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Regional inequalities in access to STEM-oriented secondary education in Latvia

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Abstract

Education scholars and human geographers have extensively studied spatial disparities in access to secondary education, both in developing countries and in advanced economies. However, very few studies have analysed access to specific types of secondary education, particularly programs oriented toward Science, Technology, Engineering, and Mathematics (STEM-oriented programs). This paper aims to fill this gap using rich geodata and administrative data on Latvia. An overview of the supply of STEM-related skills in the Nordic – Baltic region suggests that in this regard Latvia performs the worst in terms of both recent university graduates and working-age population in general. We show that 43 percent of youth aged 15 to 18 cannot reach a STEM program within 30 minutes by walking. Furthermore, estimates of earnings differentials by access time, between program types, and between two modes of travel suggest that children from wealthier families have better access to STEM programs. More densely populated settlements feature better access to STEM programs, as well as better exam results in STEM disciplines, while language exam results do not show such a pattern.

Keywords: Access to secondary education, STEM-oriented programs, regional disparities, geographic information system

JEL: I24, I28, R53

1 Introduction

Analysis of spatial structure and accessibility of basic services or facilities, such as healthcare and education institutions, have long been in the focus of human geographers (see e.g., discussion provided by Christiaanse, 2020; Farrington & Farrington, 2005). In recent years, Geographic information systems (GIS) have become instrumental in the analysis of school networks and measuring the association between access to schools and student performance, as well as their further education pathways (Dickerson & McIntosh, 2013; Falch et al., 2013; Mann & Saultz, 2019; Talen, 2001; Yoon et al., 2018). Geodata-based methods thus provide evidence for developing more effective and inclusive school networks (Alexander & Massaro, 2020). This task has become particularly important in the context of increasing international and regional mobility and depopulation in peripheral areas of Nordic and Baltic countries (Lind & Stjernström, 2015; Šūpule & Søholt, 2018; Hazans, 2015 and 2019), as well as in Europe in general (Yoon et al., 2018).

While the problem of access to schools concerns all types of programs, in the context of knowledge economy and ongoing digitalisation of virtually everything it is of particular importance for STEM-oriented programs. Both academic literature and media provide evidence for a growing demand for such programs at the primary and secondary level, as well as for a shortage of STEM skills in the labour market (Atkinson et al., 2007; Bottia et al., 2017; LETA 2021; LDDK 2022; Zvaigzne & Znotiņa 2022). STEM-related abilities are relatively rare, and it is important that children with such abilities, disregarding where they live, could get into appropriate study programs. These arguments are even stronger for socially disadvantaged young people living in peripheral areas or coming from low-income family background (Lind, 2019, pp. 336-337).

This paper contributes to the debate (in Latvia and elsewhere) on educational opportunities and optimal density of the school network at the upper secondary education level, including focus on highly demanded STEM disciplines[1]. We use GIS techniques to examine accessibility of three types of secondary education programs – general programs, STEM-oriented programs, and programs implemented in state gymnasiums ("top schools" with a proven record of

[1] See BISS, 2013; Bottia et al., 2017; LPS, 2017; Šūpule & Søholt, 2018; Kvalsund, 2019: LETA, 2019; Zaharova, 2020; Dēvica, 2021; LDDK 2022; Zvaigzne & Znotiņa, 2022; Ministry of Education and Science, 2023.

providing high-quality education; see Appendix A for details). Primary and secondary education in Latvia is provided mainly by public schools, following national regulations with municipalities as executing actors (cf. Saeima, 1999, see Appendix B for details).

The rest of the paper is structured as follows. Section 2 describes the contextual background: supply of STEM-related skills in the Nordic-Baltic region, urban – rural gap in educational attainment across the Nordic and the Baltic countries, as well as the urban – rural gap in various schooling outcomes in Norway and in Latvia. Analysis of the results of centralized state examinations in Latvia suggests that areas with poorer access to the STEM-oriented programs feature poorer results in STEM disciplines. Section 3 surveys the literature on access to schools, while section 4 describes the data and methods used in this paper. Section 5 presents descriptive evidence on access to general and STEM secondary education programs. More specifically, for each type of program, we estimate the share of the population in enrolment age having walking or driving access to these programs within a certain time. Section 6 provides descriptive and econometric evidence that children from wealthier families have better access to STEM programs. Section 7 concludes. Appendices A – D provide background information on general education systems in Latvia and Norway.

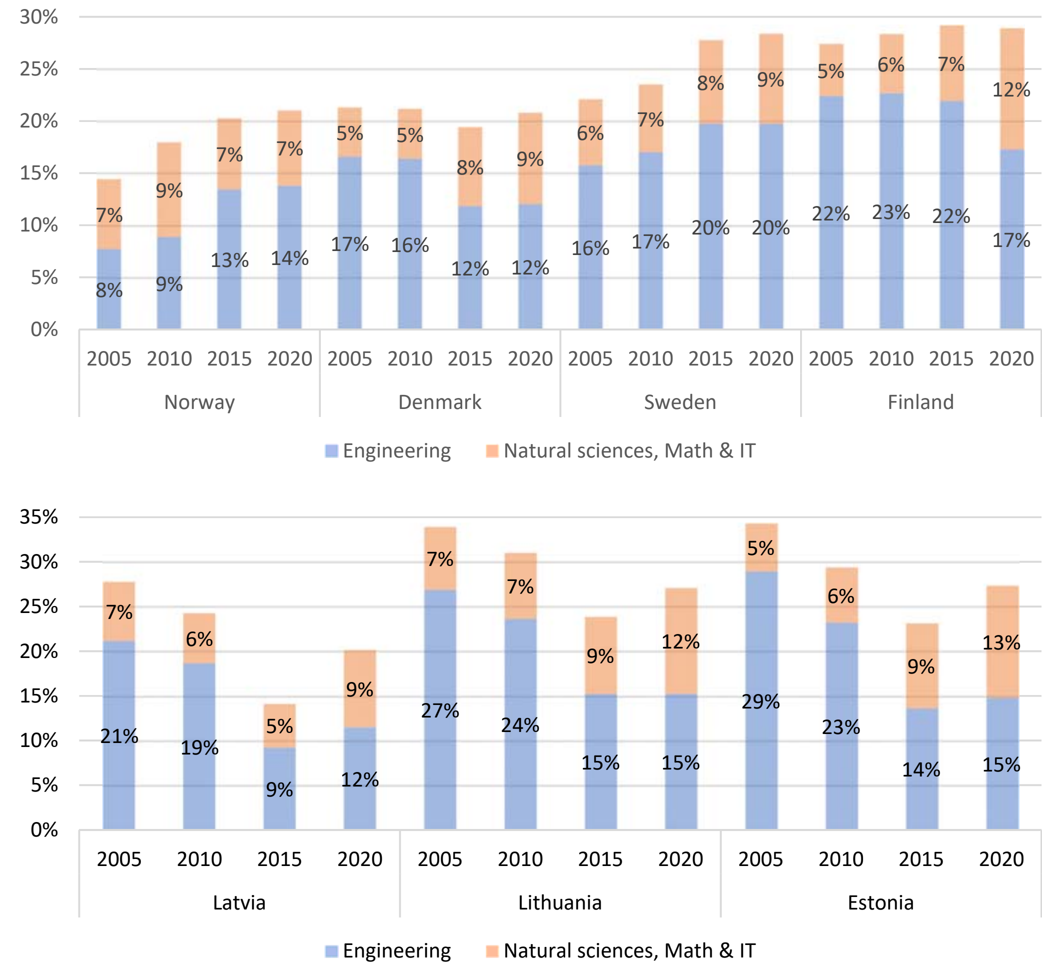
2. Contextual background

2.1 Supply of STEM skills in the Nordic-Baltic region

There are considerable similarities between the Latvian case and other European countries, when it comes to the educational system, suggesting transferability of our findings on secondary education and accessibility in Latvia and the Nordic-Baltic region to other countries. In all EU countries, school attendance is mandatory for primary and lower secondary education. Subsequent to this basic education, upper secondary education qualifies for higher education or vocational careers, typically with graduation at age 17 or 18 years. Among the youth enrolled in upper secondary education in the EU, 51.6 percent attended general programs, while 48.4 percent attended vocational programs (Eurostat 2021).

In Figure 1, we show the share of STEM field graduates among tertiary-educated working-age population across the Nordic-Baltic region from 2005 to 2020. Between 2005 and 2020, supply of STEM-related skills among tertiary-educated working-age population was growing steadily in Norway and Sweden. In Denmark and Finland, the growth was less pronounced, but the share of Natural sciences, Mathematics and IT increased at the expense of Engineering. Overall, Finland remains on top, and Sweden is catching up. By contrast, in the Baltic countries, the supply of STEM-related skills among tertiary-educated working-age population in 2020 was lower than in 2005 due to substantial decrease in the share of Engineering fields. Increase in the share of Sciences, Math, and IT was not sufficient to compensate for the shortage of engineers.

By 2020, despite the decreasing trend, the shares of STEM-graduates among tertiary-educated working-age population in Lithuania (27 percent) and Estonia (28 percent) were among the highest in the Nordic-Baltic region, just slightly below Sweden and Finland (both at 29 percent). Latvia (at 20 percent) features the lowest supply of STEM-related skills among tertiary-educated working-age population.



[2]

Figure 1. Share of STEM field graduates among tertiary-educated population aged 20 to 64, 2005-2020. Top: The Nordic countries; Bottom: The Baltic countries.
Sources: Calculation with the EU Labour Force Survey microdata.

While Figure 1 describes the overall supply of STEM professionals, Figure 2 presents the supply of STEM skills among recent university graduates from 2013 to 2021. We observe that Latvia performs the poorest among the Nordic-Baltic countries and shows nearly no improvements from 2013 to 2021. Norway and Denmark also perform below the EU-27 average. Plausibly, this has to do with important role of oil, gas and fishing industries and related resource-based value chains, where many technical fields' workers are without formal education (e.g., Sasson and Blomgren 2011). Finland and Sweden have the highest shares of

[2] Hereafter, EU-27 excludes the UK and includes Croatia.

STEM fields among recent graduates in the region. Overall, the patterns over time are similar across the NBR countries: Engineering declines, while Natural Sciences, Math and IT expand.

