of ten on this, all were now-defunct hospitals) and service locations geographically outside England (one located in Jersey), this yielded a dataset of 990 locations providing a mean of 16.06 services (median 9, interquartile range 3 to 24, max 86), the vast majority of which ultimately provided no services of relevance to the analysis. While in many cases this list of services maps on a one-to-one obvious basis to a specialty code grouping included in reference costs (NHS Digital, 2020[29]), this is not true in all cases. As a result, some judgement must be introduced at this stage: for each of the two services to be considered, specialty codes that are judged as best mapping onto these service descriptions are included. The final set does not contain private service locations contained on the list, service locations where it was not possible to match a hospital trust code to the locations' postcodes, and cases where missing data for hospitals within a trust entailed costs that were implausibly high being assigned to one small location.

For most combinations of trusts and services, activity takes place at a single site, and for such cases, the assignment of trust-level costs to locations is clear and straightforward. On occasion, however, services may be provided at multiple sites within the same trust, leaving the problem of assigning trust-level costs to individual locations in such cases.

Combining trust costs and service location catchments

A number of limitations are relevant for the data generation process.

- Catchment sizes are defined at the service location level.
- Whether a service is provided at a location is broadly indicated, e.g. indicating the presence of "cardiology".
- Costs are accounted for at the trust level.
- Trust-level costs are accounted for in detail, e.g. discerning costs in general cardiology consultation, cardiac surgery, and other cardiology-related treatments.
- Trusts typically operate multiple service locations.
- Multiple trusts can be present at the same location.

The particular nature of the available data imposed that the data generation process is based on a number of assumptions, which in turn affect the final distribution of costs over service locations, and subsequently the health cost regression results used in this report.

- The only feasibly identifiable link between service locations and the trusts that operate them, is when a trust has a location where the service is offered.
- Although, across service locations, there is presumably variance in the depth of health services offered, when defining the catchment sizes, all service locations were expected to compete on an equal footing.
- Service locations that offer more services are generally larger, have more capacity and possibly also offer more complex services. Service-specific costs are therefore downscaled from trusts to service locations proportionally to the number of services offered at a location, relative to the total number of services offered by the trust.

Given the limitations and assumptions involved in the endeavour, the process to ensure that costs are attributed to the right catchments is complex. The process by which the data is generated is outlined in the remainder of this annex. Descriptive statistics relevant for the data joining process are given in Annex Table 4.A.1.

Annex Table 4.A.1. Descriptive statistics of the inputs used to generate datasets

	Cardiology	Obstetrics and gynaecology
NHS location data		
Number of locations	238	257
Average catchment size (pop)	221 164	204 813
Min / mean / max number of trusts at location	0 / 2.91 / 7	0 / 2.51 / 6
NHS trust data		
Relevant service codes	172, 221, 320, 321, 331	500, 501, 560
Min / mean / max number of services	1 / 1.97 / 5	1 / 1.87 / 2
Cost accounts	292	241
Trusts with cost accounts	148	129
Min / mean / max number of locations	0 / 4.68 / 17	0 / 4.99 / 19
Spatial relation		
Service locations without known trusts	7	1
Trusts without known locations	7	5
Percentage costs not allocated	10%	5.5%

Preparation

First, verified service locations were stored in databases that separately describe the spatial distributions of both services. Subsequently, using the spatial interaction modelling procedure outlined in Chapters 2 and 4, floating catchment sizes are defined for the two services. All service locations were assumed to be perfectly equal. The result is a detailed account of the demography of a location's catchment, including breakdown of the location's catchment population by age group and expected number of births and deaths. The sum of total catchment populations for all service locations is always equal to the total population size of the study area.

Relevant trust cost accounts were identified as well. To do so, cost accounts for services described in Table 4.3 were maintained. This selection leaves a reduced list of cost accounts, which are reported by a limited number of trusts. Finally, for the selected services, lists are compiled that indicate total costs and total service activity for every relevant trust.

Linking trusts and facilities

Known locations and their catchments are linked to trusts through spatial location. Elementary here is a lookup table that indicates, per row, trust name and postcode of a specific site of the trust. The process to spatially link trusts and service locations for each service are:

- Create a data file with unique service locations (as sites are sometimes expected at the exactly same location).
- Create a data file with unique postcode locations, as in some cases those are in the same location as well.
- Link unique postcode locations to unique service locations by selecting the service location that is geographically closest to all postcodes accounted for.
- Link lookup table sites to postcode locations, and subsequently to service locations.
- Select, from the lookup table, only records of service locations that:
    - Belong to a trust that offers cardiology or obstetrics and gynaecology.
    - Are linked to a location at which cardiology or obstetrics and gynaecology services are offered.
    - Have, as an outcome of the spatial linking process, a less than 1 000 metres separation between the site's postcode location and health service location.
    - Identify unique combinations of trusts and locations. This is necessary because, in the lookup table, multiple administrative sites in a trust may be in the same location.
    - Compute weighted service count: sum total number of broad services offered at any selected health service location, and divide that sum by the number of trusts present at the location.
    - Distribute total costs per trust over the trust’s locations, proportional by weighted service count.
    - Sum total costs per trust per location to total costs per location.
    - Distribute total costs per location over the sites at the location, proportional by the number of services offered by the health service, relative to total services offered at the location.

Annex 4.B. Placement thresholds calibration

This annex describes the procedure to calibrate the thresholds that are used in the placement simulation.

The valuation of imputed threshold values was done through a grid search that aimed at most accurately reproducing observed service location distributions in England. The adopted location-allocation approach is meant to reproduce observed service location placement patterns accurately, under the assumption that the real-world placement patterns yield a societally acceptable balance between service location cost (as a function of its size) and travel costs.

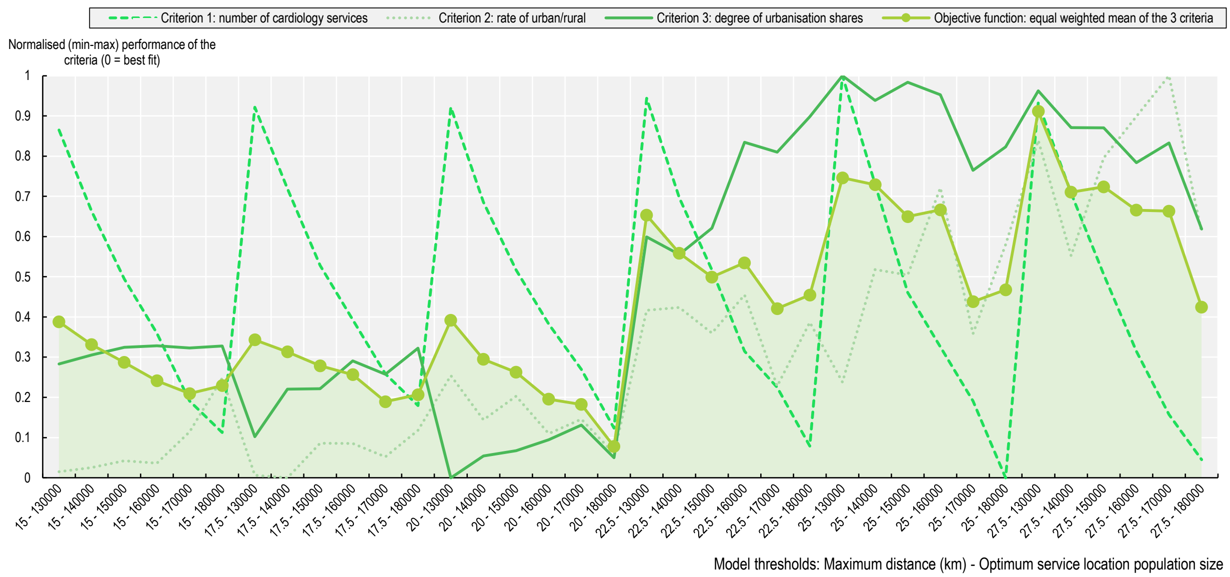
The grid search was performed by adapting values related to maximum distance, minimum size, optimal size and accessibility weighting. A composite objective function was computed to measure model accuracy given the imputed values. That function was composed of three criteria, namely percentage difference between modelled and observed nationwide number of service locations; the difference between modelled and observed rates of number of urban vs rural service locations; and the mean squared error of percentage points for shares of number of service locations by degree of urbanisation (see Box 1.2 in Chapter 1).

Annex Table 4.B.1 shows the thresholds that yield the most accurate results in England. These threshold values have therefore been selected as baseline values for allocation of birth services throughout Europe (Annex Figure 4.B.1 and Annex Figure 4.B.2). The calibration exercise also showed that some parameters have a much more substantial impact on allocation outcomes than others. In particular, the maximum catchment area distance and the facility's optimal size, which both come into play in the service location placement stage of the modelling procedure, have a considerable impact on service location distribution.

Annex Table 4.B.1. Selected threshold values

	Cardiology	Maternity and obstetrics
(1) Maximum catchment area (km)	20	20
(2) Minimum size (deaths or births as proxy for demand)	750	750
(3) Optimal size (deaths or births as proxy for demand)	1 800	1 800

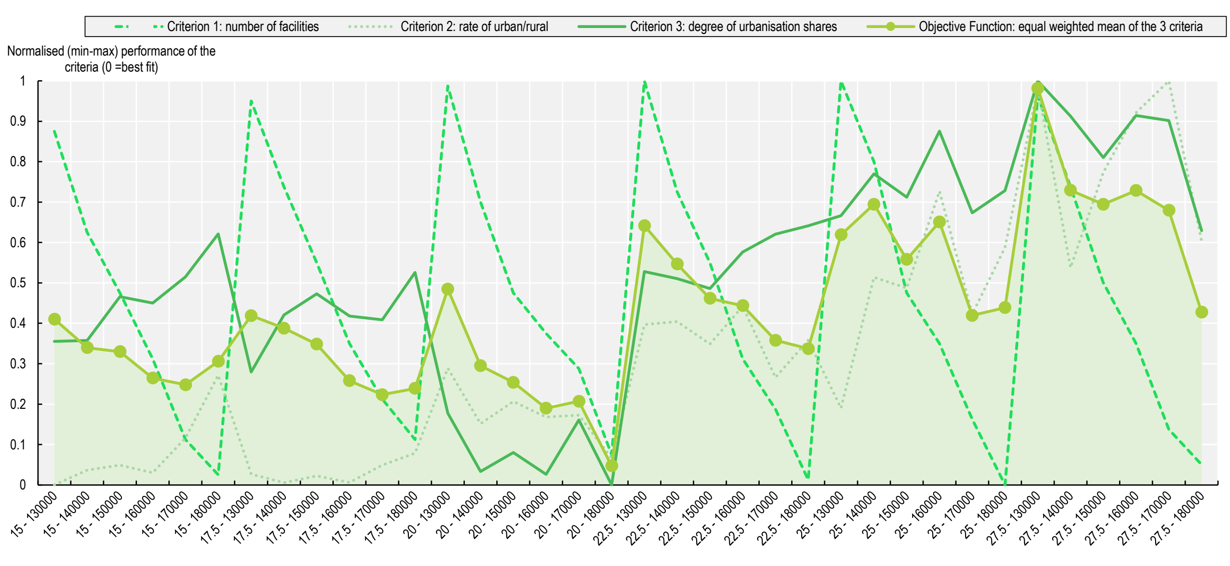
Annex Figure 4.B.1. Results of adapting maximum distance and optimal size in allocation procedure for cardiology service locations, England



Note: Criterion 1: number of observed and modelled locations (% difference in modelled vs observed total number of service locations). Criterion 2: urban/rural rate (% difference between modelled and observed urban/rural rate in number of service locations). Criterion 3: degree of urbanisation shares (mean squared error of percentage points for degree of urbanisation shares of number of service locations). Objective function: Equal weighted mean of the 3 criteria. Best fitting model thresholds: 20 km maximum distance and 180 000 optimum population size.
Source: Authors' estimations based on (Goujon et al., 2021[28]; NHS Digital, 2020[29]; NHS England, 2020[30]; Jacobs-Crisioni et al., n.d.[32]).

StatLink https://doi.org/10.1787/888934246507

Annex Figure 4.B.2. Results of adapting maximum distance and optimal size in allocation procedure for maternity and obstetrics service locations, England



Note: Criterion 1: number of observed and modelled locations (% difference in modelled vs observed total number of service locations). Criterion 2: urban/rural rate (% difference between modelled and observed urban/rural rate in number of service locations). Criterion 3: degree of urbanisation shares (mean squared error of percentage points for degree of urbanisation shares of number of service locations). Objective function: Equal weighted mean of the 3 criteria. Best fitting model thresholds: 20 km maximum distance and 180 000 optimum population size.
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StatLink https://doi.org/10.1787/888934246526

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Notes

[1] See (Luo and Qi, 2009[21]), (Wang, 2012[22]) and (Kim, Byon and Yeo, 2018[37]) for further detail on the 2SFCA method together with varying applications of health service accessibility.

[2] These groupings are 0-4 years, 5-9 years… up to a single grouping of all individuals aged 85+.

[3] The service categories are aggregated differently by hospital locations so obstetrics and gynaecology is an approximation to M&O services.

5 Present and future health care services costs and access

This chapter analyses geographical differences in the demand, cost and access to health services in Europe, focusing on the case of cardiology and maternity and obstetrics (M&O). The chapter further analyses potential future changes driven by demographic change, providing estimates on future changes in demand for both services and the consequent adjustment in provision across degrees of urbanisation. The chapter concludes with insights on the balance between accessibility and cost-efficiency in the provision of health services across territories.

Main takeaways

- On average, an estimated 9 to 11 people per 1 000 inhabitants use cardiology services in EU27+UK countries, using local death rates to approximate demand. Demand is relatively lower in cities and relatively larger in sparse rural areas and villages, especially in countries with comparatively high death rates such as Bulgaria.
- The number of M&O service locations are larger in cities than in other areas on average for EU27+UK and across all countries except in Italy (where demand is low but similar across all types) and Ireland (where demand is similar everywhere except sparse rural areas).
- The number of service locations per users does not depend so much on total population across countries than on sparsity and demographic profiles. Countries with extensive areas with a low demand density, driven by the presence of older people in the case of cardiology or women in the case of M&O, have low service provision in proximity.
- According to the estimates, users in EU27+UK countries travel on average 32 km to access cardiology services and 36 km to access M&O services. In sparsely populated countries, over 40% of the sparse rural population lives far from locations offering either service.
- While distance to services is generally lower in towns and suburbs compared to rural areas, for both cardiology and M&O services, accessibility for towns and suburbs is worse when accessibility for rural areas is low because users have to travel to the next location to access the service.
- Service provision outside of cities is a balance between accessibility and cost-efficiency: countries may have service locations that are close or service locations that are cost-efficient, but, relative to cities, no country has low distances and low costs simultaneously.
- Demand for cardiology services is expected to increase substantially in EU27+UK countries, in particular in cities and in towns and suburbs, except in rural areas of countries expecting considerable rural-to-urban migration. For M&O services, a smaller aggregate overall reduction is expected, driven by lower demand in cities in many countries.
- On average across EU27+UK countries, the number of service locations per user is expected to increase by 0.16 and 0.1 locations per 10 000 users for cardiology and M&O services respectively.
- While travel distances to locations offering cardiology services are expected to decrease following the expected increase in demand due to ageing, distances to M&O service locations are generally expected to increase, particularly in cities due to the projected move of a share of women away from cities.
- Increase in demand for cardiology services means that many countries can foresee an improvement in accessibility paired with a decrease in average cost per user. On the other hand, many countries will see a decline in demand for M&O services, potentially resulting in less service locations and reduced cost efficiency in the remaining service locations.

Introduction

Rural inhabitants often experience the greatest barriers to accessing services including reduced service availability, limited choice of services or providers, and the need for greater travel to access health care (McGrail and Humphreys, 2014[1]). Furthermore, many rural residents have poorer health conditions and a shorter life expectancy, when compared to their urban counterparts (OECD, 2021[2]; Mitton et al., 2011[3]; WHO Regional Office for Europe, 2010[4]). Geographical access is critical also to ageing societies; (Deborah, Chiu and Cao, 2018[6]; Wu and Tseng, 2018[5]; Doetsch et al., 2017[7]).

Improving access to health care services is fundamental to enhancing health outcomes and quality of life (OECD, 2021[2]; Zhao, Li and Liu, 2020[8]). Better accessibility to health care services contributes to higher health care utilisation, especially for people with chronic diseases, and helps to lower infant, maternal and emergency mortality. Achieving an equitable geographic distribution of health care resources can help cost containment by decreasing oversupply as well as improve access by increasing supply to underserved areas (Yang, Goerge and Mullner, 2006[9]).

Chapter 4 outlines a method to estimate present and future cost and access using fine-grained population grids of two health services: cardiology and maternity and obstetrics (M&O). This chapter discusses the results of this estimation for EU27+UK countries, placing emphasis on the geographical differences in both dimensions. The unit of analysis is the degree of urbanisation. The analysis highlights the important role geography and demography play in shaping service provision areas, and emphasises the balance between accessibility and cost-efficiency. To guide policies on future provision, the analysis examines expected changes in demand and supply of cardiology and M&O services following projected demographic changes across territories from EU27+UK countries.

The chapter also undertakes analysis of current estimated cost and access to cardiology and maternity and obstetrics services: it starts by outlining the results for the demand for services and continues with the results for supply, followed by a discussion on the balance between costs and access. The third section gives future estimates and the last section presents some conclusions.

Estimated current health care services access and costs

This section focuses on how the geographical distribution of demand for health services translates into differences in cost and access across EU27+UK countries. In the analysis, while accessibility is measured through kilometres travelled, costs are presented as deviations from national average costs per users in cities. Box 5.1 explains why it is necessary to index the cost data for the analysis.

This section discusses first the estimated demand for services as captured by estimated number of users. It then presents the "supply" of health services as captured by the number of locations offering cardiology or M&O services in each country. Finally, it introduces a discussion on the balance between costs and access and concludes with the analysis of accessibility and cost results.

Box 5.1. International comparability of estimated health cost data

Why is it necessary to index the cost per user results to cities?

When compared with schools, health service locations have a much larger scale, and the numbers of health service locations that are modelled are consequently much smaller. A limited number of modelled service locations, combined with the yes-or-no thresholds that are at the basis of the service location modelling, have the effect that relatively small differences in countries' geographical distribution of demand can have a big impact on the modelled supply per capita in a country.

Cost variations across the degrees of urbanisation within a country, and the tension between accessibility and cost-efficiency that are the centrepiece of this report, are not affected by overall supply per capita. However, the method may exaggerate cost differences between countries, as small differences between countries can have a big impact on the total number of service locations. An alternative set up that would, for instance, bound access to shorter travel distances "by definition" (for example being required by law), would give a different picture. For this reason, the results outlined here should be considered taking into consideration the assumptions outlined in Chapter 4. Absolute monetary costs per head are therefore not a meaningful indicator for health services, in contrast to schools, where demand differences between countries have a much more moderate effect on cost differences.

The indexing works by making all costs in a country relative to the average costs per users living in cities in a country. For instance, considering a service that would on average cost EUR 3 000 per user in cities and 4 500 in sparse rural areas in one country, and EUR 4 000 and EUR 6 000 in another country: all costs will be expressed as an index relative to the national city average, so that in both countries, user costs in cities would be 100, and user costs in sparse rural areas would be 150.

Demand for health services

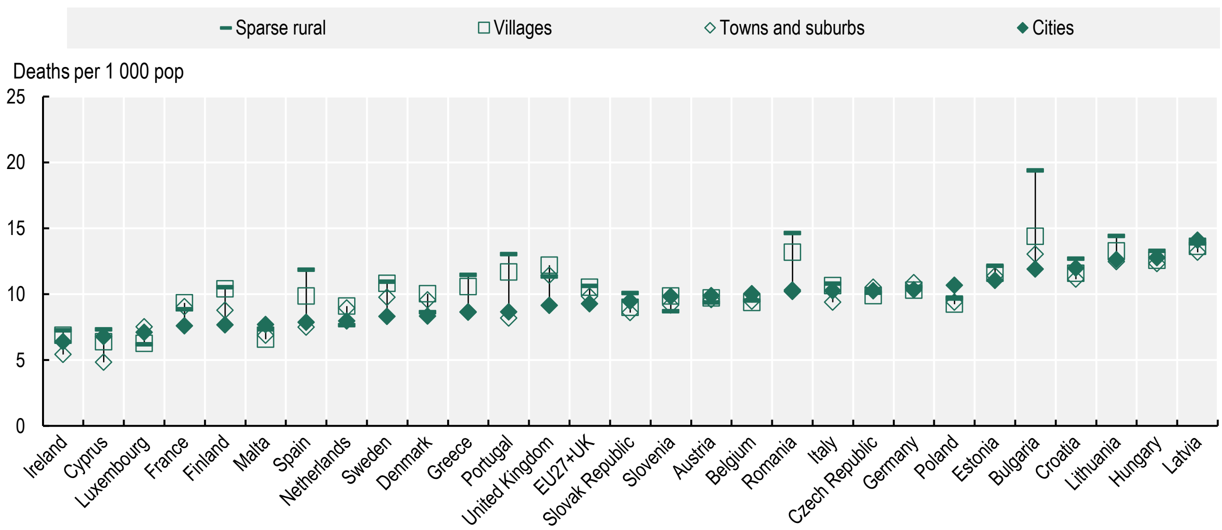
How many people use cardiology and M&O services, and how many service locations would cover the demand for cardiology and M&O services in EU27+UK countries? In this chapter, the expected number of users for each service, depending on age and sex distribution in the population, approximates the demand for the service.

As explained in Chapter 4, a person's time-to-death rather than their age, is the most accurate predictor of demand for many health services, including for cardiology. In fact, cardiovascular diseases are the leading cause of death in the EU (Eurostat, 2021[10]). Demand for cardiology services is therefore proxied by expected number of deaths in a catchment area. Higher crude death rates are likely to be due to an older population and do not necessarily reveal a higher age-adjusted mortality rate. Across EU27+UK countries, crude death rates are larger in Germany and Eastern European countries including Latvia, Hungary, Lithuania, Croatia, Bulgaria, Estonia and Poland (Figure 5.1). These countries also had higher than average hospital discharge rates for in-patients with diseases of the circulatory system in 2018 (Eurostat, 2021[10]). The variation across degrees of urbanisation is largest in Bulgaria where death rates in sparse rural areas are almost twice as large as the average for sparse rural areas in Europe (19.4 versus 10.6 deaths per 1 000 population). Other countries with significantly higher death rates in rural areas compared to cities include Romania, Portugal, and Spain.

Concerning M&O services, the predictor for demand is local birth rates. Crude birth rates, measured as the number of live births over total population in 2011, are on average higher in cities than in other areas for EU27+UK countries (Figure 5.2). Among countries with high fertility rates in 2010, they were significantly higher in cities in France, Sweden and Denmark, and similar in villages, towns and suburbs, and cities in Ireland. Countries with low fertility rates generally show less geographical variation in crude birth rates, with the largest gaps observed in Germany, Portugal, and Bulgaria.

Figure 5.1. Crude death rates by country and degree of urbanisation, EU27+UK

2011

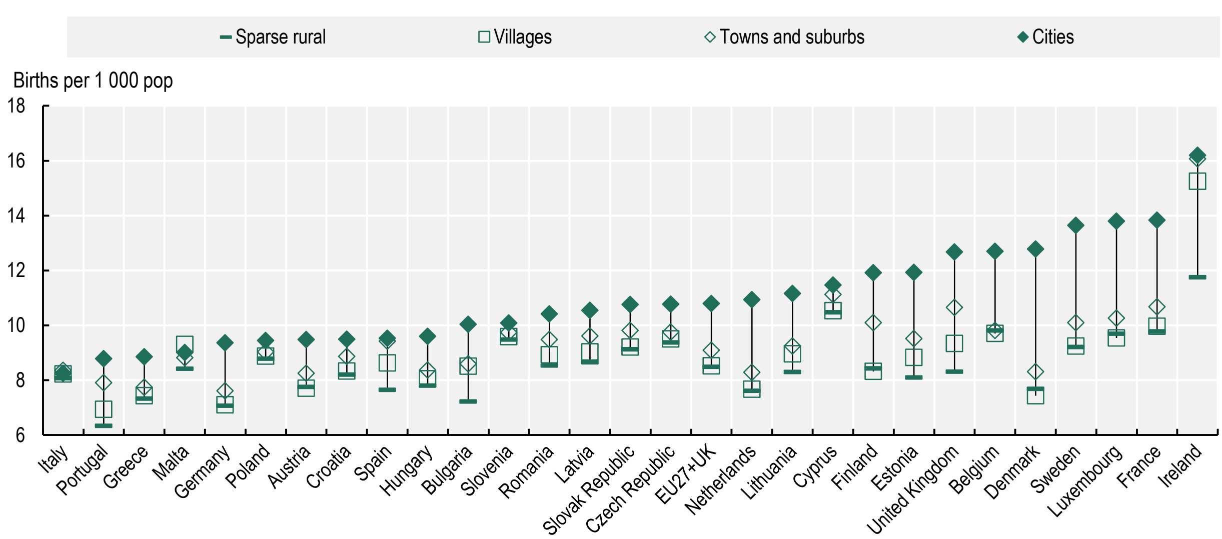


Source: Authors' elaboration based on (Goujon et al., 2021[11]) and (Jacobs-Crisioni et al., n.d.[12]).

StatLink https://doi.org/10.1787/888934246545

Figure 5.2. Crude birth rates by country and degree of urbanisation, EU27+UK

2011



Source: Authors' elaboration based on (Goujon et al., 2021[11]) and (Jacobs-Crisioni et al., n.d.[12]).

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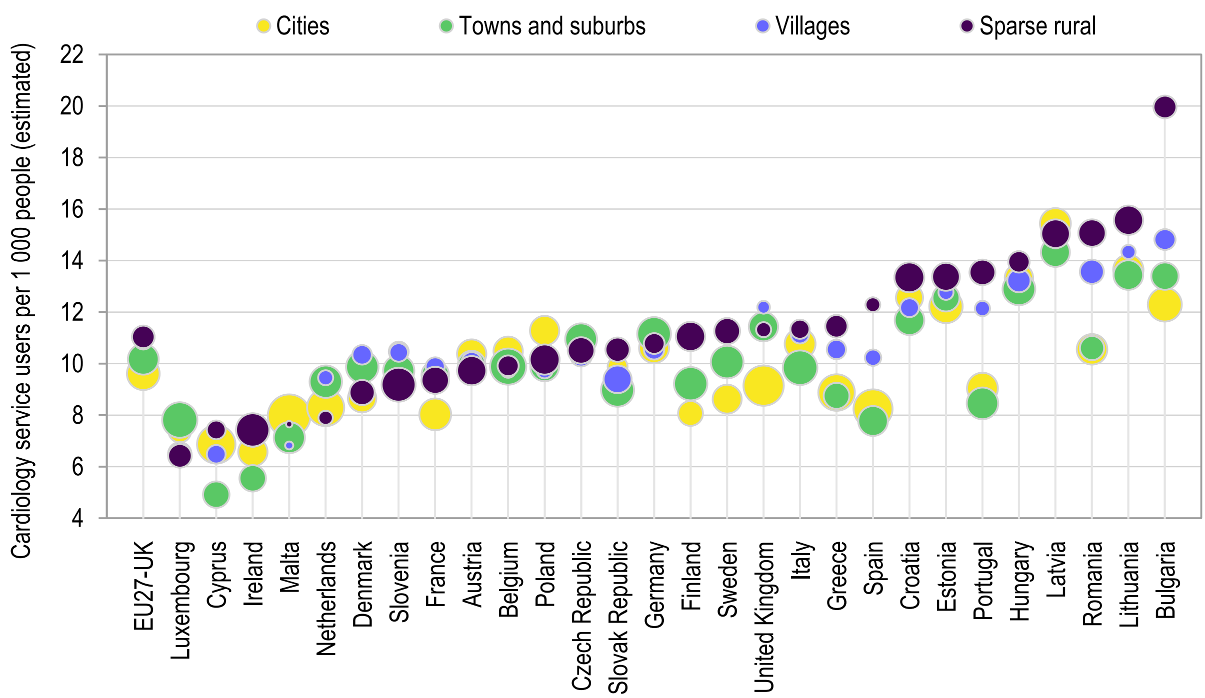
On average, an estimated 9 to 11 people per 1 000 inhabitants use cardiology services in EU27+UK countries, with relatively less demand in cities, and relatively more demand in sparse rural areas and villages (Figure 5.3). The demand for cardiology services differs substantially across countries according to the age and sex composition of the population, with generally higher relative demand in Eastern European countries and sparse rural areas of Portugal and Spain. As expected from differences in death rates, the largest gap in demand occurs in sparse rural areas of Bulgaria that have almost twice as many estimated users than the EU27+UK average.

Compared to cardiology, M&O services show similar user rates but a different distribution of demand across degrees of urbanisation. M&O user rates are larger in cities than in other areas on average for EU27+UK and across all countries except in Italy where demand is low but similar across all types, and Ireland, where demand is similar in cities, towns and suburbs, and villages (Figure 5.4).