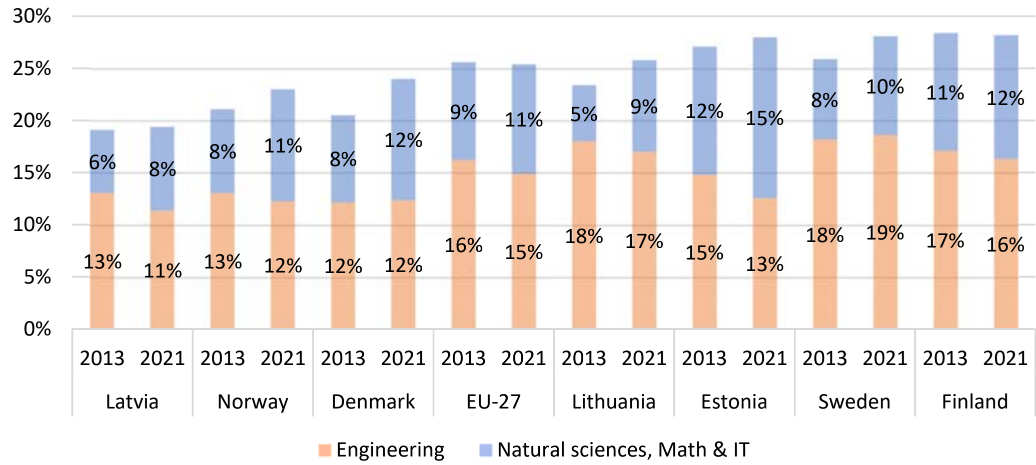


Figure 2. Share of STEM fields' graduates among all tertiary graduates in the Nordic countries, the Baltic countries and EU-27, 2013 and 2021.
Notes: For EU-27, data for 2014 are used instead of 2013.
Sources: Own compilation based on Eurostat data (dataset educ_uoe_grad03).

Figure 3 compares the share of STEM fields' graduates among post-secondary non-tertiary (i.e. ISCED 4) vocational education graduates across Nordic and Baltic countries in 2013 and 2021. Note that this mainly involves education in subjects associated with engineering. A substantial increase in this share is found in all countries considered excluding Estonia and Sweden. By 2021, Lithuania and Finland (37 and 29 percent, respectively) featured the highest STEM shares among ISCED 4 graduates, followed by Sweden and Latvia (25 and 23 percent). Significantly lower shares were observed in Estonia, Norway, and, especially, Denmark. As mentioned above, in Denmark and Norway, much of the technical work in the resource-based industries is traditionally conducted by personnel without formal education in relevant fields, which explains why non-tertiary vocational education in these fields is less developed.

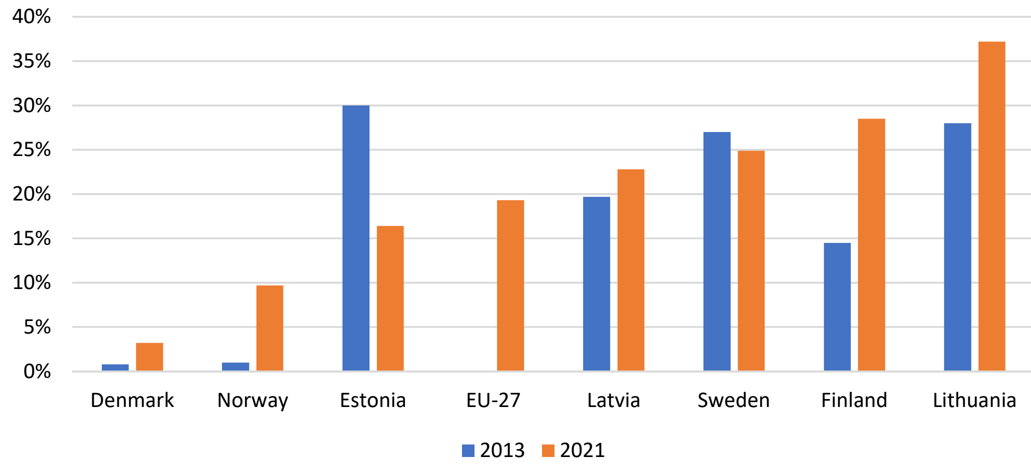


Figure 3. Share of STEM fields' graduates among all post-secondary non-tertiary vocational education graduates in the Nordic countries, the Baltic countries and EU-27, 2013 and 2021.

Notes: For EU-27, data for 2013 (and 2014) are not available.

Sources: Own compilation based on Eurostat data (dataset educ_uoe_grad03)

Considering the supply of STEM skills among secondary-educated working-population across the Nordic-Baltic countries (Figure 4), Latvia and Lithuania have had a negative development since 2010, becoming the countries with the lowest shares of STEM fields' graduates in the region by 2020. Among the Nordic countries, Norway distinguishes itself as the country with the by far the lowest (although growing) share of STEM fields' graduates in the secondary-educated segment.

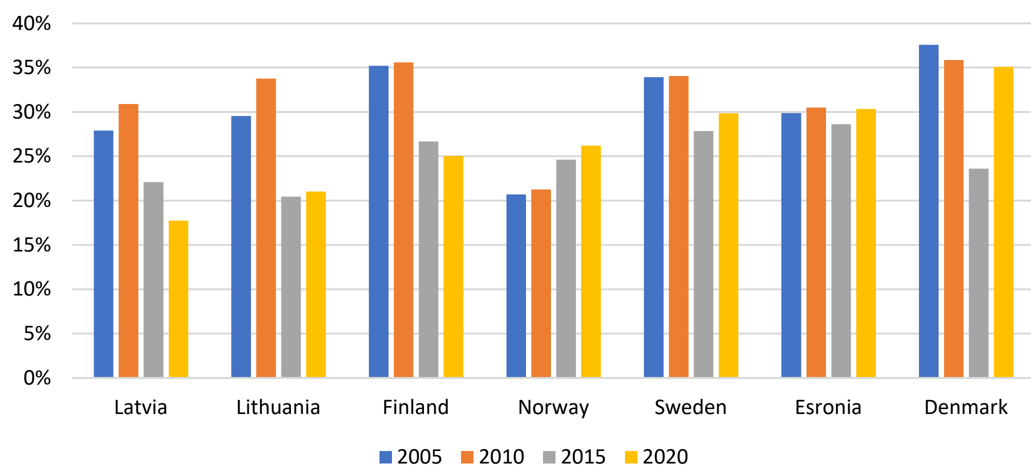


Figure 4. Share of STEM fields graduates among secondary-educated working-age population. Nordic and Baltic countries, 2005 to 2020.

Sources: Calculation with the EU Labour Force Survey microdata.

2.2 Urban – rural education gap in Norway and Latvia

Closing in on the Nordic-Baltic region, we consider educational attainment of working-age population by degree of urbanisation (Figure 5). The figure clearly shows that educational attainment in rural areas is significantly lower than in cities and towns[3]. In all Nordic and Baltic countries, the share of tertiary-educated in rural areas is lower than elsewhere. Moreover, in the Baltic countries and Denmark, rural areas feature a higher proportion of low-educated residents. This implies that children living in rural areas have, on average, lower parental background in terms of socio-economic group (see panel A of Table E2 in Appendix E) and highlights the importance of convenience access to different types of secondary-level programs in rural areas.

Another message from Figure 5 is that for any degree of urbanisation, the upper secondary graduation rates are somewhat higher in the Baltics and Finland than in Scandinavia. Higher shares of foreign-born population in the Scandinavian countries[4], is one of the factors behind these differences. Other factors are related to education policies (e.g., how strict the requirements for graduating are) and national classifications of education programs.

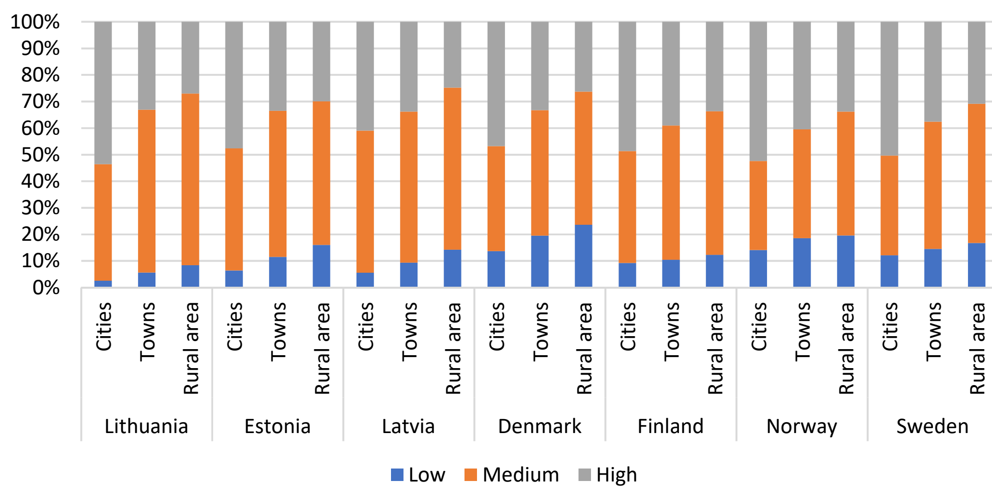


Figure 5. Educational attainment of working-age population by degree of urbanisation. Nordic and Baltic countries, 2015 and 2020 average.
Notes: Low: below upper secondary education. Medium: Upper secondary or post-secondary non-tertiary education. High: Tertiary education. *Sources: Calculation with the EU Labour Force Survey microdata*.

[3] For a broader perspective on regional differences in educational attainment, see Eurostat (2021).
[4] See e.g. Hazans et al. 2023: Table A1.

In our further benchmark analyses, we focus on Latvia and Norway as our selected cases. Compared to Latvia, Norway is a notch richer and more sparsely populated country, so it is interesting to if similar patterns are found there as in Latvia. Norwegian educational and spatial data is also relatively rich, enabling suitable descriptive benchmark analyses. We refer to Appendix C for a short description of key characteristics of the Norwegian system relevant for the comparison.

We start by considering the performance within lower secondary schools in Norway across centrality levels (measured by Statistics Norway's centrality index, Høydahl 2021) and parental education. In Figure 6, we have illustrated the average mastering level in national tests along these dimensions. The similarities between the results in reading and mathematics are striking. Expectedly, pupils with tertiary-educated parents generally perform better than children of people with less than tertiary education do.

Children of parents with unknown education level perform even worse than do those of parents with non-tertiary education. This is likely related to over-representation of Non-Western first- and second-generation immigrants in this category. Generally, multicultural pupils must learn more in terms of language and cultural contexts than their Norwegian classmates, and their parents often are less equipped in terms of education and language skills when it comes to providing educational support at home.

Test results in both reading and mathematics tend to be better in urban areas, where the accessibility to school in terms of travel time is better (Figure 6). The largest difference is between the most urbanised areas in central parts of the Oslo Region and other areas. The pattern is less clear for children of parents with unknown education, which *inter alia* may be related to concentration of immigrants in urban territories or to smaller school classes in remote rural areas.