Figure 5.3. Cardiology users per 1 000 people (estimated) by country and degree of urbanisation, EU27+UK

2011

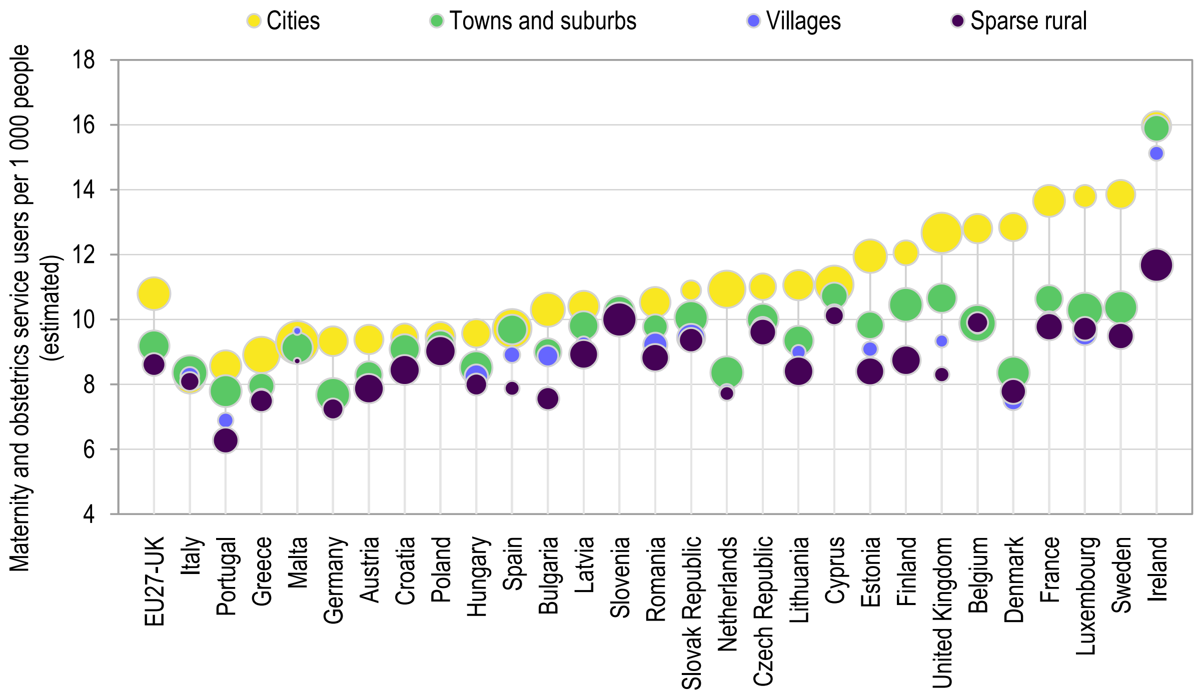


Note: Bubble areas represent the share of national population.
Source: Authors' elaboration based on (Goujon et al., 2021[11]) and (Jacobs-Crisioni et al., n.d.[12]).

StatLink https://doi.org/10.1787/888934246583

Figure 5.4. Maternity and obstetrics service users per 1 000 people (estimated) by country and degree of urbanisation, EU27+UK

2011



Note: Bubble areas represent the share of national population.
Source: Authors' elaboration based on (Goujon et al., 2021[11]) and (Jacobs-Crisioni et al., n.d.[12]).

StatLink https://doi.org/10.1787/888934246602

Service locations

From estimated demand, it is possible to estimate the service locations and their catchment areas for cardiology and M&O services. As described in Chapter 4, service locations are not categorised according to the degree of urbanisation in each country because service locations may be in a specific area but serve a mix of population coming from different areas. Table 5.1 confirms that cardiology and M&O services placed in a given degree of urbanisation serve a mix of population coming from different areas. This is particularly true for services placed in rural areas: for instance, over 40% of users of services located in sparse rural areas travel from towns and suburbs and cities.

Table 5.1. Composition of catchment areas of cardiology and maternity and obstetrics service locations by degree of urbanisation, EU27+UK

2011

Location by degree of urbanisation	Population in catchment area living in sparse rural areas (%)	Population in catchment area living in villages (%)	Population in catchment area living in towns and suburbs (%)	Population in catchment area living in cities (%)
Cardiology				
Sparse rural	36.3	20.6	40.7	2.4
Villages	37.1	26.0	33.9	3.1
Towns and suburbs	26.7	18.8	49.1	5.4
Cities	11.1	7.1	18.2	63.6
Maternity and obstetrics				
Sparse rural	35.3	17.5	43.5	3.7
Villages	36.9	25.4	33.8	4.0
Towns and suburbs	25.0	17.4	51.9	5.6
Cities	8.7	6.1	18.1	67.0

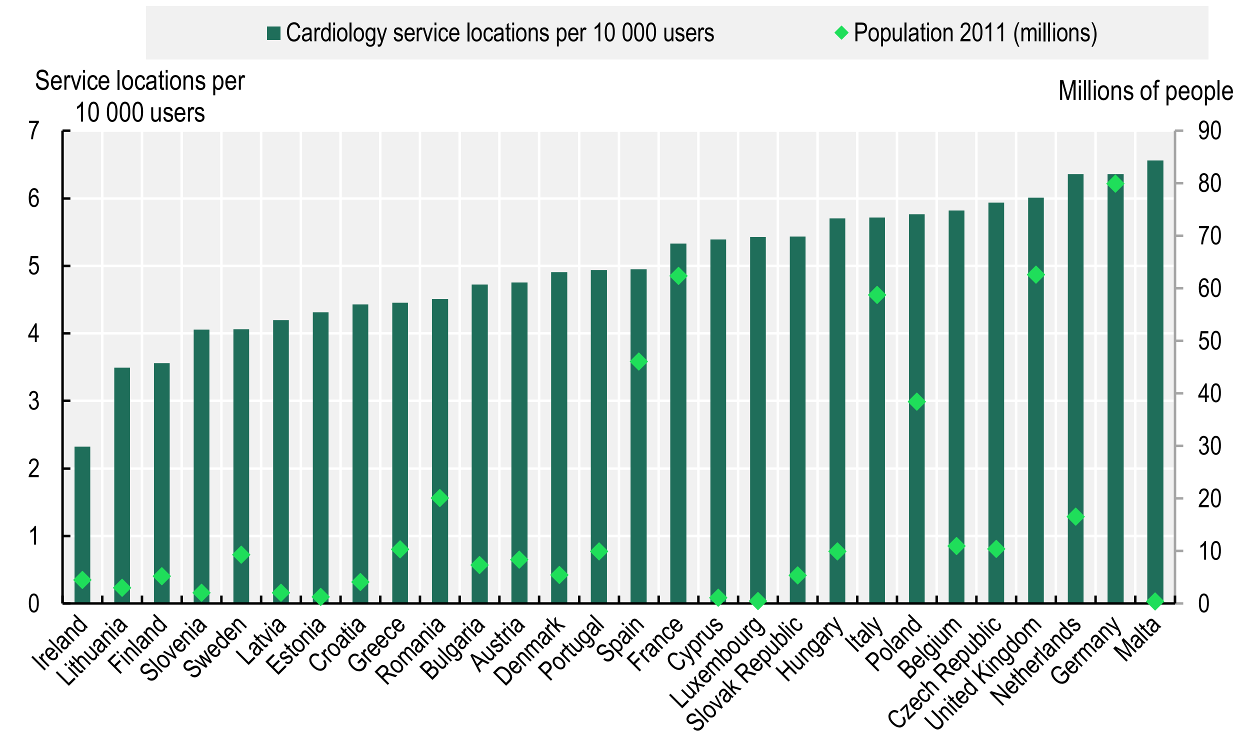
Source: Authors' elaboration based on (Goujon et al., 2021[11]) and (Jacobs-Crisioni et al., n.d.[12]).

Estimates of cardiology and M&O service locations per 10 000 users plotted against country's total population show that for both services, the number of service locations per users has no clear relationship with total population across countries (Figure 5.5 and Figure 5.4). The number of service locations can be relatively high in relatively small countries like Malta, the Netherlands, and the Czech Republic. This happens because the placement of cardiology or M&O service locations depends not only on absolute demand, but also on sufficient density of users in the service catchment area. The consequence is that countries with extensive areas with a low demand density have low service provision in proximity.

Moreover, low demand results not only from the general distribution of population over space, but also from demographic profiles. The most striking example is the case of cardiology services in Ireland, where due to relatively low population densities and a young population, the demand for cardiology services in the modelled catchments is too low in rural areas and even in some cities, so that cardiology services exist only on the largest cities.

Figure 5.5. Cardiology locations per 10 000 users (estimated) by country, EU27+UK

2011

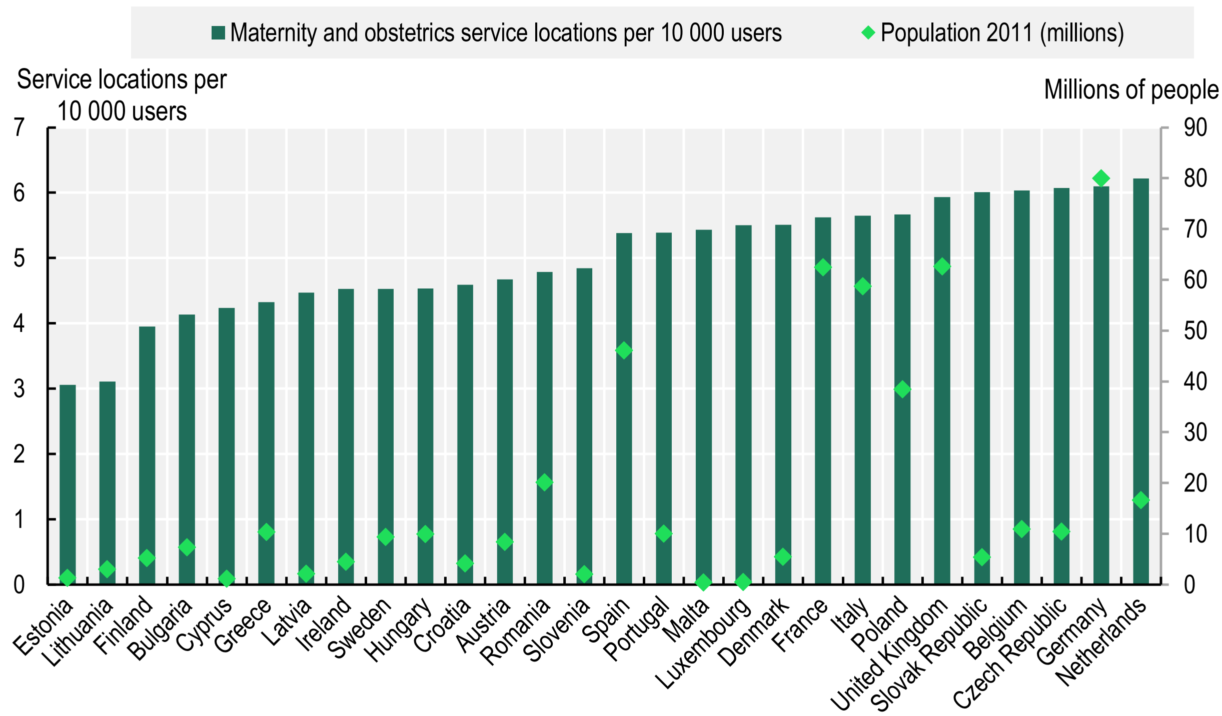


Source: Authors' elaboration based on (Goujon et al., 2021[11]) and (Jacobs-Crisioni et al., n.d.[12]).

StatLink https://doi.org/10.1787/888934246621

Figure 5.6. Maternity and obstetrics locations per 10 000 users (estimated) by country, EU27+UK

2011



Source: Authors' elaboration based on (Goujon et al., 2021[11]) and (Jacobs-Crisioni et al., n.d.[12]).

StatLink https://doi.org/10.1787/888934246640

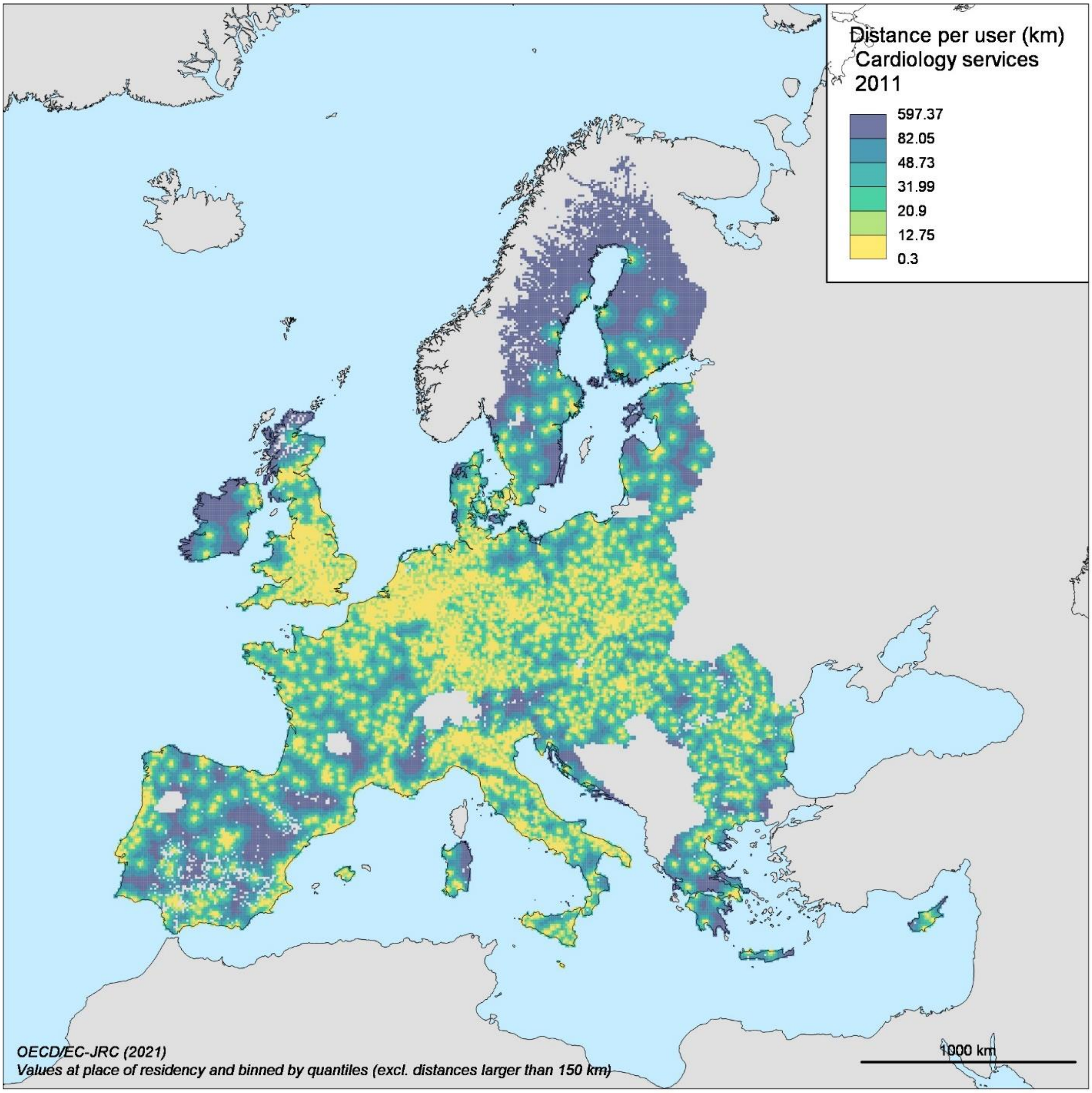
Geographical differences in access to services

This section discusses the results of the estimates of geographical differences in accessibility to present-day services obtained from the method outlined in Chapter 4. According to the estimates, users in EU27+UK countries travel on average 32 km to access cardiology services (Figure 5.7) and 36 km to access M&O services (Figure 5.8).[1] Urban areas with high density of demand show the lowest distances across degrees of urbanisation. Distances are low across the board in countries where sparse rural areas are scarce, such as Belgium, the Netherlands, and the United Kingdom. Spain and France, on the other hand, have a mix of areas with relatively low and high access, while Nordic and Baltic countries, Ireland, and parts of Spain and Portugal stand out as areas with considerably longer distances.

While the general pattern of accessibility is similar for both cardiology and M&O services, there are some notable differences. Ireland, with its relatively young and disperse population, has better access to M&O services than to cardiology services. In contrast, in the east of Portugal, with an older population, access to cardiology is higher than access to M&O services.

Figure 5.7. Distance to cardiology service locations per user (estimated), EU27+UK

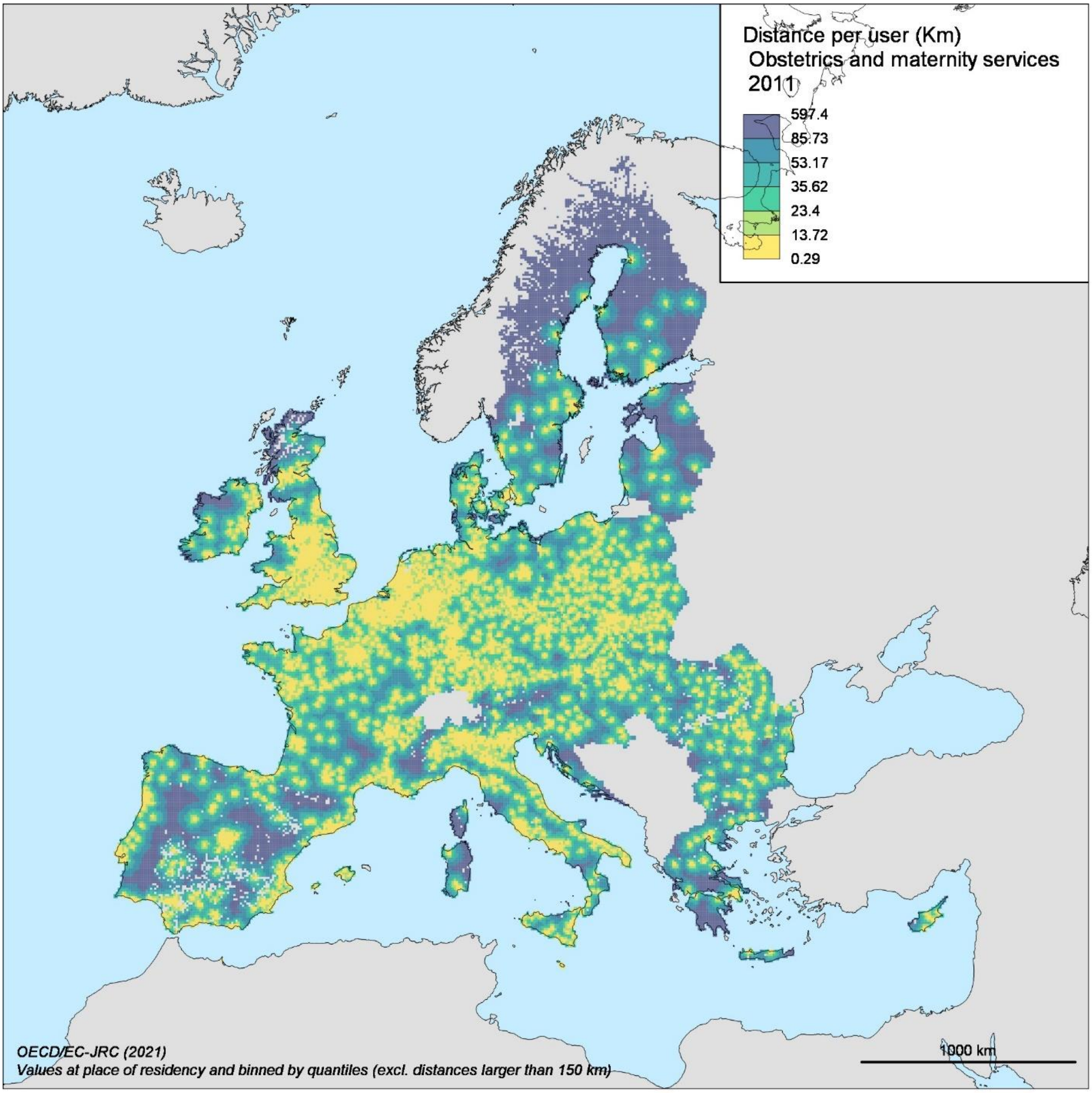
2011



Source: Authors' elaboration based on (Goujon et al., 2021[11]) and (Jacobs-Crisioni et al., n.d.[12]).

Figure 5.8. Distance to maternity and obstetrics service locations per user (estimated), EU27+UK

2011



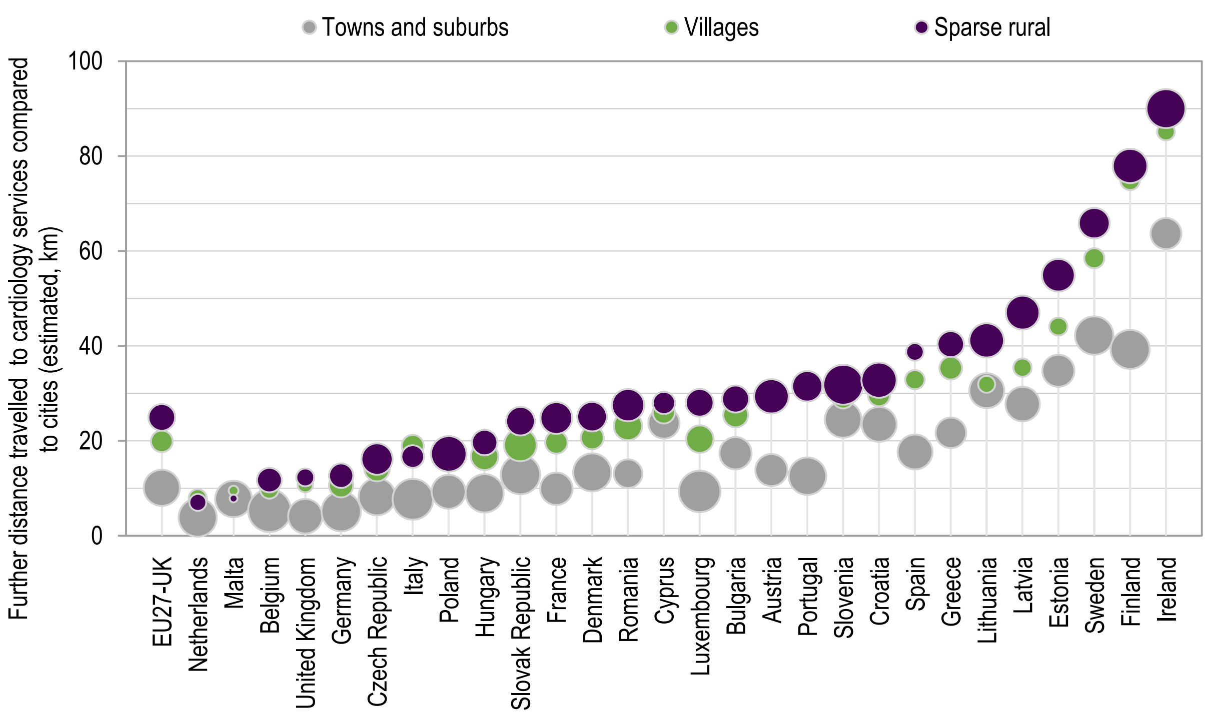
Source: Authors' elaboration based on (Goujon et al., 2021[11]) and (Jacobs-Crisioni et al., n.d.[12]).

While distances outside of cities are always larger, the penalty of living outside of cities in terms of travelled distance to services differs substantially across countries. In relatively dense countries where large expanses of sparse rural areas are rare, such as the Netherlands, Malta, Belgium, and the United Kingdom, users are fairly close to health services regardless of where they live (Figure 5.9 and Figure 5.10). On the other hand, in countries with large sparsely populated areas such as the Nordic and Baltic countries, rural-urban disparities in accessibility are much larger. In the extreme cases, users of cardiology living in sparse rural areas in Sweden, Finland and Ireland have to travel at least 60 km more than users in cities, as do users of M&O services in Finland and Latvia.

While distance to services is generally lower in towns and suburbs compared to rural areas, for both cardiology and M&O services, accessibility for towns and suburbs is worse when accessibility for rural areas is low (Figure 5.9 and Figure 5.10). This result contrasts with the schools accessibility results presented in Chapter 3. In fact, service provision in towns and suburbs depends not only on demand from the towns and suburbs themselves but from demand in surrounding areas. This means that limited demand in surrounding rural areas can imply that no service is present in a given town or suburb, in which case users from these areas have to travel longer to the next available location.

Figure 5.9. Further distance travelled to cardiology service locations relative to cities (estimated) by country and degree of urbanisation, EU27+UK

2011

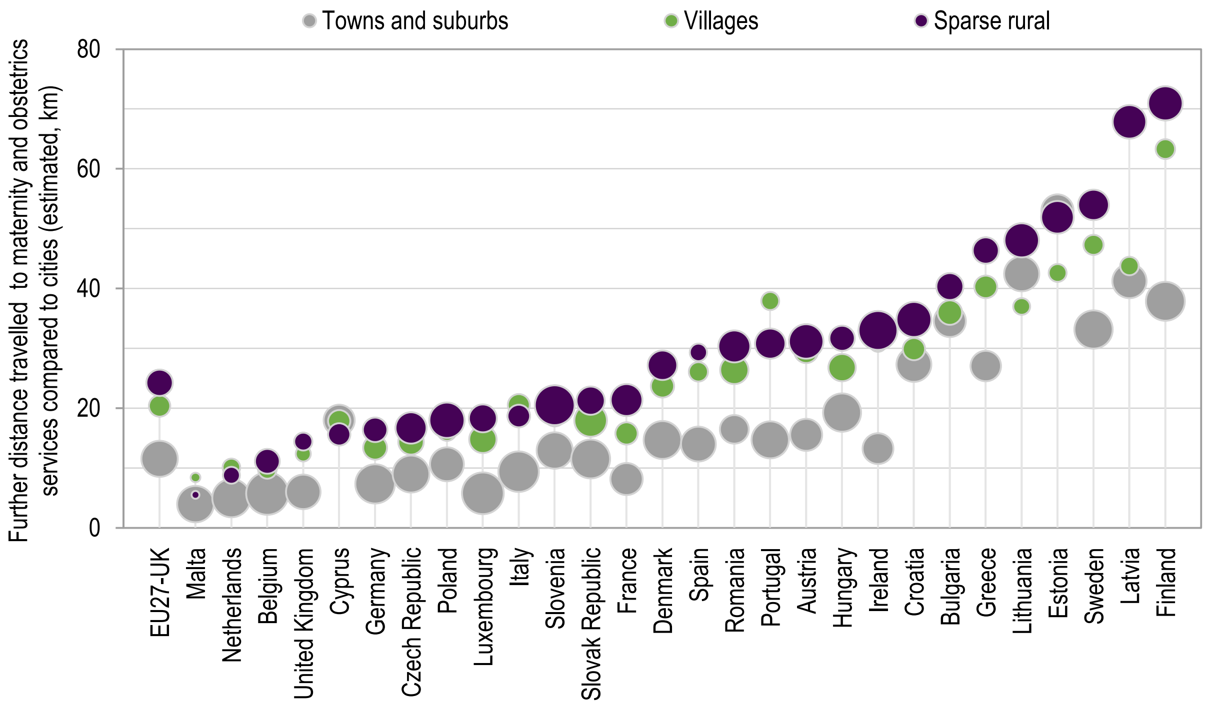


Note: Bubble areas represent the share of national population.
Source: Authors' elaboration based on (Goujon et al., 2021[11]) and (Jacobs-Crisioni et al., n.d.[12]).

StatLink https://doi.org/10.1787/888934246659

Figure 5.10. Further distance travelled to maternity and obstetrics service locations relative to cities (estimated) by country and degree of urbanisation, EU27+UK

2011



Note: Bubble areas represent the share of national population.
Source: Authors' elaboration based on (Goujon et al., 2021[11]) and (Jacobs-Crisioni et al., n.d.[12]).

StatLink https://doi.org/10.1787/888934246678

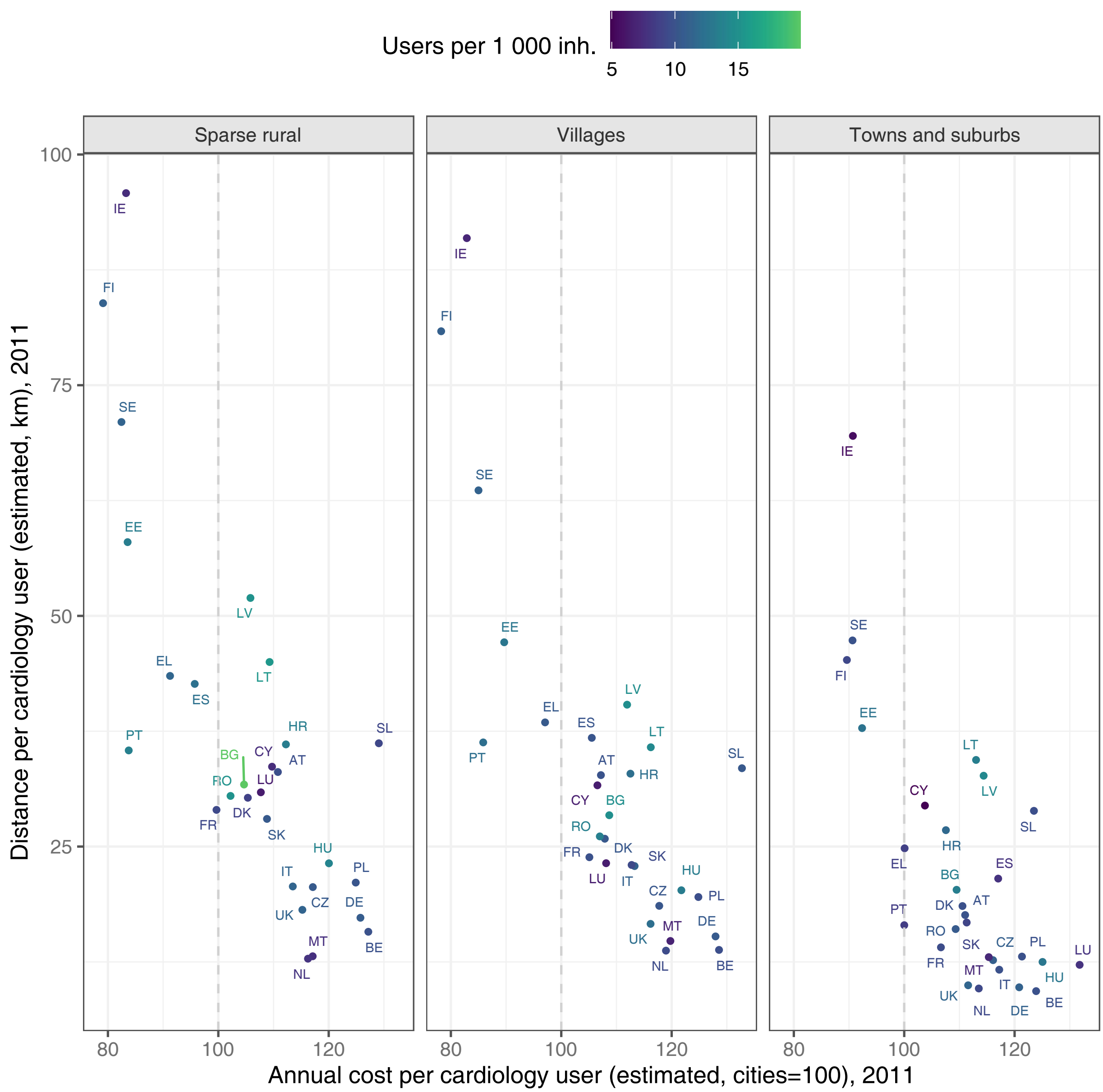
Relation between costs and accessibility

To study the relationship between costs and distances, annual costs are expressed as indexes relative to costs per user in cities, while distances are expressed as the average additional distance relative to distances travelled by city dwellers.