In Norway, research economists specialised in the education sector annually perform efficiency analyses of the primary and lower-secondary sector on behalf of the central government. These analyses are mainly conducted using data envelopment analysis with operational costs or educational staff as inputs, pupils, school performance and school environment as outputs, and various contextual controls, including immigrant background, parental educational level and earnings, and proximity to neighbouring education institutions (e.g. Borge et al., 2020). In a recent report, Rødseth et al. (2022) show that smaller distances to neighbouring schools is associated with higher cost-efficiency of primary and lower-secondary education.

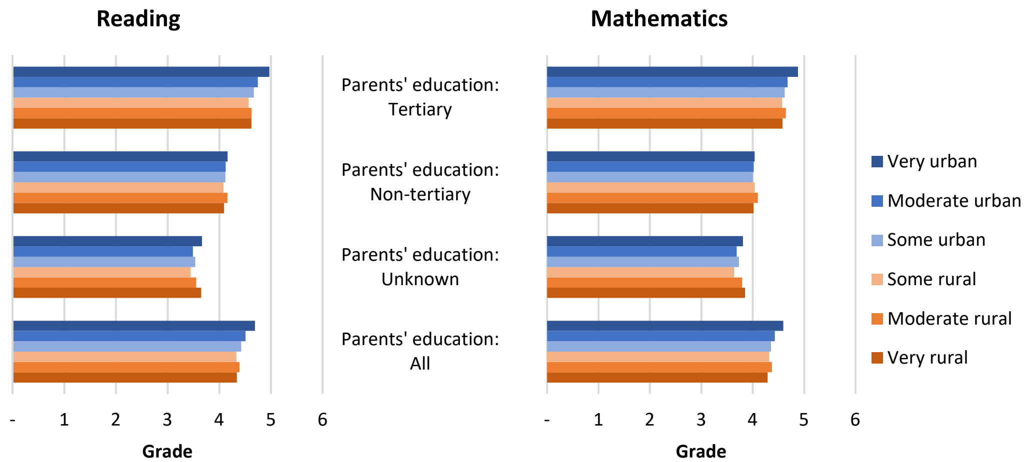


Figure 6. Average mastering level in national tests at the ninth grade. Norway, 2019, by subject, parental education, and degree of urbanisation.
Source: Statistics Norway.

Norway does not have separate STEM-oriented programs within upper secondary education. At schools offering general programs, mathematics is mandatory (with an optional advanced level), while informatics and natural sciences constitute optional subjects. Some schools offer technically oriented vocational programs. Vocational students must also follow one year of theoretical education and may qualify for higher education by attending another year of theoretical education.

Data on exam results at Norwegian upper secondary schools across urbanisation levels and parental educational background is not publicly available. However, data on upper secondary completion rates across these dimensions (with further distinction between general and vocational programs) are available, as illustrated in Figure 7. Here, the degree of urbanisation is measured at the county level, i.e. somewhat rougher than in Figure 6. Although this implies some measurement errors, the centrality index remains a decent proxy of access to education. Positive correlation between urbanisation level and completion rates is evident for vocational programs. On the other hand, for general programs, the graduation level of children with non-tertiary educated parents are relatively low in the most urbanised areas. However, at least two circumstantial factors suggest that the relationship between school performance and accessibility is stronger than what Figure 7 suggests.

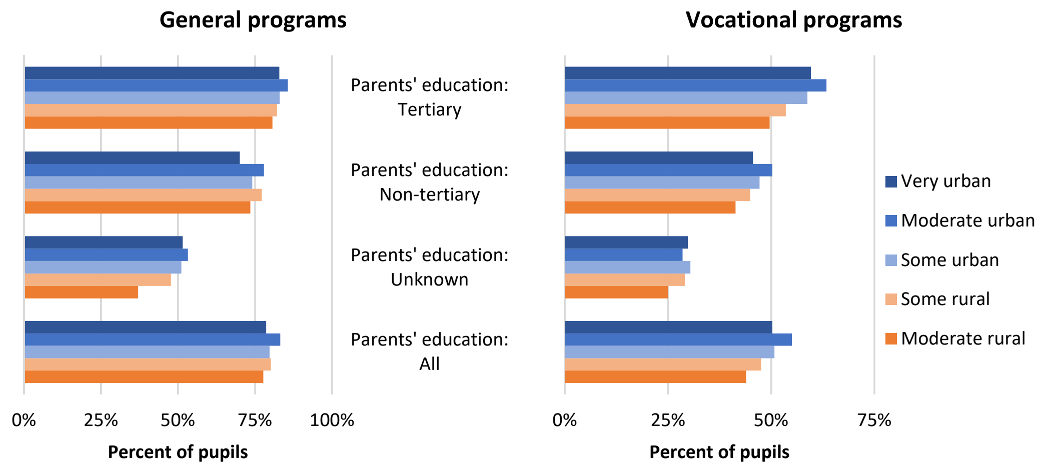


Figure 7. Upper secondary graduation rate, by program type, parental education level, and degree of urbanisation. Norway, 2019.
Source: Statistics Norway.

First, upper secondary enrolment is higher in urban areas, where pupils are to a larger extent engaged in general programs, as shown in Figure 8 (left panel). General programs are more theory-oriented than vocational programs. Thus, a large portion of students attending general programs implies higher graduation level, as less equipped students are less likely to enrol in general programs. The lower share of vocational students in urban areas is despite of a broader access to variety of vocational programs. Plausibly, this is related to a relatively easy access to higher education in some urban areas, as well as to attractive resource-based labour market for non-tertiary educated workers along the Norwegian coast.

Second, as depicted in Figure 8 (right panel), there are relatively many immigrants, especially Non-Western immigrants, among students in urban areas. Although some immigrant groups are likely be more hard-working compared to the natives, integration barriers may in general contribute to lower graduation rate.

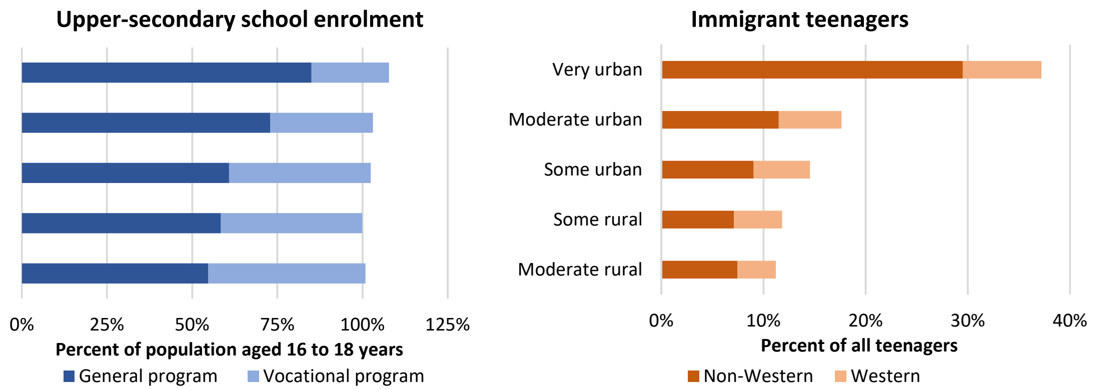


Figure 8. Upper secondary school enrolment (left panel) and share of immigrants among teenage population (right panel), by urbanisation level. Norway, 2019.

Notes: Immigrants from Europe, North America and Oceania are referred to as Western, while immigrants from Africa, Asia (including Turkey), Latin America and the Caribbean are recognized as Non-Western.
Sources: Statistics Norway.

We now turn to Latvian school performance in terms of results of the centralized exams, which are the basis for entering universities[5].

In Figure , we depict STEM and language exam results by types of settlement. The Figure clearly shows that more densely populated settlements (where access to STEM programs is better, see section 5 below) feature better exam results in STEM disciplines. Contrary to the STEM results and the Norwegian exam results, language exam results in Latvia do not show such a pattern.

Furthermore, average STEM exam scores were significantly higher in state gymnasiums (61 percent) than in general education institutions (42 percent) and vocational schools (21 percent)[6].

[5] On the Latvian education system, see Appendix A.
[6] Source: Education information system data and own compilation.

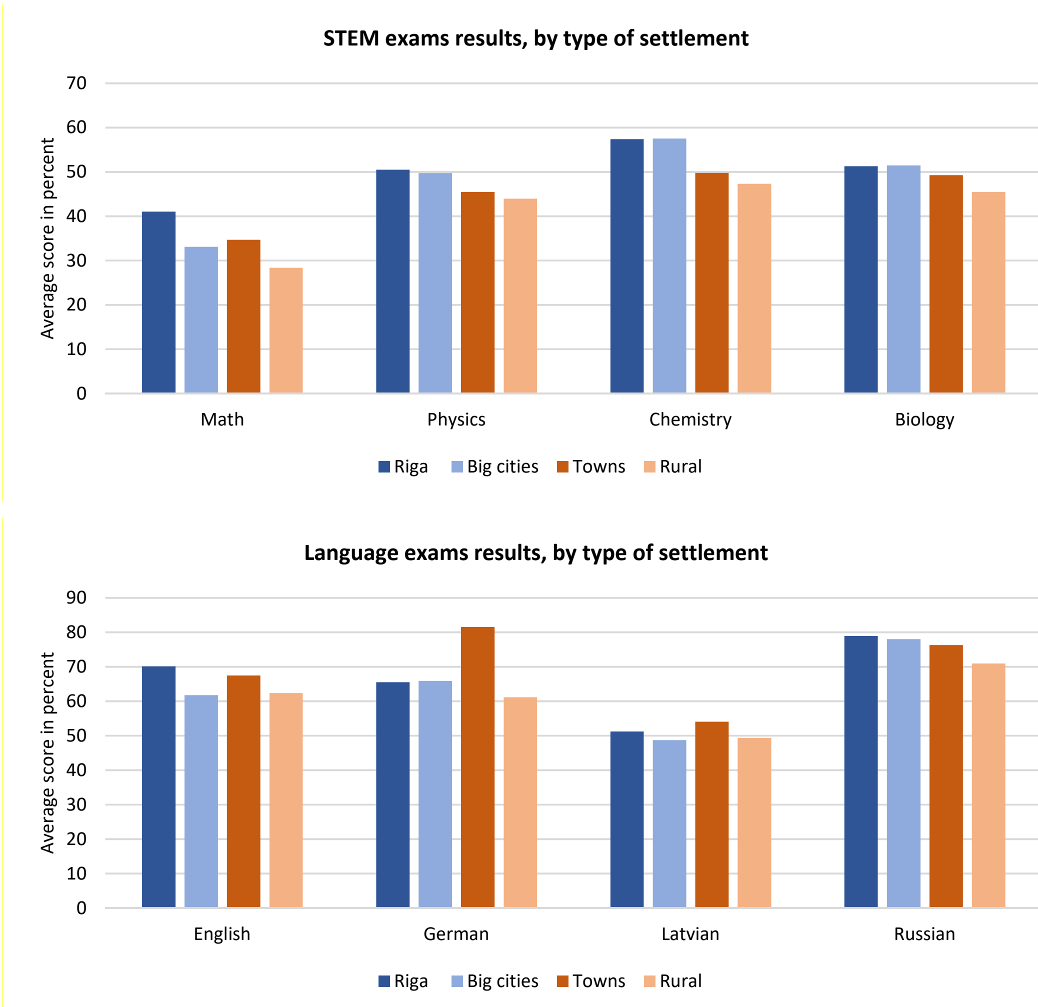


Figure 9. STEM and language exam results, by type of settlement. Latvia, 2021.
Sources: Education information system data and own compilation.