In general, service provision outside of cities is a balance between accessibility and cost-efficiency: countries may have service locations that are fairly close or service locations that are cost-efficient, but, relative to cities, no country has low distances and low costs at the same time (Figure 5.11 and Figure 5.12). However, there are important differences between cardiology and M&O services. For cardiology services, while many countries have lower annual costs per user outside cities, in most cases users outside of cities have to travel over 25 km more on average to access the service (Figure 5.11). For M&O services, travelled distances are generally shorter compared with cardiology service locations, but this higher access is paired with higher annual costs per user (Figure 5.12).

Figure 5.11. Cardiology services annual cost versus distance per user relative to cities by country and degree of urbanisation, EU27+UK

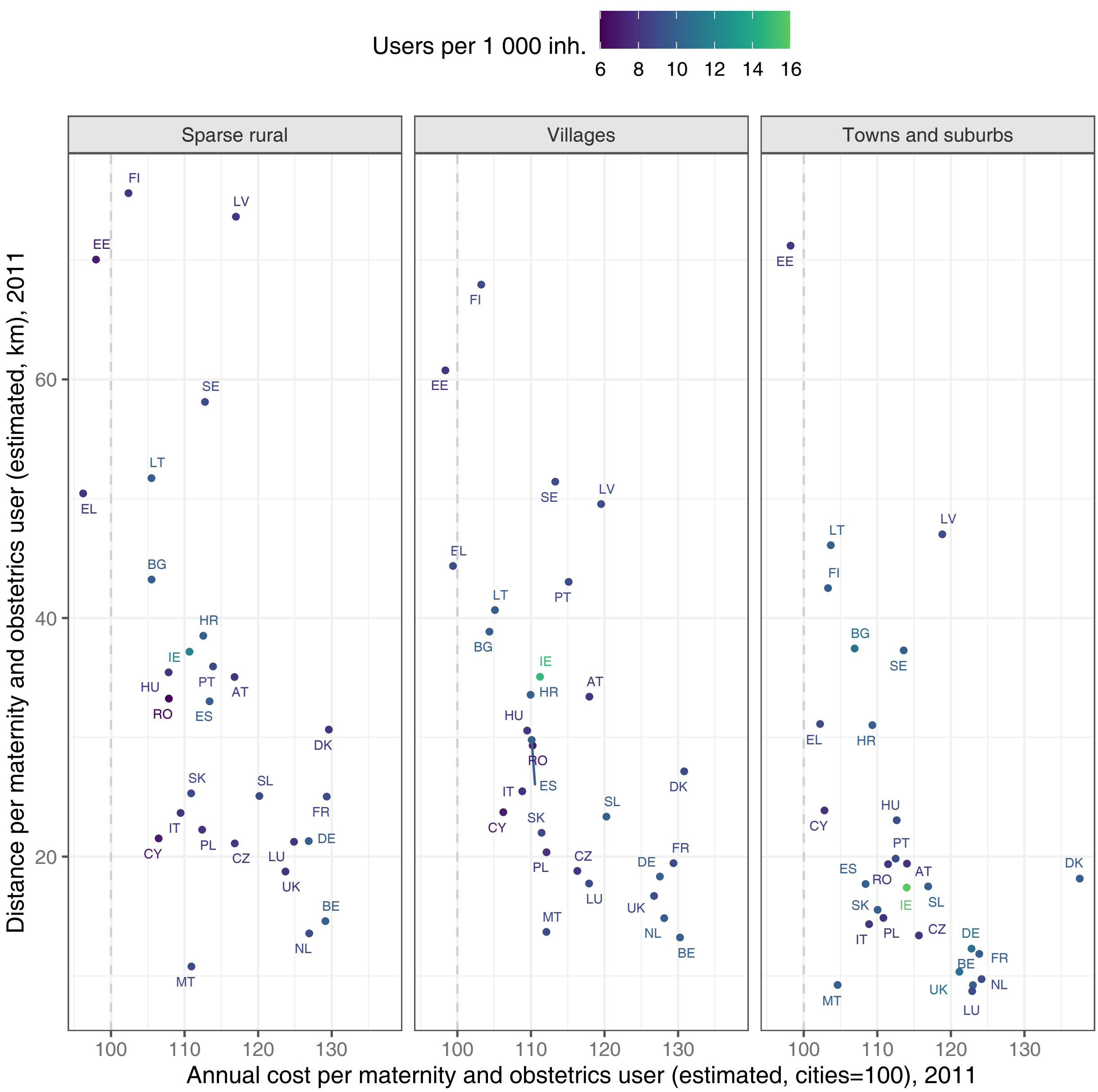
2011



Note: In the figure, all bubbles for cities would score 100 on the x-axis and 0 on the y axis, and therefore city results are not shown.
Source: Authors' elaboration based on (Goujon et al., 2021[11]) and (Jacobs-Crisioni et al., n.d.[12]).

Figure 5.12. Maternity and obstetrics services annual cost versus distance per user relative to cities by country and degree of urbanisation, EU27+UK

2011

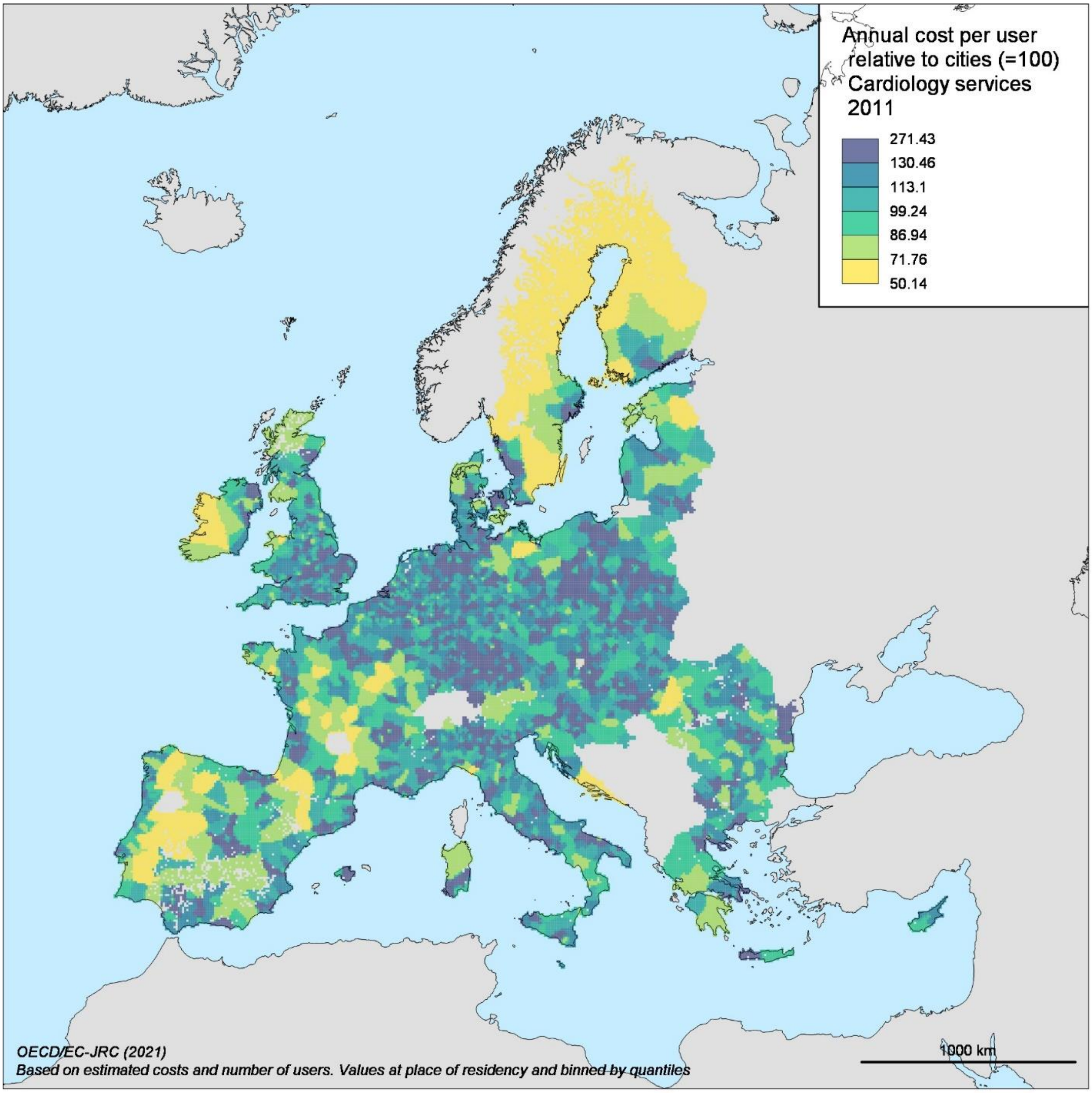


Note: In the figure, all bubbles for cities would score 100 on the x-axis and 0 on the y axis, and therefore city results are not shown.
Source: Authors' elaboration based on (Goujon et al., 2021[11]) and (Jacobs-Crisioni et al., n.d.[12]).

The map of average annual costs per user by degree of urbanisation shows that for both services, catchment areas are large where costs are low, for example in the north of Sweden and Finland, the west of Ireland and in the centre of France (Figure 5.13 and Figure 5.14). In these cases, cost-efficiency is high at the expense of considerable travel distances for users. On the other hand, the main cities in Europe are typically served at relatively low costs per user in relatively small catchment areas. These cities are surrounded by suburban service locations that operate at an often much higher cost because they serve relatively small catchments with a lower density user base. This is visible in London and Madrid, where the difference between urban core and urban periphery stands out both for cardiology and M&O services.

Figure 5.13. Annual costs per cardiology user relative to cities (estimated), EU27+UK

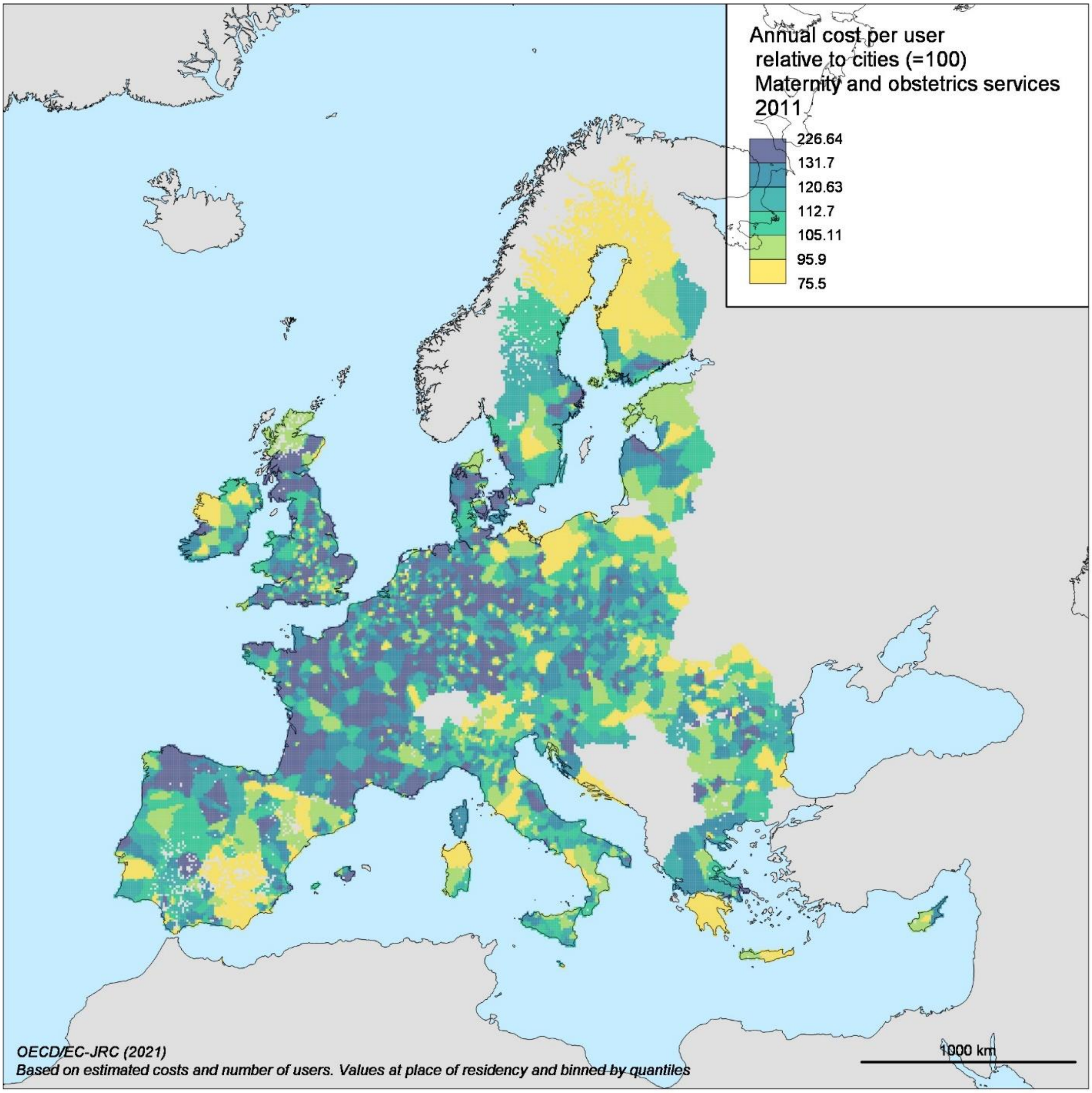
2011



Source: Authors' elaboration based on (Goujon et al., 2021[11]) and (Jacobs-Crisioni et al., n.d.[12]).