3 Literature Survey: Why school accessibility matters

Belief that schools' accessibility is a matter of social inclusion and justice (Christiaanse, 2020; Farrington & Farrington, 2005; Lundahl, 2018; Talen, 2001) emerges from their role in shaping individual's path in the labour market (Lundahl, 2018, p. 123). Social scientists have long discussed how to maintain schools in sparsely populated areas (see BISS, 2013; Cedering & Wihlborg, 2020; Falch et al., 2013; Kļave & Tūna, 2013/2014; Lind, 2019; Lind & Stjernström, 2015; Šūpule & Søholt, 2018)[7]. Another strand of literature explores the role of transport infrastructure in the context of access to schools (Kenyon, 2011; Newson et al., 2010;

[7] This debate differs in context from studies on the consequences of poor school accessibility in the developing countries (e.g., Das & Das, 2021; Moreno-Monroy et al., 2018).

Vasconcellos, 1997, among others). Yet another approach refers to using remote teaching methods and helping less well-off families with the facilities to access remotely provided material as a substitute to better physical access, e.g. when distance is an obstacle to post-compulsory participation (Dickerson & McIntosh, 2013, p. 756; Lind, 2019, p. 344; Lind & Stjernström, 2015, p.3). Bernard et al. (2004) provide meta-analysis of studies comparing distance education with classroom instruction.

A longer travel distance to school requires more time and financial resources, which puts those living further in a disadvantaged position compared to others (Lind, 2019, pp. 336-337). Consequently, this reduces the time left for social and spare time activities (Cedering & Wihlborg, 2020, p. 606; Kvalsund, 2019, p. 185; Lind & Stjernström, 2015, p. 2; Talen, 2001, p. 466). Children from lower-income families more likely rely on public transport (Moreno-Monroy et al., 2018, p. 117), which reinforces adverse social effects of a longer distance to school (Lind, 2019, pp. 336-337). Noteworthy, studies devoted to the links between school size and student outcomes, as well as studies of the effects of school consolidation, tend to ignore negative externalities associated with increased travel time (OECD 2018, p. 131).

The literature also provides evidence that school proximity has a positive effect on graduation propensity (Falch et al., 2013, p. 171-175), pupils' achievements (Talen, 2001, p. 481) and intention to pursue post-compulsory education (Dickerson & McIntosh, 2013, p. 742), supporting argument for a denser school network.

Focusing particularly on schools' accessibility and impact on pupils' intentions to continue education, studies demonstrate variety in approaches based on either the distance to school (e.g., Das & Das, 2021; Dickerson & McIntosh, 2013; Talen, 2001) or the time required to cover the distance with a particular mode of transport (e.g., Falch et al., 2013).

The findings indicate that in more developed countries, pupils are willing and able to cover longer distances to get to school. While in India, according to Das & Das (2021), even a 2–3 km distance to secondary school significantly reduces probability to continue education beyond compulsory, a similar effect in England is observed if the distance to educational facility is at least 8 km (Dickerson & McIntosh, 2013)[8]. On the other hand, Falch et al. (2013), based on a study conducted in Norway, have found importance of the 30-minute limit of travel time – if a secondary school is within a half-an-hour reach, the probability of dropping out decreases. In line with this, Chillón and et al. (2015) find that in Norfolk County (UK), 14-year-old children

[8] Moreover, according to Dickerson & McIntosh (2013) this distance effect does not concern young people who have a clear intention to continue studies.

walk to school if it no more than three kilometres away, otherwise they commute. In terms of time, three kilometres take about 30 minutes of walking. Thus, the literature provides empirical evidence suggesting that a 30-minute reach is acceptable for a student to attend school without significant loss of performance[9].

While national legislations set common quality standards for the education provision in developed societies, small (rural) schools face a number of challenges to meet these criteria. Most commonly, they have greater difficulties to attract competent teachers (Lind & Stjernström, 2015, p. 2; OECD, 2014, p.64; Šūpule & Søholt, 2018, p. 2) and to provide the same range of subjects to choose and extra-curricular opportunities like larger schools (see Alloway & Dalley-Trim, 2009, pp. 56‒57). Along with efficiency, these arguments are used to justify a need for the optimization of the school network towards larger establishments (see e.g., Cabinet of Ministers, 2021; Kvalsund, 2019; Ministry of Education and Science, 2023; Turlajs, 2017). The level of school performance is one of the factors that parents, especially, those with higher socio-economic status, consider when choosing a school for their child (Musset, 2012, pp. 32-35). This can facilitate outflow of the best students from rural to urban schools, with a further detrimental effect on the quality of education in rural areas.

The debate outlined above often focus on the primary education level or on small rural schools in general (see e.g., Cedering & Wihlborg, 2020; Kvalsund, 2019; Lind & Stjernström, 2015; Šūpule & Søholt, 2018; Talen, 2001). Studies devoted to access to upper secondary education in developed countries are relatively rare; Falch et al. (2013) and Lind (2019) are among the few exceptions. There are, however, several reasons why access to secondary education deserves special examination. First, lower accessibility results in higher dropouts (Falch et al., 2013) and in switching to vocational education (Dickerson & McIntosh, 2013, p. 748), contributing to maintenance of rural-urban skills gap (Newbold & Brown, 2015; Van Maarseveen, 2021; Zafira et al., 2019). Second, students' achievements at the secondary education level explain up to half of a country's international economic competitiveness (Baumann & Winzar, 2016, p. 13; see also Hanushek & Woessmann, 2010). Next, the crucial role of universities and tertiary-educated labour force for countries' welfare and economic growth, as well as regional development is well documented in the literature (see, e.g., Crowley et al., 2020; Fonseca & Nieth, 2021; Kivi & Paas, 2021; Valero & Van Reenen, 2019), and

[9] The literature ir largely silent on the reasons for using time or distance when estimating school accessibility. Plausibly, the choice is determined by data availability and by the tools used for converting distance into travel time.

secondary education, being a necessary step towards higher education, is thus a crucial resource as well.

Hence, restricted access to secondary schools in rural areas likely has negative long-term effects on the young person's future labour market prospects and, more generally, on economic growth and welfare of the country.

Over the last decade, GIS tools have gained prominence in the analysis of educational policies, especially because being well suited for assessing school accessibility (Yoon et al., 2018, p. 2). Our paper seeks to contribute to this strand of the literature. In addition to access to schools in general, another issue related to the needs of the labour market in the context of digital transformation is availability and quality of education in STEM disciplines. Although there is an ongoing debate about the benefits of offering selective, general, or inclusive STEM education (Lynch et al. 2018, among others), the overall aim of this debate is to draw attention to labour shortage in STEM fields (Atkinson et al., 2007). Whereas STEM-oriented educational institutions have not been considered as separate units in the previous analysis of school accessibility, we contribute to this debate by comparing access to STEM-oriented and general secondary programs in Latvia.

4 Data and Methods

For our analysis, we have merged data from several sources. Data on institutions of secondary education (including location, programs provided and the number of students for the school year 2021/22) were extracted from the State Education Information System in December 2021. These data were amended with online data on traffic intensity at specific times[10].

For each program type, we have developed walking and driving accessibility areas (AAs) at five-minute intervals using estimated access time on a Monday at 8:00 in the direction of the place of receipt of the service. The AAs were generated with *ArcGIS Pro 2.9 Network Analyst* tool "Service Area". This tool "determines network service areas around facilities. A network service area is a region that encompasses all streets that can be accessed within a given distance or travel time from one or more facilities" (pro.arcgis.com, n.d.). In total, 12 AAs (five minutes to one hour) were generated for each program type and travel mode. The *Dissolve* option was

[10] These data are available from the state-owned LLC "Latvian State Roads" at https://data.lvceli.lv/opendata/EN/RealtimeTraffic/

used to merge the AAs of multiple programs that have the same time cut-off values[11]. Finally, Data of the state border of Latvia from the State Land Service were used to restrict the calculation of AAs to Latvia's territory. To sum up, for each program type, there are up to 12 walking AAs and up to 12 driving AAs.

Finally, for each AA, we provide two indicators, (i) the number of residents aged 15-18 (the typical enrolment age for the secondary education level) at the beginning of 2021, and (ii) gross average and median earnings in 2020 of employees residing in that AA. Both indicators have been calculated on request by the Central Statistical Bureau of Latvia using AAs' borders data along with the experimental statistics on population[12] and earnings by place of residence[13] in regions, cities, municipalities, towns, rural territories, neighbourhoods, and densely populated areas.

Anonymised student-level data on the results of state centralized examinations by school were obtained from the National Center for Education of the Republic of Latvia.

5 Access to secondary education programs: Descriptive evidence

5.1 Access to secondary education programs by type of settlement and population density

We start by documenting basic facts: The proportion of advanced (STEM or gymnasium) programs in rural areas is substantially lower than in towns and cities. STEM programs account for 37 to 38 percent of all general and STEM programs in towns and cities, but just for 14 percent in rural areas (Table 1). The proportion of gymnasium programs in rural areas is two percent, compared to 23 percent in towns and 14 percent in cities (Table 1). Together, STEM or gymnasium programs account for nearly half of all programs in towns and for 44 percent in cities, while in rural areas this proportion is just 16 percent (Table 1).

To sum up, the supply of secondary education programs in rural areas provides much less possibilities for further education or employment than in towns and cities. This is likely to be a real obstacle for youth living in remote rural areas.

[11] If for the given travel time range, the AAs of different programs do not have a common border, they are, nonetheless, merged into one multipart AA.
[12] Dataset RIG010, https://data.stat.gov.lv/pxweb/lv/OSP_PUB/START__POP__IR__IRD/RIG010?s=rig010&
[13] Dataset RIG110, https://stat.gov.lv/lv/statistikas-temas/darbs/alga/tabulas/rig110-menesa-darba-samaksa-pec-dzivesvietas-regionos-novados?themeCode=DS

Table 1. Number of general and STEM secondary education programs, by type of settlement. Latvia, end of 2021.

	Rural areas	Towns	Seven largest cities	Total
General programs	71	97	129	297
of which gymnasium programs	1	19	13	33
STEM programs	12	56	79	147
of which gymnasium programs	1	16	16	33
Total	83	153	208	444
STEM programs /Total	14 percent	37%	38%	33%
Gymnasium programs/Total	2%	23%	14%	15%
(STEM or Gymnasium programs)/Total	16%	49%	44%	41%

Notes: The table reports number of different locations of provision of general and STEM programs. Some schools operate (and provide the same programs) at several locations, this is why numbers in col. "Total" slightly exceed those reported in Table A1.
Sources: State Education Information System data and calculations.

Figure 10 reinforces the message from Table 1 by presenting the distribution of the number of general, STEM and gymnasium programs across settlements of different population size. Provision of general programs is roughly U-shaped and balanced between settlements of different size with 30 percent of programs located in small settlements, 27 percent – in the capital city, Riga, 22 percent – in other large cities, and 21 percent – in medium-sized rural and urban settlements. By contrast, distribution of gymnasium and, especially, STEM programs is skewed to the right (Fig. 10).

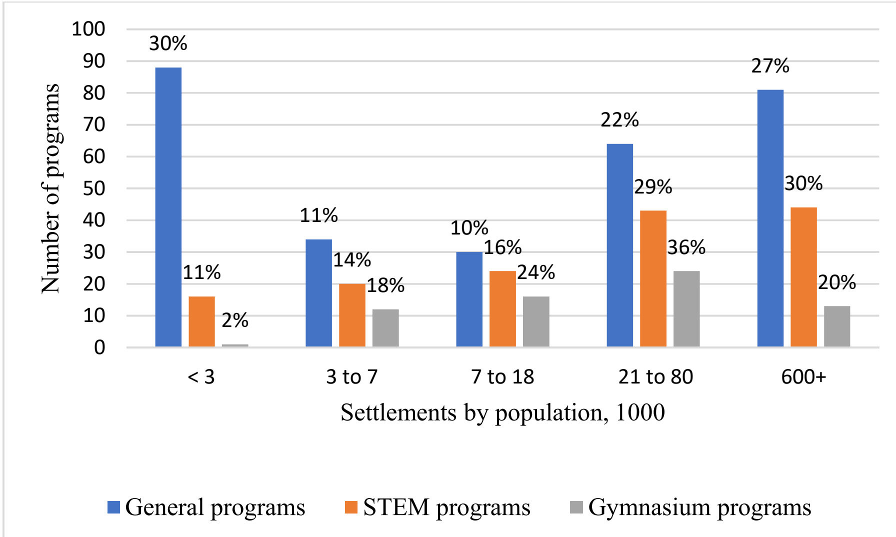


Figure 10. Provision of general, STEM, and state gymnasium programs by size of settlement. Latvia, end of 2021.

Notes: See Notes to Table 1. *Sources*: State Education Information System data, experimental population statistics (Central Statistical Bureau of Latvia, dataset IRE071), and calculations.

In what follows, we provide evidence that a not negligible proportion of the target population cannot access STEM and gymnasium programs in a reasonable time.

Table 2 reports, for each type of programs, average population density (APD hereafter) in the territories with walking access time up to 30 minutes, 30 – 60 minutes and over 60 minutes.

Table 2. Average resident population density by program type and walking access time.

Persons per km²

Walking time	General programs	STEM programs	State gymnasium programs
0 - 30	1126	1669	2150
30 - 60	75	162	780
60+	7	9	15

Sources: Calculation using *ArcGIS Pro 2.9 Network Analyst* tool "Service Area", State Education Information System data, and experimental statistics on population density (Central Statistical Bureau of Latvia, dataset IRD062).

Comparison with the population density by type of settlement (Table 3) suggests that students able to reach a state gymnasium within 30 minutes by walking (APD = 2150) live mainly in Riga or in the most densely populated areas of other cities and medium towns[14]. This is confirmed by a map featuring just 23 locations with state gymnasiums along with about 50

[14] Just one state gymnasium is located in a rural settlement (however, in 2023, this settlement was granted a town status).

urban locations with walking access time to a state gymnasium over 60 minutes (Appendix D, top panel of Figure D1). Students who can reach a STEM program by walking for up to 30 minutes (APD = 1669) are more dispersed across the country: respective map features about 50 locations distant from each other plus a whole cluster in Riga (Appendix D, bottom panel of Figure D1). This includes 12 rural locations (Table 1). However, the territory where access to a STEM program requires 30 to 60 minutes of walking features APD = 162, which is typical for small towns and townships (Table 3). In other words, not only remote rural areas but also many small urban settlements lack a comfortable walking access to STEM programs.

By contrast, the territory where access to a general program requires 30 to 60 minutes of walking features APD = 75, which is typical for rural settlements (Table 3). Recall, however that almost a quarter of the general programs are located in rural areas (Table 1). Thus, only some rural settlements lack a comfortable walking access to general programs.

Table 3. Population density by type of settlement. Latvia, beginning of 2022.

Persons per km^2

	Rural	Small towns and townships	Medium towns Ex. Top 8	Medium towns Top 8	Large cities (excl. Riga)	Riga
Min	1	124	359	1093	568	1000
Max	113	349	996	1526	1591	8338
Median	7	250	628	1190	1218	2719
N	540	28	36	8	9	6

Notes. For Riga, the table reports density by district. Average population density in Riga was 2188. *Sources*: Calculations with data of Central Statistical Bureau of Latvia (dataset IRD062) and Office of Citizenship and Migration Affairs (Republic of Latvia).

The next subsection presents estimates of the share of population aged 15 to 18 able to access state gymnasiums, as well as STEM and general secondary education programs within a given time by walking or driving.

5.2. Accessible target population by program type, travel mode and access time

Figure 11 presents the target population accessible for education programs as driving time (panel A) or walking time (panel B) increases. General programs are almost completely accessible for the target population within 30 minutes by driving, while four percent of the target population cannot reach a STEM program within 30 minutes by driving. Access to the state gymnasiums has the lowest coverage – even by driving 15 percent of the target population cannot reach a nearest state gymnasium within half an hour (Figure 11, panel A).

In Latvia, walking is an important travel mode, as it is an efficient way to reach secondary schools for many residents. Yet, 43 percent of the target population cannot reach a STEM-oriented program within 30 minutes by walking, and 72 percent cannot reach a state gymnasium program within 30 minutes by walking (Figure 11, panel B). A comparable figure for the general programs is 34 percent.

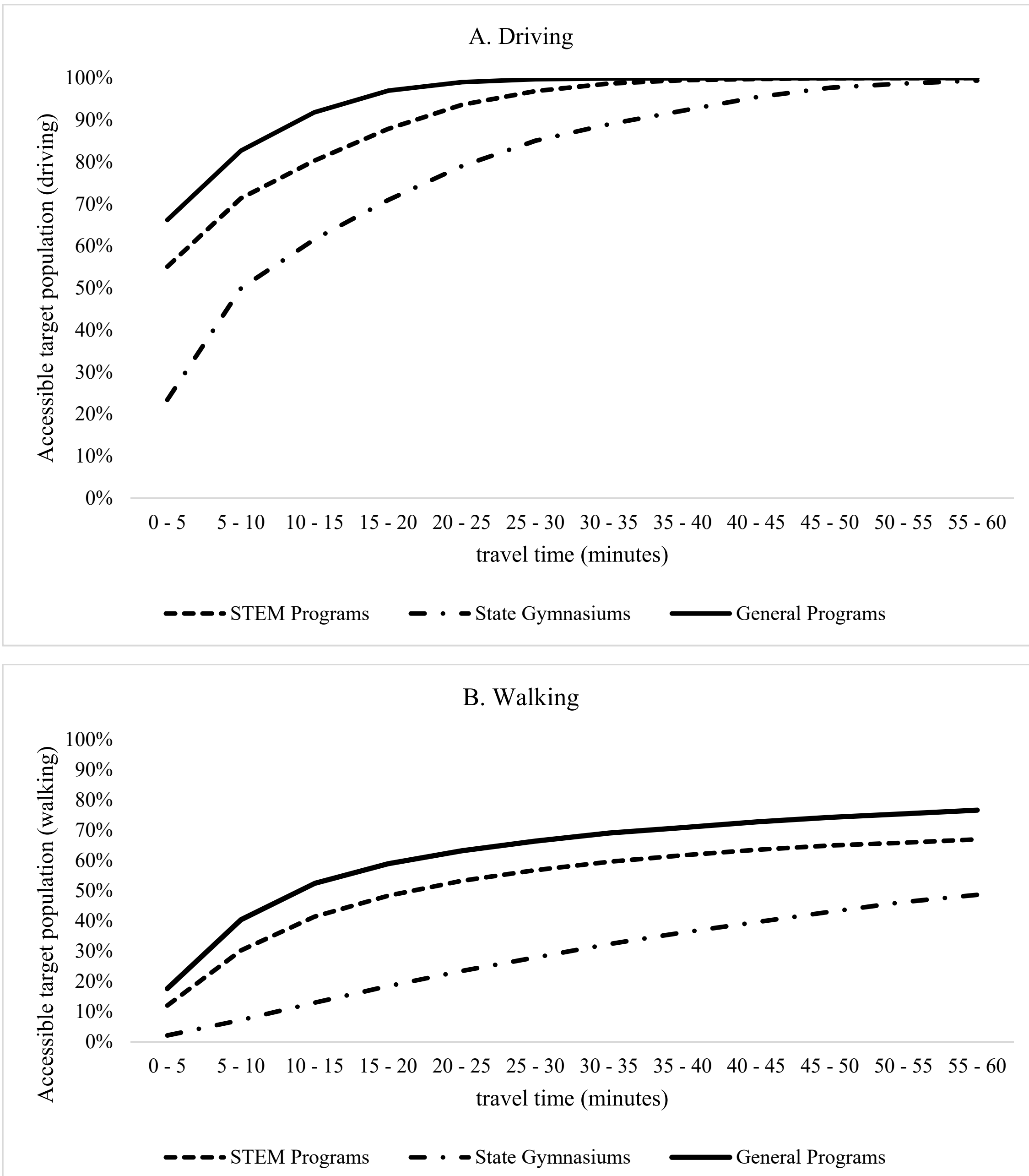


Figure 11. Accessible target population for state gymnasiums, as well as STEM and general secondary education programs by driving and walking time.
Sources: Calculation using *ArcGIS Pro 2.9 Network Analyst* tool "Service Area", State Education Information

System data, experimental population statistics (Central Statistical Bureau of Latvia, dataset IRE071), and online data on the place-and-time specific traffic intensity from https://data.lvceli.lv/opendata/EN/RealtimeTraffic/.