Figure 5.14. Annual costs per maternity and obstetrics user relative to cities (estimated), EU27+UK

2011

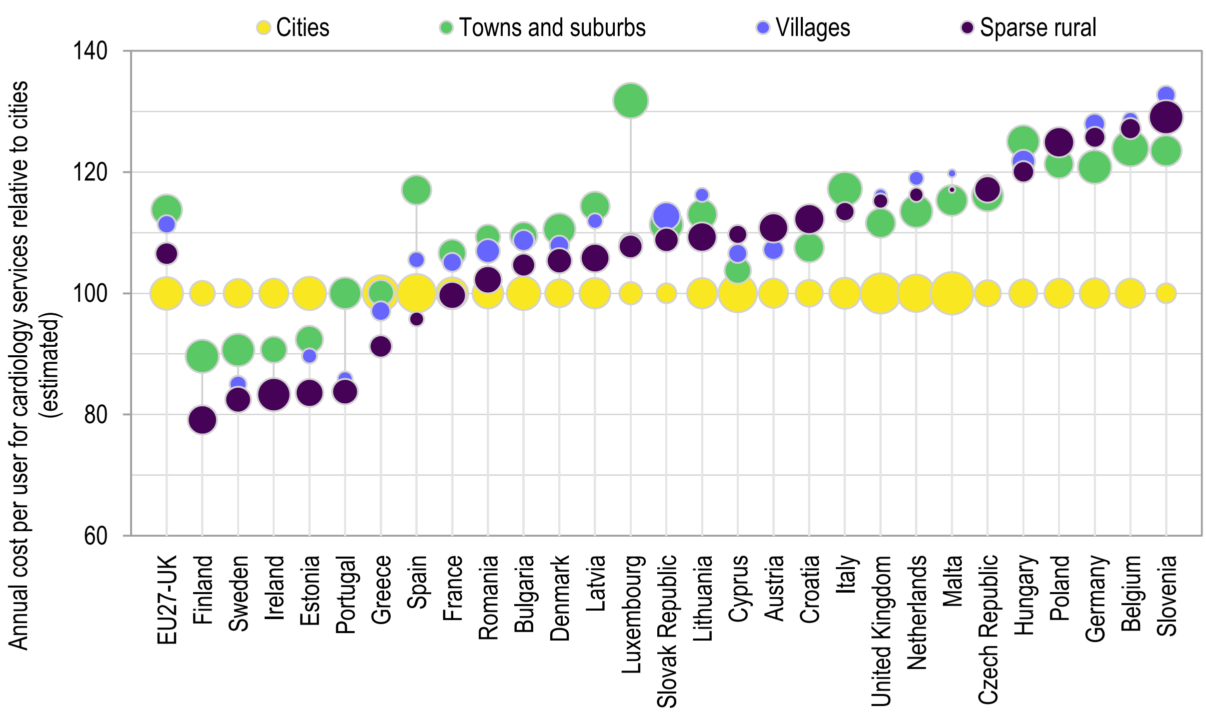


Source: Authors' elaboration based on (Goujon et al., 2021[11]) and (Jacobs-Crisioni et al., n.d.[12]).

When summarised by degree of urbanisation, the results show that, in all countries, provision of health services to cities is relatively cost-efficient compared to health service provision outside of cities. For cardiology, a limited number of countries have relatively expensive service provision in cities (Figure 5.15). These countries have generally service locations serving a large sizeable catchment area, which implies more cost-efficiency but also much longer travel distances to services for users outside cities. These large catchment areas are common for cardiology services, with service provision costs undershooting the costs for towns and suburbs in many countries. For M&O services, while cities generally have relatively lower costs (Figure 5.16), the majority of countries do not exhibit a similar pattern, with altogether less differences in costs between the different non-urban degrees of urbanisation and costs for towns and suburbs typically slightly lower than for rural areas.

Figure 5.15. Annual costs per user for cardiology services relative to cities (estimated) by country and degree of urbanisation, EU27+UK

2011

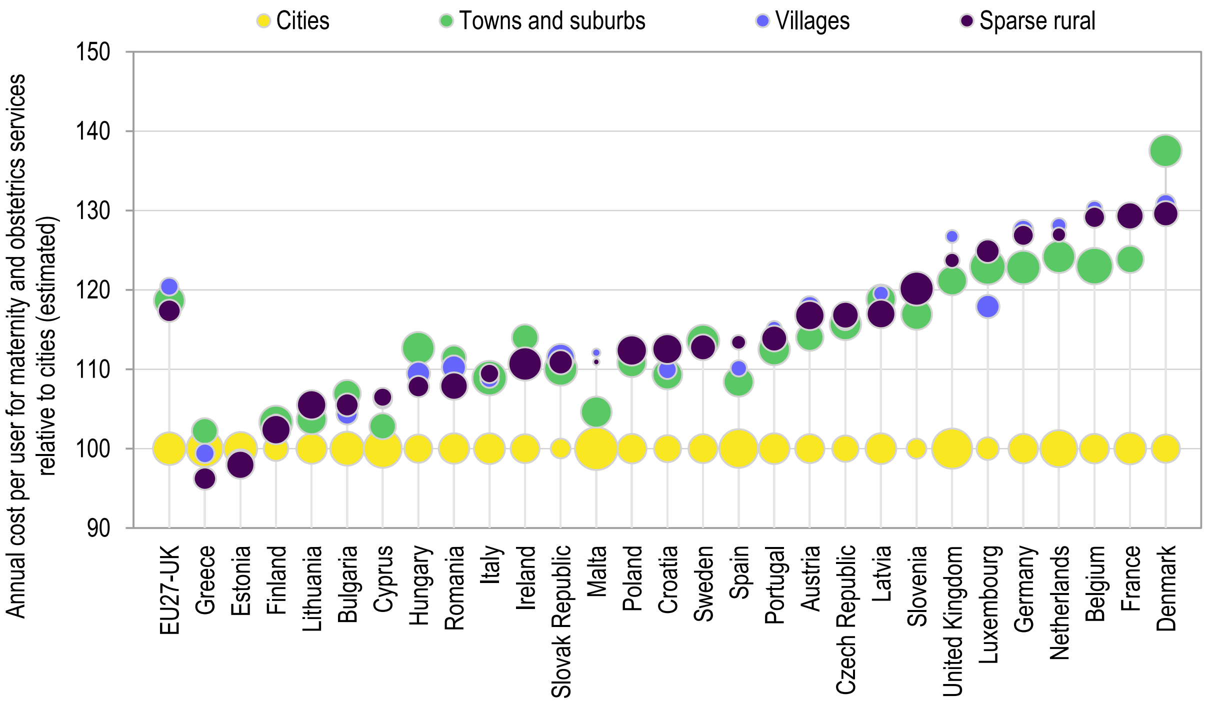


Note: Bubble areas represent the share of national population.
Source: Authors' elaboration based on (Goujon et al., 2021[11]) and (Jacobs-Crisioni et al., n.d.[12]).

StatLink https://doi.org/10.1787/888934246697

Figure 5.16. Annual costs per user for maternity and obstetrics services relative to cities (estimated) by country and degree of urbanisation, EU27+UK

2011



Note: Bubble areas represent the share of national population.
Source: Authors' elaboration based on (Goujon et al., 2021[11]) and (Jacobs-Crisioni et al., n.d.[12]).

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Estimated future health care services access and costs in EU27+UK

Expected ageing, fertility changes and migration will contribute to considerable demographic changes in EU27+UK countries. These changes will affect demand for services, hence also for cardiology and M&O services. Ageing for instance reduces the demand for M&O services but increases the demand for cardiology services. International migration may exacerbate drops in demand in some countries, while offsetting the effect of ageing in others.

This section describes projected changes in the number of users and service locations across countries, and subsequent changes in the access and cost of cardiology and M&O services.

Changes in health services demand and supply

Demand for cardiology services is expected to increase substantially in EU27+UK countries, in particular in cities and in towns and suburbs (Figure 5.17). Drops in cardiology demand are limited to rural areas in countries where considerable outmigration is foreseen, such as Romania, Hungary, Latvia, Lithuania and Spain. Changes in demand for M&O services are less straightforward, with a much smaller aggregate negative change that possibly hides a substantial geographical redistribution of demand due to opposing trends (Figure 5.18).

Figure 5.17. Change in number of cardiology users (estimated) by country and degree of urbanisation, EU27+UK

2011-35

Country name	Sparse rural	Villages	Towns and suburbs	Cities
EU27-UK	96800	100051	359383	328695
Spain	-6595	215	19678	57532
Italy	10376	11394	55789	52044
Germany	9386	25491	57462	37635
France	59955	22189	41015	32522
Poland	-652	6723	32651	28952
United Kingdom	21951	9267	25072	23710
Netherlands	8768	6691	24939	19820
Romania	-16267	-6775	9291	15309
Greece	219	2375	5996	11955
Portugal	-2060	550	9048	10262
Czech Republic	8712	5291	9862	5978
Bulgaria	-10379	-2507	2597	5602
Austria	5151	3179	6010	4394
Finland	5417	2698	9082	3750
Belgium	2340	3128	15353	3248
Sweden	6456	3562	10076	2817
Ireland	3454	757	2739	2673
Slovak Republic	1409	2832	6715	2645
Denmark	4808	3262	6619	2047
Cyprus	-1157	308	846	1413
Malta	116	55	659	1340
Hungary	-3544	-673	3897	1291
Croatia	-1219	387	1315	888
Slovenia	2722	462	1545	729
Lithuania	-8737	-938	208	675
Luxembourg	248	480	1046	438
Estonia	-461	29	314	422
Latvia	-3617	-382	-441	-1396

Source: Authors' elaboration based on (Goujon et al., 2021[11]) and (Jacobs-Crisioni et al., n.d.[12]).

StatLink https://doi.org/10.1787/888934246735

Figure 5.18. Change in number of maternity and obstetrics users (estimated) by country and degree of urbanisation, EU27+UK

2011-35

Country name	Sparse rural	Villages	Towns and suburbs	Cities
EU27-UK	44476	13672	-17245	-191082
Spain	-12098	-12040	-39062	-68184
Poland	-21493	-3869	-17252	-30612
Germany	-6068	-4098	-14021	-25357
France	43887	17764	19660	-17413
Romania	-800	278	-2726	-15844
Greece	-1439	-517	-1426	-12213
Netherlands	6878	2993	11528	-8497
Ireland	660	-530	-3173	-7895
Bulgaria	-3494	-2537	-3673	-6453
Czech Republic	358	-654	-2952	-5144
Lithuania	-5074	-902	-3041	-3775
Sweden	8612	2634	8220	-3446
Slovak Republic	-2795	-3171	-7102	-3384
Portugal	-2809	-764	-4823	-3099
Latvia	-2376	-349	-1420	-2976
Finland	4672	1745	1885	-2182
Hungary	-1181	-925	919	-2014
Estonia	-447	-104	-457	-1735
Croatia	-1417	-214	-1498	-1560
Cyprus	-2685	-152	-306	-1090
Slovenia	-1376	-471	-1061	-530
Malta	138	5	6	-51
Denmark	3955	3199	5746	45
Luxembourg	838	823	2122	407
Austria	3646	728	1233	2861
Italy	15232	5440	16217	7432
Belgium	4475	2482	10232	8443
United Kingdom	16677	6878	8980	13184

Source: Authors' elaboration based on (Goujon et al., 2021[11]) and (Jacobs-Crisioni et al., n.d.[12]).

StatLink https://doi.org/10.1787/888934246754

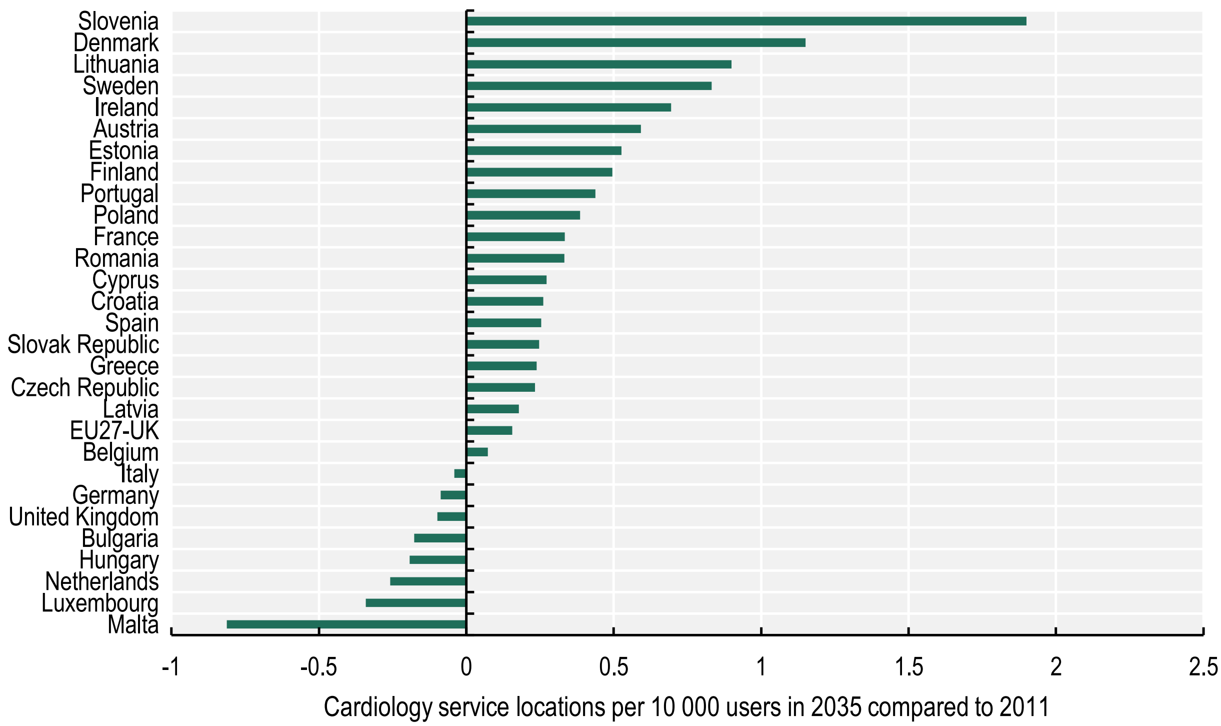
Changes in demand, combined with the geographical distribution of population, imply changes in the number of projected cardiology and M&O service locations. Such changes are substantial for a number of countries.

For cardiology services, the number of service locations per user is expected to increase by 0.16 locations per 10 000 users in EU27+UK countries, with changes ranging from 1.9 in Slovenia to -0.8 in Malta (Figure 5.19). In absolute terms, the number of cardiology service locations is expected to increase from 2 798 to 3 379. The increases in the number of service locations per 10 000 users are largest in Slovenia, Denmark, Lithuania and Sweden. For Slovenia, a change of about 2 service locations per 10 000 users represents an increase from 8 to 15 service locations between 2011 and 2035. In some countries, changes in levels and distribution of demand are projected to lead to a lower number of service locations per user in the future. This is the case for Malta, Luxemburg, the Netherlands, Bulgaria, the United Kingdom, and Germany.

For M&O services, on the other hand, the number of service locations per user is expected to decrease by 0.1 service locations per 10 000 users on average for EU27+UK countries(in absolute terms a decrease from 2 650 to 2 539 M&O service locations), with changes ranging from 1 in Cyprus to -2.2 in the Slovak Republic (Figure 5.20. The reductions are largest in the Slovak Republic, Latvia, Croatia, and Slovenia. While the largest reduction represents a projected decrease from 32 to 14 M&O service locations in the Slovak Republic, smaller changes in the number of service locations per user may still represent a significant reduction in absolute terms: in Spain, for instance, the M&O service locations are projected to fall from 235 in 2011 to 161 in 2035. On the other hand, a group of 10 countries is expected to have more service locations per user in the future, including Cyprus, Estonia, Luxemburg, and Bulgaria.