Figure 12 presents a compact summary of the main findings from Figure 11 regarding walking access. It appears that for secondary education programs of all types, a substantial proportion of the target population is unable to reach the programs by walking even within an hour. This proportion ranges from about a quarter for general programs to one-third for STEM programs and to over one-half for programs in state gymnasiums.

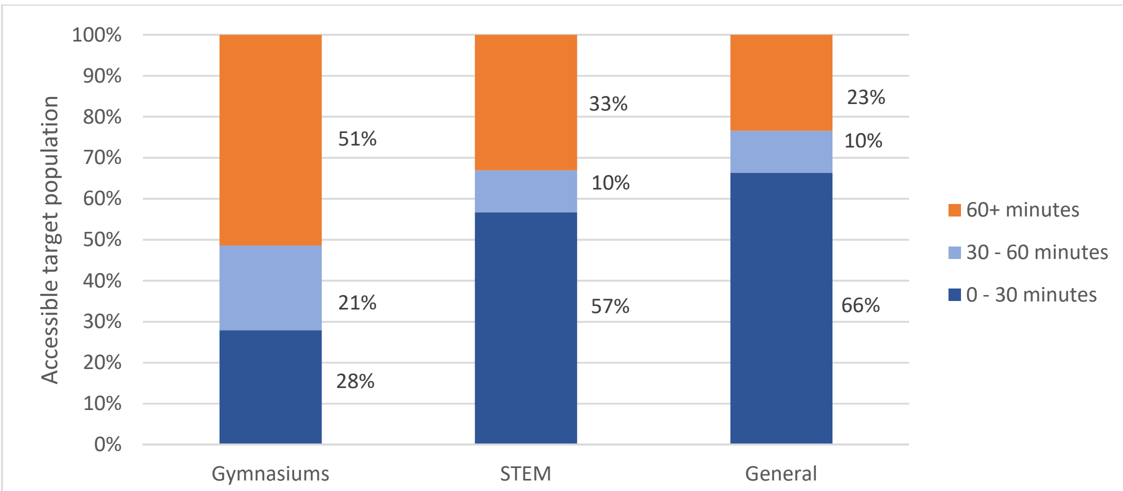


Figure 12. Secondary education walking access time, by program type.
Sources: Figure 11 (panel B) and compilation.

6 Do children from wealthier families have better access to STEM programs?

Table 4 presents evidence that both average and median monthly earnings decline as walking access time increases. This holds for secondary education programs of all types. In areas where it takes more than an hour to reach a state gymnasium or a STEM program by walking, average earnings are by 11 percent lower than in the areas where similar programs are accessible by walking within 30 minutes. For general programs this income differential is even larger – almost 15 percent, which is in line with the fact that in this case the "60+ minutes walking access area" refers to smaller and less densely populated settlements than for STEM and gymnasium programs (see Table 2 and Figure 10).

Table 4. Average and median monthly earnings by secondary education walking access time. Latvia, 2020.

	Average gross monthly earnings, EUR	Median gross monthly earnings, EUR

	Program type			Program type		
Access time	Gymnasiums	STEM	General	Gymnasiums	STEM	General
0 to 30 minutes	1100	1071	1064	818	806	802
30 to 60 minutes	1066	1065	1085	801	790	794
60+ minutes	979	950	909	750	732	710
	Earnings differential: 60+ minutes vs. 0-30 minutes					
	-11.1%	-11.3%	-14.6%	-8.4%	-9.2%	-11.5%

Sources. Calculation with State Education Information System, State Revenue Service data, experimental population statistics, and online data on the place-and-time specific traffic intensity from https://data.lvceli.lv/opendata/EN/RealtimeTraffic/.

Similar earnings differentials by driving access time are substantially larger. This could be expected because a 30-minutes difference in driving time corresponds to a much larger distance than the same difference in walking time. In areas where it takes 30 to 60 minutes to reach a state gymnasium (respectively, STEM) program by driving, average earnings are by about 18 (respectively, 15) percent lower than in the areas where similar programs are accessible by driving within 30 minutes (Table 5). In line with the case of walking access time, similar differential for general programs is larger, reaching 21 percent.

Table 5. Average and median monthly earnings by secondary education driving access time. Latvia, 2020.

	Average gross monthly earnings, EUR			Median gross monthly earnings, EUR		
	Program type			Program type		
Access time	Gymnasiums	STEM	General	Gymnasiums	STEM	General
0 to 30 minutes	1056	1035	1030	794	782	779
30 to 60 minutes	870	878	815	693	687	631
	Earnings differential: 30 to 60 minutes vs. 0 to 30 minutes					
	-17.6%	-15.2%	-20.9%	-12.7%	-12.1%	-19.0%

Sources. Calculation with State Education Information System, State Revenue Service data, experimental population statistics, and online data on the place-and-time specific traffic intensity from https://data.lvceli.lv/opendata/EN/RealtimeTraffic/.

Table 6 presents econometric evidence for negative association between average (or median) earnings and driving access time for secondary education programs. For the state gymnasium programs and STEM programs, a ten-minute increase in driving access time is associated with a 6.1 (respectively, 7.4) percent decline in the average gross monthly earnings of employees residing in the accessibility area. For the general programs, the corresponding effect (11.9 percent) is larger, in line with the results reported in Table 5. All these effects are highly significant, and the models feature an excellent fit, with R-squared ranging between 0.88 and

0.96 (thus, location explains most of the average earnings' variance). The results for median (rather than average) earnings are similar, with slightly smaller effects.

To sum up, children from wealthier families have better access to both the state gymnasiums and the STEM programs. The same is true also for the general secondary education programs; however, the overall access to these programs is better, with 100 percent of the target population being able to access them within 30 minutes by driving (see Figure 11, panel A).

Table 6. Average and median monthly earnings vs secondary education driving access time, by program type

	Dependent variable							
	Average gross monthly earnings, log				Median gross monthly earnings, log			
	Program type				Program type			
	Gymn.	STEM	General	All	Gymn.	STEM	General	All
Time/10	-0.061***	-0.074***	-0.119***	-0.071***	-0.043***	-0.056***	-0.095***	-0.052***
(minutes)	*0.005*	*0.007*	*0.014*	*0.006*	*0.003*	*0.003*	*0.005*	*0.004*
Program (vs. General)								
STEM				0.019				0.015
				0.014				*0.011*
Gymnasium				0.066**				0.050**
				0.019				*0.014*
_cons	7.026***	6.997***	7.003***	6.975***	6.723***	6.704***	6.710***	6.686***
	0.013	*0.009*	*0.011*	*0.016*	*0.007*	*0.003*	*0.003*	*0.01*
N	12	11	9	32	12	11	9	32
R2	0.956	0.906	0.881	0.864	0.953	0.961	0.977	0.883

Notes. The table reports regression coefficients with robust standard errors (in *Italic*). Observations correspond to driving and walking accessibility areas (AAs) with access time 0 – 5, 5 – 10, …, 55 – 60 minutes, weighted by the number of residents aged 15 to 18. AAs with less than 15 such residents are excluded (this refers to the 55 – 60 minutes driving AA for the STEM programs and the 45 – 60 minutes driving AAs for the general programs). Each included AA (except one) has at least 40 residents aged 15–18 and at least 500 employees. Earnings are total earnings from all jobs. The independent variable (Time) is the average access time for the given AA and program type (e.g., 2.5 minutes for the 0 – 5 minutes AA, 7.5 minutes for the 5 – 10 minutes AA, etc.). Legend: [*] p < 0.10; * p < 0.05; ** p < 0.01; *** p < 0.001.
Sources: Calculation with State Education Information System, State Revenue Service data, experimental population statistics, and online data on the place-and-time specific traffic intensity from https://data.lvceli.lv/opendata/EN/RealtimeTraffic/.

Another finding from Table 6 concerns comparison across types of programs. Employees living within a territory with a given driving access time for the state gymnasium programs earn, on average, by 6.6 percent more than earn those with the same access time for the general programs (Table 6, col. "All"). Similar earnings differential between gymnasiums and STEM programs is 4.7 percent[15], and both differentials are strongly statistically significant. By contrast, the differential between STEM and general programs (defined in the same way and presented in Table 6) is smaller (1.9 percent) and not statistically significant.

Is *walking* access time for secondary education programs also negatively associated with average or median earnings? Preliminary evidence from Table 4 was inconclusive, reporting a significant decline in earnings only for access time above one hour. Table E1 (in Appendix E) presents results parallel to those in Table 6 (see discussion above) for the case of walking access time. Walking access time is negatively linked to average earnings in the case of state gymnasiums and to median earnings as long as STEM and general programs are concerned or when all programs are pooled together. In all these cases, the link is quite weak: a ten-minute increase in walking access time is associated with a 0.4 to 0.7 percent decline in earnings of employees residing in the accessibility area, with R-squared ranging between 0.300 and 0.365. The link between driving or walking access time and earnings (or, more generally, between residence location and earnings) is not necessarily causal. One of the mediating factors is education level, which is, on average, lower in less urbanized areas (see Figure 5). However, the urban – rural gap in socio-economic status remains significant also after controlling for education and other demographic characteristics (Table E2 in Appendix E).

In fact, causality might run in both directions, e.g. existing economic environment explains wage level, while the spatial structure of the wage level[16] explains residential choice of individuals, as well as business location decisions. Furthermore, local governments in Latvia receive 75% of personal income tax paid by residents of respective territory. Hence, in areas with higher earnings, local can afford a denser school network, implying a smaller access time. With this in mind, in Table 7 we document models where average or median earnings "explain" driving access time for secondary education programs[17]. It appears that a ten-percent increase in average earnings is associated with reduction of driving access time by 15.7 minutes for gymnasiums, by 12.3 minutes for STEM programs, and by 7.4 minutes for general programs. Likewise, a ten-percent increase in median earnings is linked to reduction of driving access

[15] This can be seen from Table 7 as 0.066 – 0.019 = 0.047. Testing the difference to be zero gives $p = 0.003$.
[16] Here and elsewhere in this paper we refer to spatial earnings (or wage) differentials by residence. Commuting makes these differentials generally smaller than similar differentials by job location (Hazans 2004).
[17] These are "reversed" versions of the models presented in Table 6.

time by 22 minutes for gymnasiums, by 17 minutes for STEM programs, and by 10 minutes for general programs.