Figure 5.19. Change in cardiology service location counts per 10 000 users (estimated) by country, EU27+UK

2011-35



Source: Authors' elaboration based on (Goujon et al., 2021[11]) and (Jacobs-Crisioni et al., n.d.[12]).

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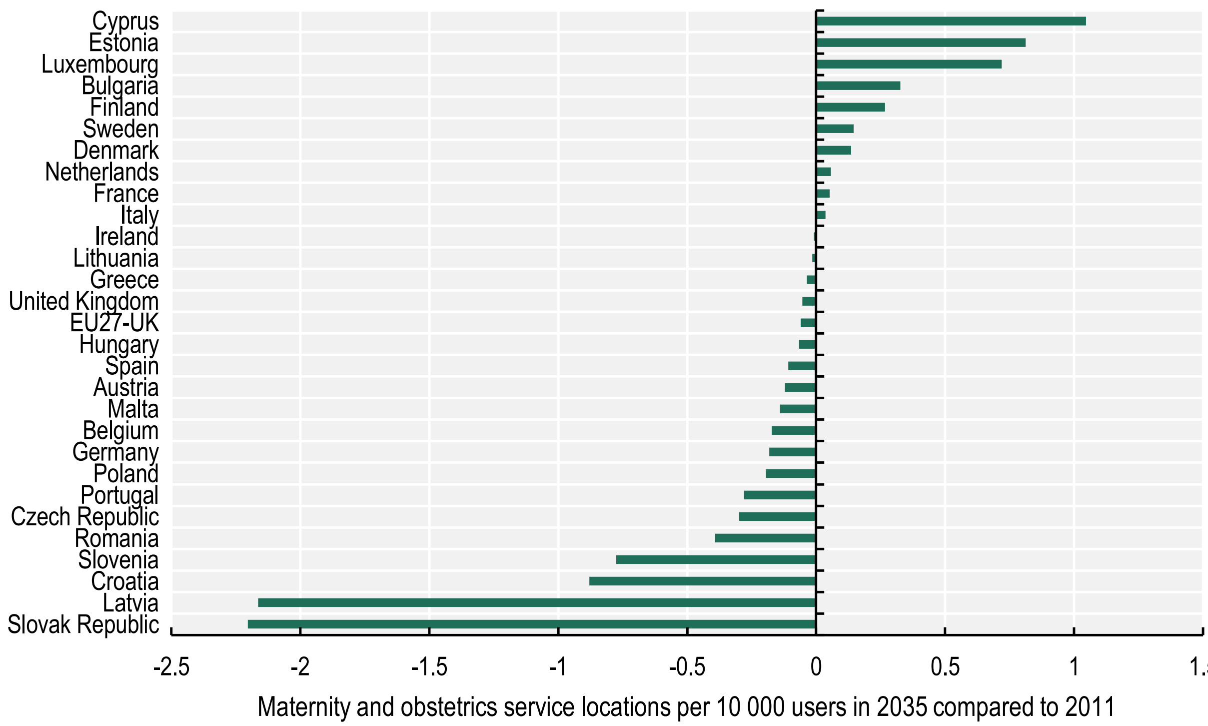
Figure 5.20. Change in maternity and obstetrics service locations counts per 10 000 users (estimated) by country, EU27+UK

2011-35



Source: Authors' elaboration based on (Goujon et al., 2021[11]) and (Jacobs-Crisioni et al., n.d.[12]).

StatLink https://doi.org/10.1787/888934246792

Consequences for accessibility

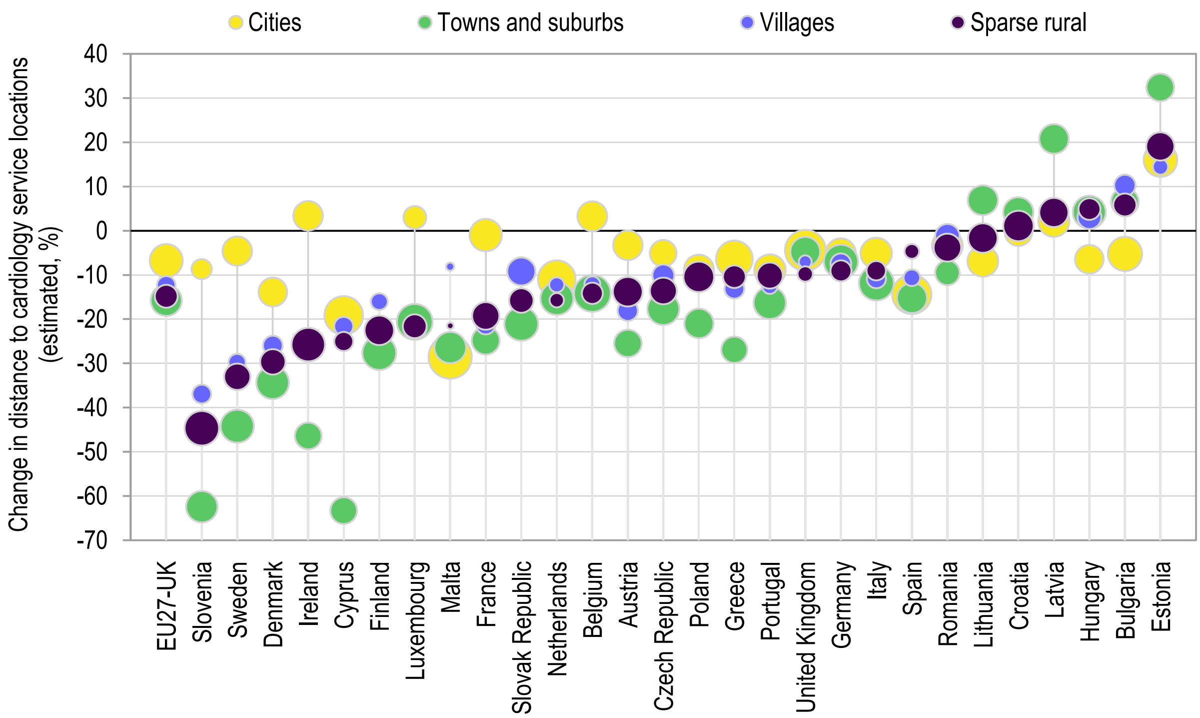
The foreseen changes discussed previously will affect access to health care services substantially. Accessibility improvements are expected where increases in demand allow for additional service locations, while decreases can be expected in places where future local demand is expected to decline. This section focuses on the changes in accessibility to cardiology and M&O services following population changes between 2011 and 2035.

For cardiology services, travel distances to locations offering the service are expected to decrease across most EU27+UK countries because of the expected increases in demand and supply, following ageing (Figure 5.21). In this context, however, some countries may face a decline in accessibility. This is the case in most of Estonia, and areas outside cities in the other Baltic countries, Bulgaria, Hungary and Romania. In general, accessibility improvements following the appearance of additional future service locations are most noticeable outside of cities, because modelled travel distances in cities are already low, and some of the additional future demand may be covered with existing service locations.

While in general terms access to M&O service locations is expected to decline, the patterns are more mixed than for the case of cardiology, owing to different trends in future demand across countries (Figure 5.22). In a limited set of countries including Austria, Belgium, France and Italy, access to M&O services is expected to be stable or improve slightly across the territory. In the majority of EU27+UK countries, accessibility to M&O services is expected to decline the most in cities, due to the projected move of a share of women away from cities.

Figure 5.21. Change in distance to cardiology service locations (estimated) by country and degree of urbanisation, EU27+UK

2011-35

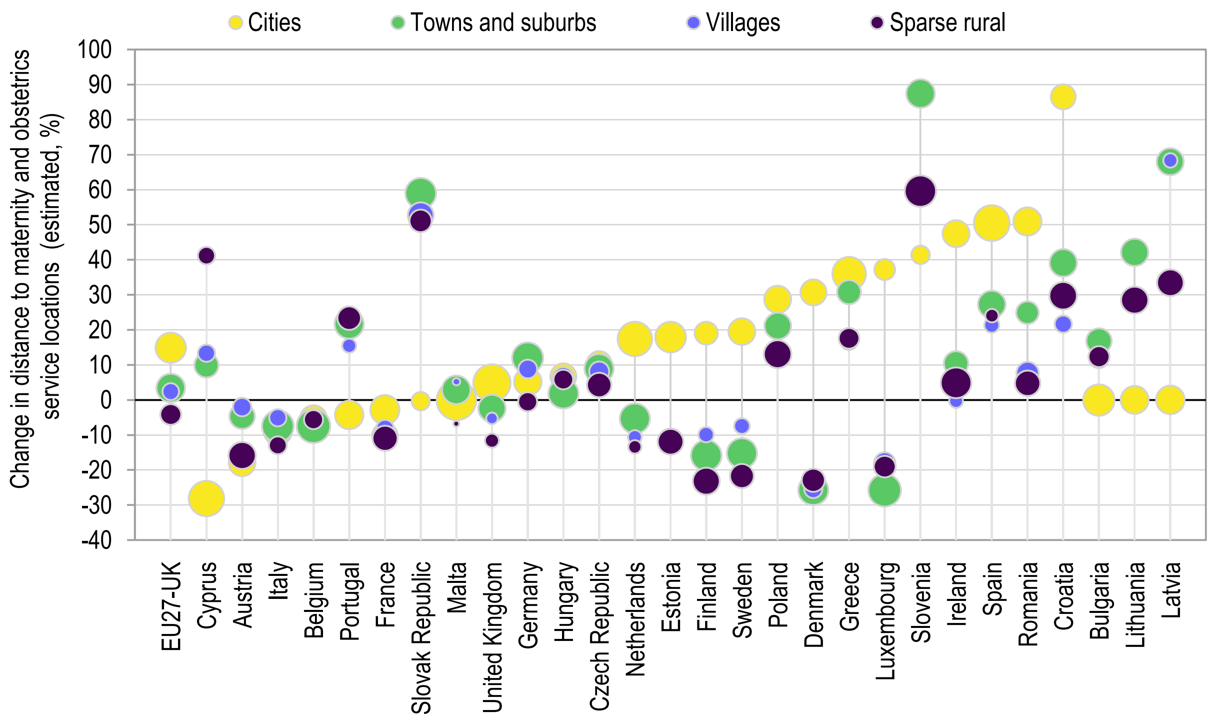


Note: For readability of the figure, values above 100% are not shown. Bubble areas represent the share of national population.
Source: Authors' elaboration based on (Goujon et al., 2021[11]) and (Jacobs-Crisioni et al., n.d.[12]).

StatLink https://doi.org/10.1787/888934246811

Figure 5.22. Change in distance to maternity and obstetrics service locations (estimated) by country and degree of urbanisation, EU27+UK

2011-35



Note: For readability of the figure, values above 100% are not shown. Bubble areas represent the share of national population.
Source: Authors' elaboration based on (Goujon et al., 2021[11]) and (Jacobs-Crisioni et al., n.d.[12]).

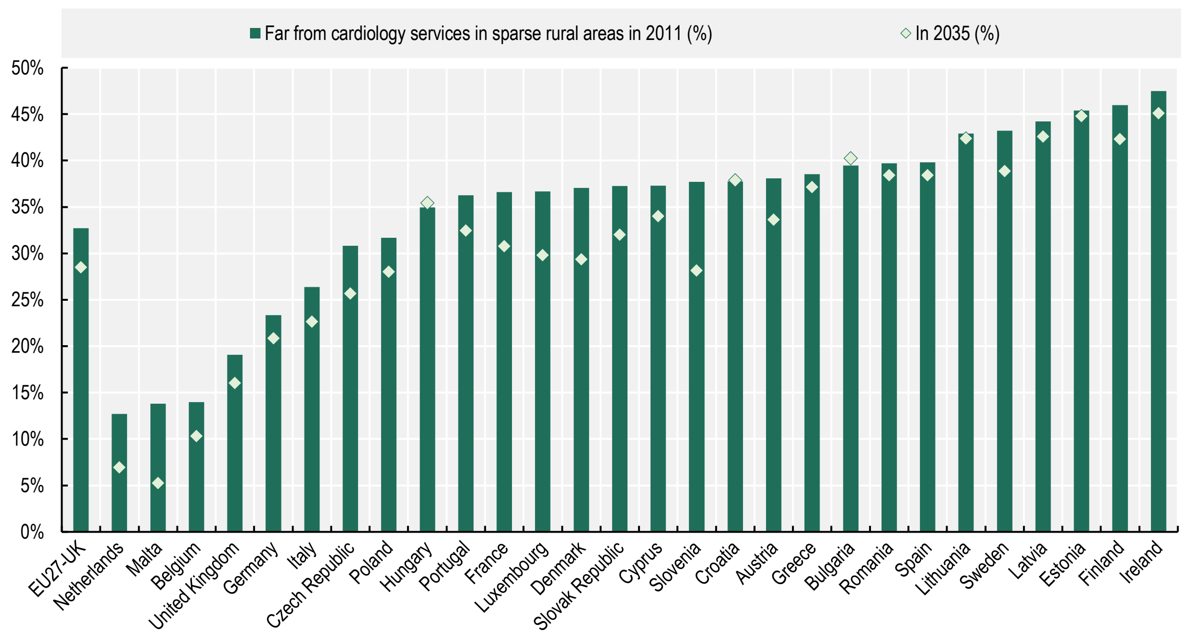
StatLink https://doi.org/10.1787/888934246830

While users in sparse rural areas are the most disadvantaged in access to health care services, future access is projected to increase for services experiencing demand increases. For cardiology, the share of sparse rural population that lives far from a cardiology service location is expected to decline by 2035 in most countries (Figure 5.23). Bulgaria, Croatia, Estonia, Hungary, and Lithuania are exceptions to this pattern. In those countries, population change is projected to worsen access to cardiology in sparse rural areas.

For M&O services, the future access projections are more mixed, with a slight overall decrease in the sparse rural population living far from these service locations, but considerable variance across countries (Figure 5.24). In countries with an urbanised and dense population distribution including Belgium, Malta, the Netherlands, and the United Kingdom, less than 20% of the sparse rural population lives far from a cardiology service location, and less than 30% lives far from an M&O service location. On the other hand, in Nordic and Baltic countries, over 40% of the sparse rural population is expected to live far from service locations by 2035.