Table 7. Secondary education driving access time vs average and median monthly earnings, by program type

	Dependent variable							
	Driving access time (minutes)							
	Program type				Program type			
	Gymn.	STEM	General	All	Gymn.	STEM	General	All
log(*aw*)	-157.0***	-122.2***	-73.8***	-122.0***				
	11.3	*12.9*	*7.8*	*11.2*				
log(*mw*)					-219.7***	-170.3***	-103.1***	-168.2***
					15.1	*10.4*	*4.8*	*14.4*
Program (vs. General)								
STEM				2.7				2.8[*]
				1.7				*1.5*
Gymnasium				9.3***				9.6***
				2.1				*2.2*
_cons	1103.7***	855.8***	517.7***	851.6***	1477.4***	1142.3***	692.0***	1125.1***
	78	*89*	*53.5*	*78.4*	*100.1*	*69.7*	*31.8*	*95.8*
N	12	11	9	32	12	11	9	32
R2	0.956	0.906	0.881	0.884	0.953	0.961	0.977	0.900

Notes: *aw* and *mw* refer, respectively, to average and median total earnings from all jobs. The table reports regression coefficients with robust standard errors (in *Italic*). Observations correspond to driving and walking accessibility areas (AAs) with access time 0 – 5, 5 – 10, …, 55 – 60 minutes, weighted by the number of residents aged 15 to 18. AAs with less than 15 such residents are excluded (this refers to the 55 – 60 minutes driving AA for the STEM programs and the 45 – 60 minutes driving AAs for the general programs). Each included AA (except one) has at least 40 residents aged 15–18 and at least 500 employees. The dependent variable (Time) is the average access time for the given AA and program type (e.g., 2.5 minutes for the 0 – 5 minutes AA, 7.5 minutes for the 5 – 10 minutes AA, etc.) Legend: [*] p < 0.10; * p < 0.05; ** p < 0.01; *** p < 0.001.
Sources: Calculation with State Education Information System, State Revenue Service data, experimental population statistics, and online data on the place-and-time specific traffic intensity from https://data.lvceli.lv/opendata/EN/RealtimeTraffic/

7 Discussion and conclusions

In this paper, we have delved into the accessibility of secondary education programs, with a particular focus on STEM (Science, Technology, Engineering, and Mathematics) education, within the context of Latvia. Our investigation has shed light on the distribution of programs across various types of settlements and has provided insights into the relationship between access to education and socioeconomic factors. Here, we synthesize our findings and discuss their implications for educational policy and practice, drawing parallels with experiences in other European countries, such as Norway.

One of our primary findings is the marked disparity in access to STEM programs between rural and urban areas. We have observed that densely populated regions, such as cities and larger towns, tend to offer a higher proportion of STEM programs compared to rural locales. This disparity underscores the critical need to address geographical inequalities in educational provision, as limited access to STEM education can impede opportunities for career advancement of rural youth and hinder economic development of the country.

Moreover, our analysis has revealed a significant correlation between access to STEM programs and socioeconomic status. Children from more affluent families tend to enjoy better access to both STEM programs and state gymnasiums, underscoring the role of economic resources in shaping educational opportunities. This socioeconomic disparity in access to education raises concerns about equity and social mobility, as it may perpetuate existing inequalities and restrict the upward mobility of disadvantaged students.

In addition to examining access to education, we have explored the relationship between accessibility and educational outcomes, particularly in STEM disciplines. Our findings indicate that regions with better access to STEM programs tend to yield higher exam results in STEM subjects, highlighting the crucial role of proximity to educational resources in developing STEM skills. However, we do not observe a clear relationship between accessibility and linguistic skills, proxied by language exam results.

By contextualizing our findings within the broader European landscape, we have identified common themes and challenges that transcend national boundaries. While educational systems and policies may vary across countries, the issue of access to education remains a universal concern. Lessons learned from the Latvian case can thus offer valuable insights for policymakers and educators in other European contexts striving to address issues of educational equity and access.

In conclusion, our study underscores the significance of ensuring equitable access to secondary education programs, particularly in STEM fields, as a means of promoting social inclusion, economic development, and human capital formation. Addressing geographical and socioeconomic disparities in educational provision demands a comprehensive approach that includes targeted investments in infrastructure, resources, and support services for underserved communities. By prioritizing accessibility and equity in education, policymakers can unlock the full potential of all students and contribute to building a more prosperous and inclusive society.

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Appendix A. General education programs at the upper secondary level in Latvia[19]

In Latvia, there are four broad types of general upper secondary education programs:

(i) Programs of mathematics, natural sciences and engineering direction (STEM programs);

(ii) Programs of general education direction (general programs);

(iii) Programs oriented at social sciences and humanities;

(iv) Professionally oriented general education programs

In this study, we focus on STEM and general programs; other programs constitute less than 10 percent of all programs (see Table A1). In addition, we pay a special attention to the STEM and general programs implemented in the *state gymnasiums*. To obtain the state gymnasium status, a secondary school should satisfy a set of requirements regarding the quality and variety of provided education, well as professional activities of teachers (for details, see Cabinet of Ministers, 2020). One of the requirements refers to the average score on the centralised state exams (at grade 12) over the last three years being no less than 65 percent.

Table A1. Programs of upper secondary education by school type, 2021/2022

Type of Program	Vocational secondary education schools	State gymnasiums	General secondary education schools	Total
General programs	4	31	228	263
STEM programs		30	110	140
Other		9	22	31
Total (programs)	4	70	360	434
Total (schools)	4	31	231	266

Source: State Education Information System.

Our study covers 266 educational institutions, of which 31 are state gymnasiums, 231 are [other] secondary education schools, and four are vocational secondary education schools[20]. During the school year 2021/2022, these schools provided 434 secondary education programs, including 140 STEM programs and 70 programs implemented in the state gymnasiums (Table A1).

[19] This Appendix describes the supply of programs for students graduating in 2022.

[20] Vocational secondary education schools do not provide STEM programs.

Appendix B. Characteristics and challenges of Latvian education policy

Primary and secondary education in Latvia is provided mainly by public schools (few private schools operate in large cities). Provision of education has to follow national regulations, while municipalities are key actors making decisions on establishing, maintenance or closure of schools (Saeima, 1999).

Intensive school closures began, amidst the financial crisis, in 2009, after the reform of the system of teachers' remuneration21. The reform cut the minimum state-financed teacher's wage per workload by 27.5 percent; in addition, it introduced per capita funding which favours schools with larger classes and larger student – teacher ratio and provides incentives for school consolidation (OECD 2018, p.53). The "money follows student" model is disadvantageous for small schools, especially those with less than 90 students as they receive insufficient financing for teachers' salaries (Eurydice, 2021, p.30; Hazans, 2010, Fig. 18 and 21; OECD, 2014, Table A2.12; Šūpule & Søholt, 2018, p. 2). Attracting qualified teachers in knowledge-intensive STEM disciplines is particularly challenging for small schools (OECD, 2014, p.64). According to survey conducted in the framework of PISA 2015, Latvia was one of just six out of thirty-four countries where the share of qualified science teachers in rural schools is significantly lower than in urban schools (OECD 2018, Annex Table 3.A.3)[22].

During the first post-reform school year, number of public schools declined by 12.6 percent, number of total (teaching and non-teaching) workloads – by 21.5 percent, and total school staff – by 18.8 percent (Hazans 2010, Table 2). Schools closures were driven mainly by cost considerations: closed (or absorbed via merger) schools were of much smaller size than others within the same type of settlement were; moreover, they featured lower student – teacher ratio and higher per-student maintenance cost (Hazans 2010, p.7). Another argument for closing small rural schools repeatedly raised in the debate over the whole period of 2009 – 2023[23] refers to the quality of education: on average, rural schools feature much weaker results, especially in STEM subjects, in the centralised exams (see e.g. Figure 9 in section 2 above) and in international tests[24].

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[21] See Hazans (2010, pp. 4 – 5 and Table 1) for details.

[22] In this context, one has to bear in mind that systems with a narrow rural-urban gap in science performance tend to show better academic performance across the entire system (OECD 2018, p. 124).

[23] See e.g. Granta (2018), Krasnopjorovs (2023), LETA (2019), Zaharova (2020).

[24] Ministry of Education and Science (2023, p. 3-4 and Fig. 2.6) provides evidence of significant urban – rural achievement gap in PISA 2018, TIMSS 2019, and PIRLS 2021.

On the other hand, local governments prevented further closures by redistributing funds from big schools to small ones, from urban to rural schools, from secondary schools to other schools, and form school with high student-teacher ratio (S/T) to the ones with low S/T (Hazans 2010, p.17). Such redistribution became less feasible after a substantial increase in the minimum state-financed teacher's wage per workload (Cabinet of Ministers, 2016) and introduction of certain regulations for class size at the upper secondary level (Cabinet of Ministers, 2018). Consequently, school closures intensified, while the average school size and gross student – teacher ratio began to grow, thus reversing the previous trend (see Figure B1 for secondary schools).

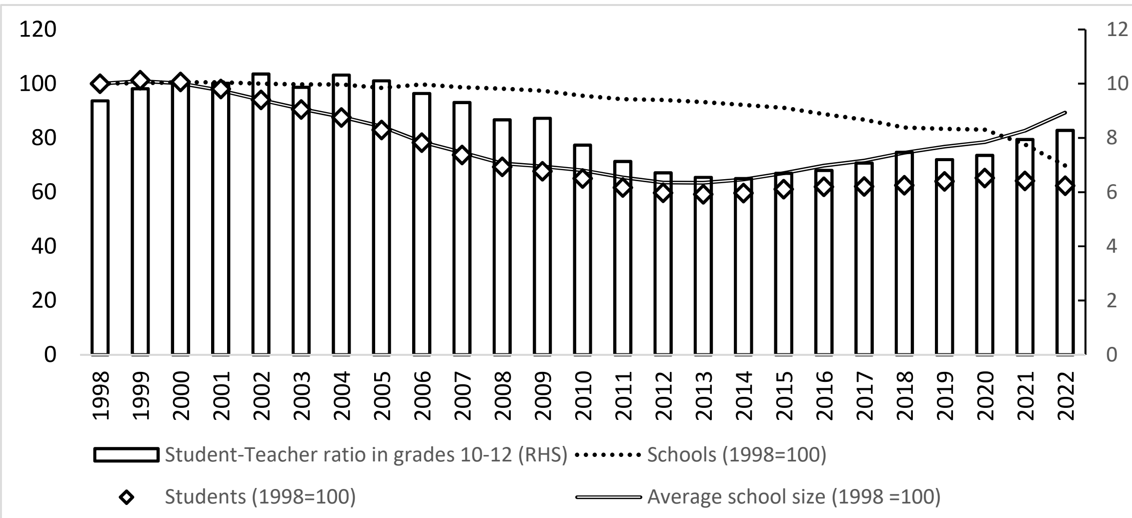


Figure B1. Number of secondary general full-time schools and students therein, 1998 – 2022.