Figure 5.23. Share of users living far from cardiology services in sparse rural areas (estimated) by country, EU27+UK

2011-35

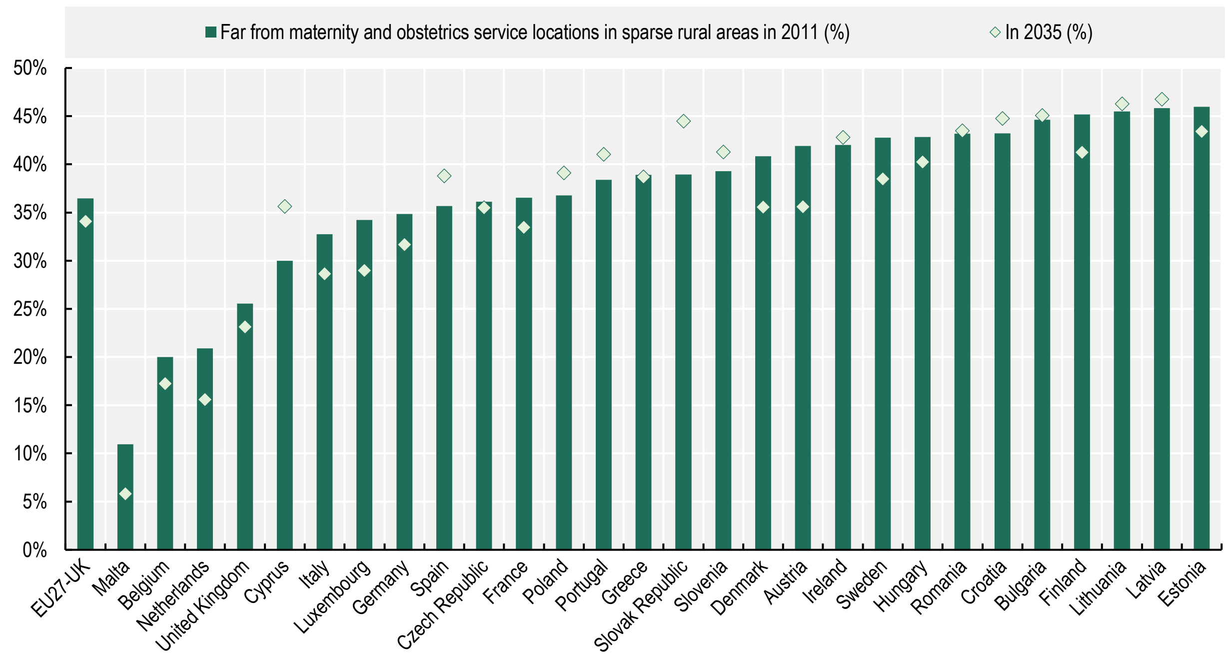


Source: Authors' elaboration based on (Goujon et al., 2021[11]) and (Jacobs-Crisioni et al., n.d.[12]).

StatLink https://doi.org/10.1787/888934246849

Figure 5.24. Share of users living far from maternity and obstetrics services in sparse rural areas (estimated) by country, EU27+UK

2011-35



Source: Authors' elaboration based on (Goujon et al., 2021[11]) and (Jacobs-Crisioni et al., n.d.[12]).

StatLink https://doi.org/10.1787/888934246868

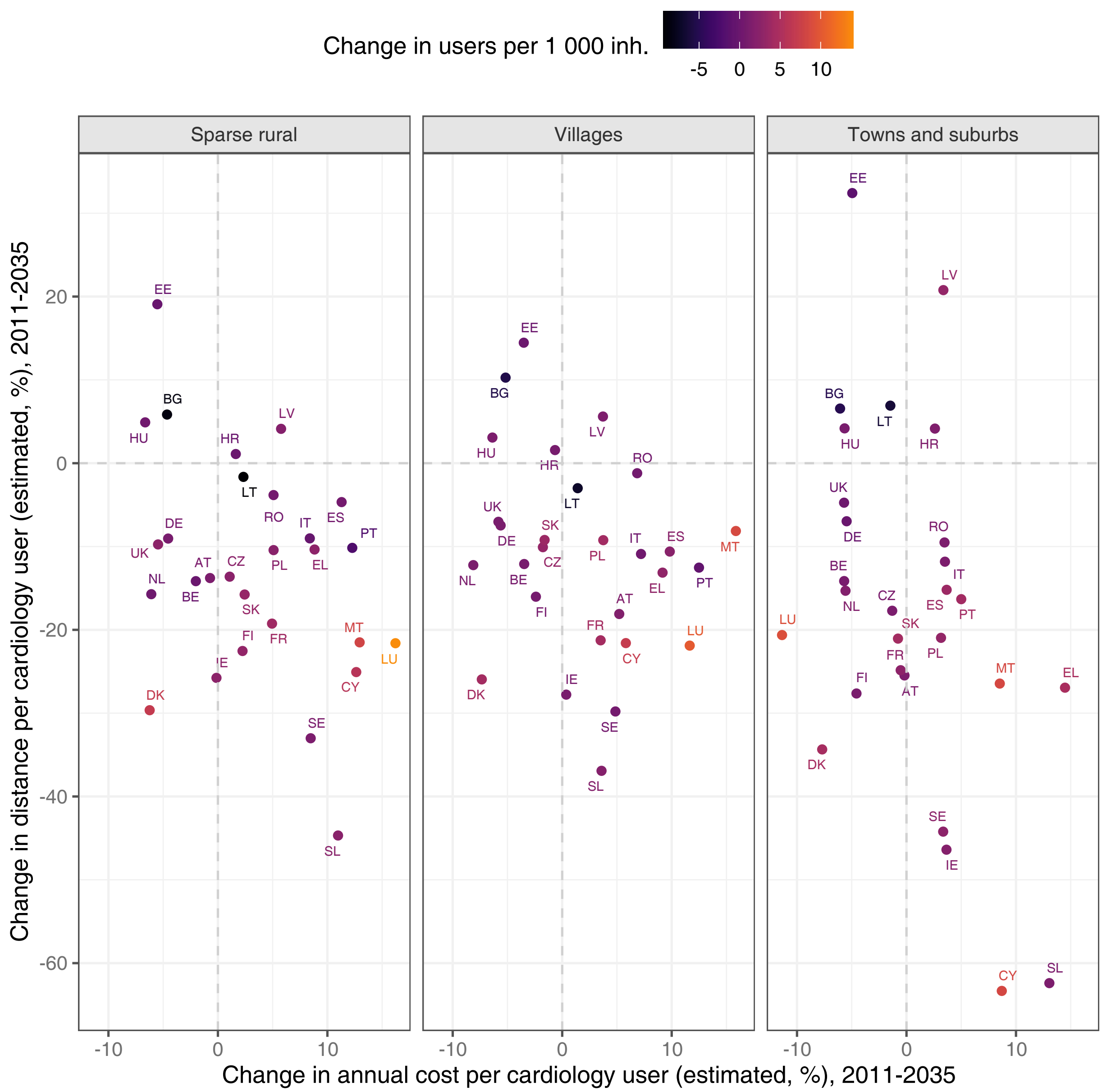
Changes in the relation between costs and accessibility

The foreseen changes in demand and supply will likely affect the balance between costs and access in the EU27+UK. For cardiology, the increase in demand means that many countries can foresee an improvement in accessibility paired with a decrease in average cost per user (Figure 5.25). This happens under the assumption that new service locations may appear to partly satisfy additional demand. However, countries expected to face considerable outmigration, including Bulgaria, Estonia and Latvia, may see a decline in access to cardiology services because the reduction of demand is expected to lead to further concentration of supply in cities. On the other hand, countries with relatively large cardiology demand increases in rural areas including Ireland, Slovenia and Sweden may experience increased access in towns and suburbs due to additional service locations serving these areas and their rural hinterland. These accessibility gains come however at the cost of higher costs per user.

M&O services have almost the opposite trends to cardiology, following the expected changes in demand for these services (Figure 5.26). Future accessibility improvements are much more limited in scope, with a limited number of countries seeing increased demand for this service, and consequently both accessibility and cost-efficiency improvements. Many EU27+UK countries will see a decline in demand for M&O services, potentially resulting in less service locations and reduced cost efficiency in the remaining service locations. In Estonia, however, accessibility is expected to improve, despite an overall decrease in demand, although at a much-reduced cost efficiency.

Figure 5.25. Changes in cardiology annual costs versus distance per user relative cities (estimated), EU27+UK

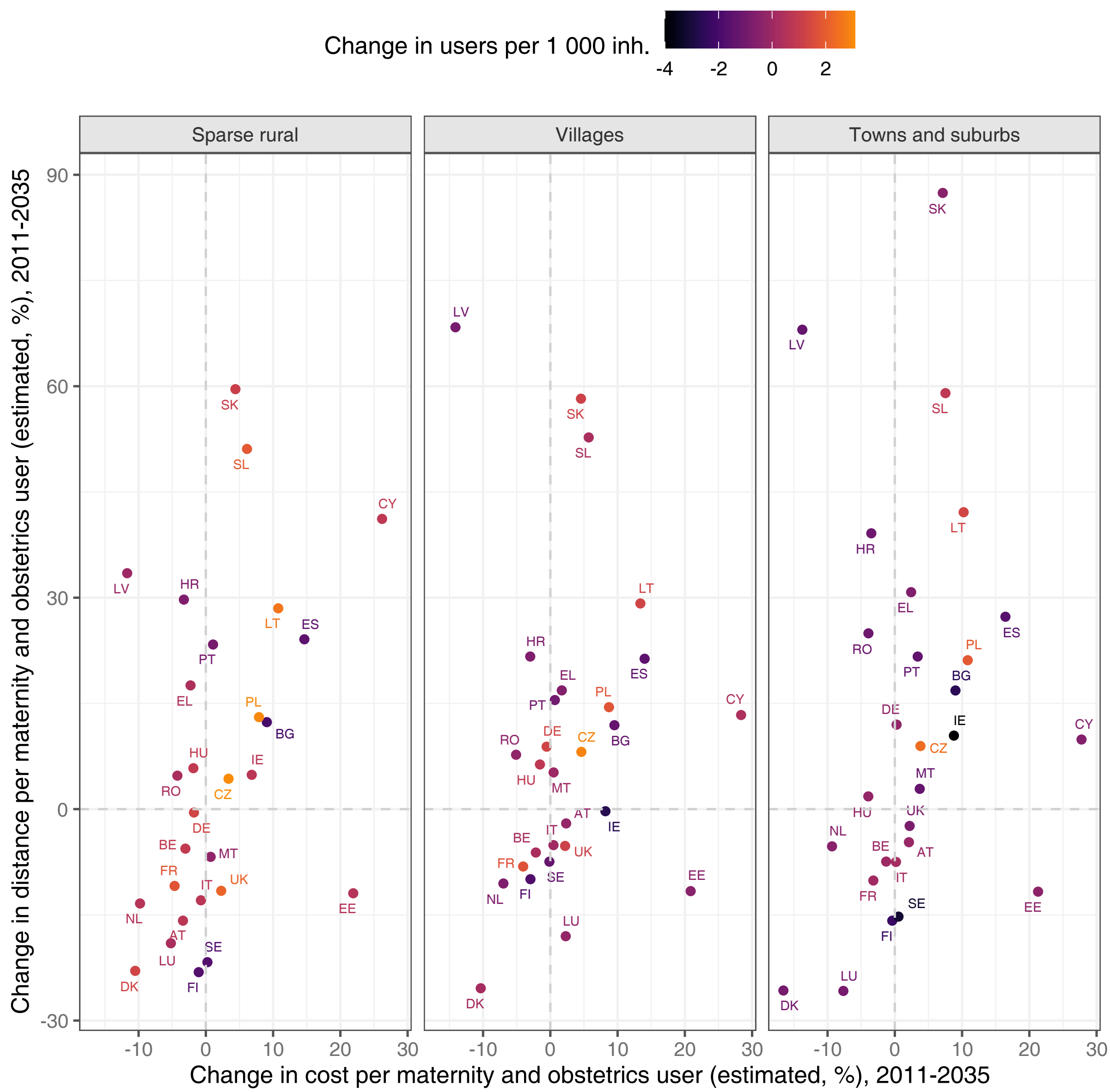
2011-35



Source: Authors' elaboration based on (Goujon et al., 2021[11]) and (Jacobs-Crisioni et al., n.d.[12]).

Figure 5.26. Changes in maternity and obstetrics annual costs versus distance per user relative cities (estimated), EU27+UK

2011-35



Source: Authors' elaboration based on (Goujon et al., 2021[11]) and (Jacobs-Crisioni et al., n.d.[12]).

Conclusion

This chapter applies the method outline in Chapter 4 to estimate access and costs of cardiology and maternity and obstetrics (M&O) services to EU27+UK countries. The estimations aim to capture how the geographical distribution of the population and demographic factors affects the present and future demand for services, and how these demand patterns translate into differences in cost and access across places.

The results for cardiology and M&O services in this chapter demonstrate that low demand for a service is not only driven by the general distribution of population over space, and also by the demographic profiles. On average for EU27+UK countries, the demand for cardiology services, approximated by local death rates, is relatively larger in rural areas and lower in cities. In contrast, the demand for M&O services, approximated by local birth rates, is larger in cities than in rural areas.

The simulated placement of service location results in median user travel distances of about 32 km for cardiology and 37 km for M&O services. These figures however mask significant geographical variations. While users outside cities always have to travel longer distances, the difference is small in relatively dense countries against countries with large sparsely populated areas, reaching an additional 60 km in some cases.

Importantly, this chapter highlights that, because of the relatively large catchment areas of the services considered, health services placed in a given degree of urbanisation serve a mix of population coming from different areas. This is particularly true for services placed in rural areas: for instance, over 40% of users of services located in sparse rural areas travel from towns and suburbs, and cities. This insight has relevance for service provision in towns and suburbs, as some will be serving relatively sparse rural hinterlands, and others will not reach sufficient user demand and will have their population also travelling long distances to access specific health services. In this sense, as accessibility for towns and suburbs is worse when accessibility for rural areas is low, access does not directly depend on local densities but also on what happens in surrounding areas.

The results in this chapter clearly show that health service provision outside cities is a balancing act between costs and access. In sparsely populated areas, the implication is that good access to health services is possible only at a much higher cost or vice-versa, that relatively more cost-efficient provision comes at the cost of significant distance to services. There are important differences in this general principle between cardiology and M&O services. For cardiology services, while many countries have lower costs per user outside cities, in most cases users outside of cities have to travel over 25 km more on average to access the service. For M&O services, travelled distances are generally shorter compared with cardiology service locations, but this higher access is paired with higher costs per user.

Foreseen demographic changes will have mixed effects on services cost and access. Demand for cardiology services and consequently the number of service locations are expected to increase substantially in EU27+UK countries as a result of ageing, in particular in cities and in towns and suburbs. Fertility trends expressed in lower expected births will decrease the demand and service locations for M&O services in many countries, and particularly in cities. International migration may exacerbate drops in demand in some countries, while offsetting the effect of ageing in others. Changes in demand will certainly increase the pressure of decisions between accessibility and cost efficiency, especially in places experiencing the largest demographic changes.

The data elaborated in this chapter also can help to undertake more refined analysis in specific countries to better understand the costs and access implications of current and future cardiology and M&O services.

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Note

[1] A few very large distances (close to 600 km) are present in isolated islands and border communities that, due to geography, typically have to make a long detour to reach services in the simulated access set up.

OECD Rural Studies

Access and Cost of Education and Health Services

PREPARING REGIONS FOR DEMOGRAPHIC CHANGE

Current population trends and the COVID-19 pandemic reinforce the need for efficient public service provision while guaranteeing good access to all. Population decline and ageing in rural regions affect the provision of services through lower economies of scale and scope, professional shortages and longer distances. Reliable estimates of the costs and access arising from demographic and geographical differences can help adapt the provision of services to different territorial realities. This report provides internationally comparable fine-grained present and future estimates of the cost and physical access to education (primary and secondary) and health services (cardiology, maternity and obstetrics) in European countries. The report finds that demographic change in the next decades will likely further strain the trade-off between costs and access, especially in remote rural areas. Adapting to changes in demand following lower fertility rates and ageing implies that services will need to become more widely available, while others will have to concentrate more. This report aims to support evidence-based policy decisions to ensure service provision allows for both cost efficiency and a sufficient level of access in all territories.

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