Notes: The data refer to the beginning of school year. Number of students excludes preschool students. *Sources*: Central Statistical Bureau of Latvia, datasets IZG080 and IZG190.

Both average school size and average class size are much smaller in rural areas than in towns and cities (Table B1). Among 27 European OECD member countries, Latvia's urban – rural gap is the third largest in terms of student – teacher ratio and the fifth largest in terms of class size (OECD 2018, Figure 3.5). On one hand, this implies higher per-student costs. On the other, there is evidence from different countries that students educated in smaller schools have better outcomes later in life (Berry & West, 2010) and that smaller school and class sizes are particularly beneficial for students in the early grades and for those with a lower socio-economic background (Chetty et al., 2011; Dynarski et al., 2013).

Table B1. Average class and school size (school year 2022/2023), by degree of urbanisation.

	Cities	Towns and suburbs	Rural areas	Total
		Average class size		
Grades 1 – 6	24	20	13	16
Grades 7 – 9	24	20	14	17
Grades 10 – 12	25	23	16	20
		Average school size		
Elementary schools	396	306	152	212
Primary schools	411	324	120	187
Secondary schools	874	725	416	619
State gymnasiums	902	705	430	617
Total	726	529	230	384

Notes: School size includes preschool students.

Sources: Ministry of Education and Science (2023, Tables 2.3, 2.5).

Two other factors further weakening the position of rural schools is depopulation of rural areas resulting from low birth rate and out-migration (Hazans 2015, 2019) and competition between educational institutions (Šūpule & Søholt, 2018, p. 13). Between 2001 and 2015, youth population (0 to 14 years) in predominantly rural areas declined by 39 percent (OECD 2018, Figure 1.3), while on average in Latvia this decline was 30 percent[25]. In Latvia, parents are free to choose the school they consider most appropriate for their child. While preference is given to pupils who live in the municipality or, in the case of urban areas, in pre-defined school's catchment area, enrolment from other municipalities is also widely accepted. These patterns, have led to school closing and consolidation being more intensive in rural areas (Hazans, 2010, Fig.9; BISS, 2013, p. 6-12).

In 2023, the Ministry of Education and Science came up with a new plan of optimisation of the school network, as well as a new model of financing teacher salaries[26]. The plan includes stricter criteria for the minimal class size, as well as the minimal number of students at each study level (grades 1 – 3, 4 – 6, 7 – 9, and 10 – 12); the criteria vary by degree of urbanisation. Importantly, at the upper secondary level (grades 10 – 12), the state would not finance teacher salaries if these quantitative criteria are not met. In the context of access to schools, the plan

[25] Central Statistical Bureau of Latvia, dataset IRD040.

[26] Ministry of Education and Science (2023, sections 3.1.2 and 3.2). The plan refers to a forthcoming background study *OECD. "Re-organising the school network in Latvia. Modelling costs and accessibility of schools for an evidence-based re-organisation."*

foresees that the access time in one direction (with the transport provided by municipality) should be within 40 minutes for grades 1 to 6 and within 55 – 60 minutes for grades 7 to 12. Moreover, for grades 7 to 12, the distance between schools should not exceed 50 km. These criteria are largely in line with the plan proposed by Turlajs (2017) to concentrate educational establishments in regional development centres while ensuring access within one hour. The plan is still under discussion with social partners, and there are indications[27] of a new targeted investment fund being added to the plan, similarly as it was done in Estonia, see OECD (2018, p.54).

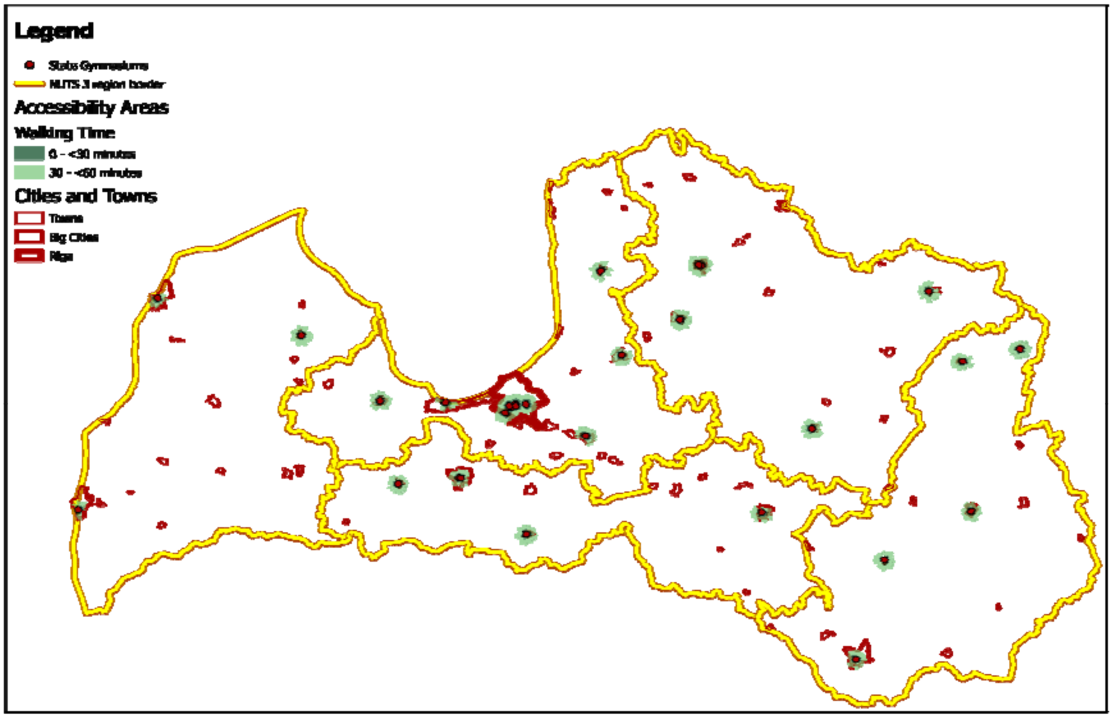
Although the government is focusing on promoting the attractiveness of vocational training (see Cabinet of Ministers, 2021), overall general education in Latvia remains popular – about 59 percent of basic school graduates pursued their education in general secondary schools in 2019 and 2020 (Central Statistical Bureau, dataset IZG180). However, only 62 percent of general secondary school graduates continue their studies at higher level (ibid.), disproportionally more frequently in social sciences and humanities (see Figure 2 in section 2.1). Low performance in STEM disciplines in schools is referred to as the key factor explaining insufficient demand for tertiary education in STEM fields, leading to shortage of STEM professionals in Latvia's labour market (LETA 2021; LDDK 2022; Zvaigzne & Znotiņa, 2022), aggravated by disproportionally high emigration rates among such professionals (Hazans, 2018, pp. 30-32).

[27] LETA (2024).

Appendix C. Some Key Characteristics of the Norwegian School System

The Norwegian policies regarding primary and lower secondary education are focused on not encouraging a quality gap between schools. Instead, the system seeks to provide the same quality of education for everyone, thereby helping the ones falling behind (e.g., with special teaching resources) and ensuring a good school environment (e.g., with emphasis on after-school care). Most primary and secondary schools are public, although some private schools exist in urban areas and exceptionally in rural areas without public school. Private schools in Norwegian primary and lower secondary education schools are required to have an alternative teaching arrangements and philosophy to be allowed. Yet, there are some private schools supplying upper secondary education, but these do not stand out with particularly strict admission requirements compared to the public schools. (See OECD 2020 and Utdanningsdirektoratet 2020 for more background on the Norwegian education system.)

Appendix D. Maps



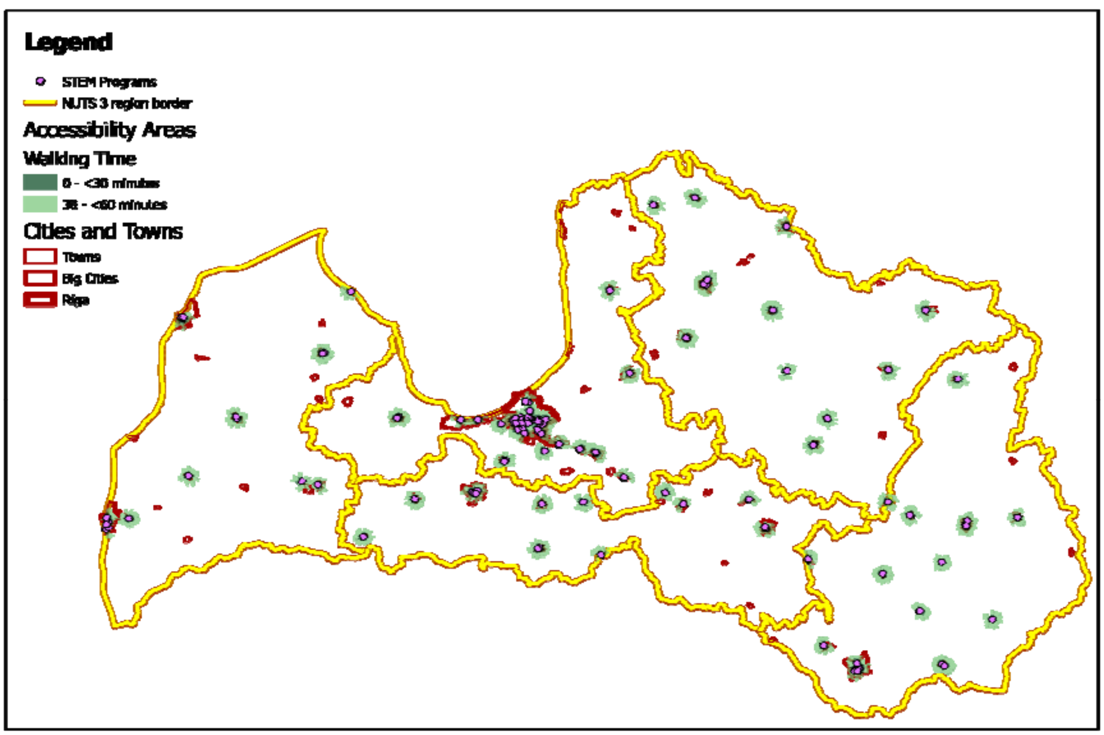


Figure D1. Accessibility of state gymnasiums (top panel) and STEM programs (bottom panel) by walking time. Latvia, end of 2021.

Sources: Calculation using *ArcGIS Pro 2.9 Network Analyst* tool "Service Area" and State Education Information System data.

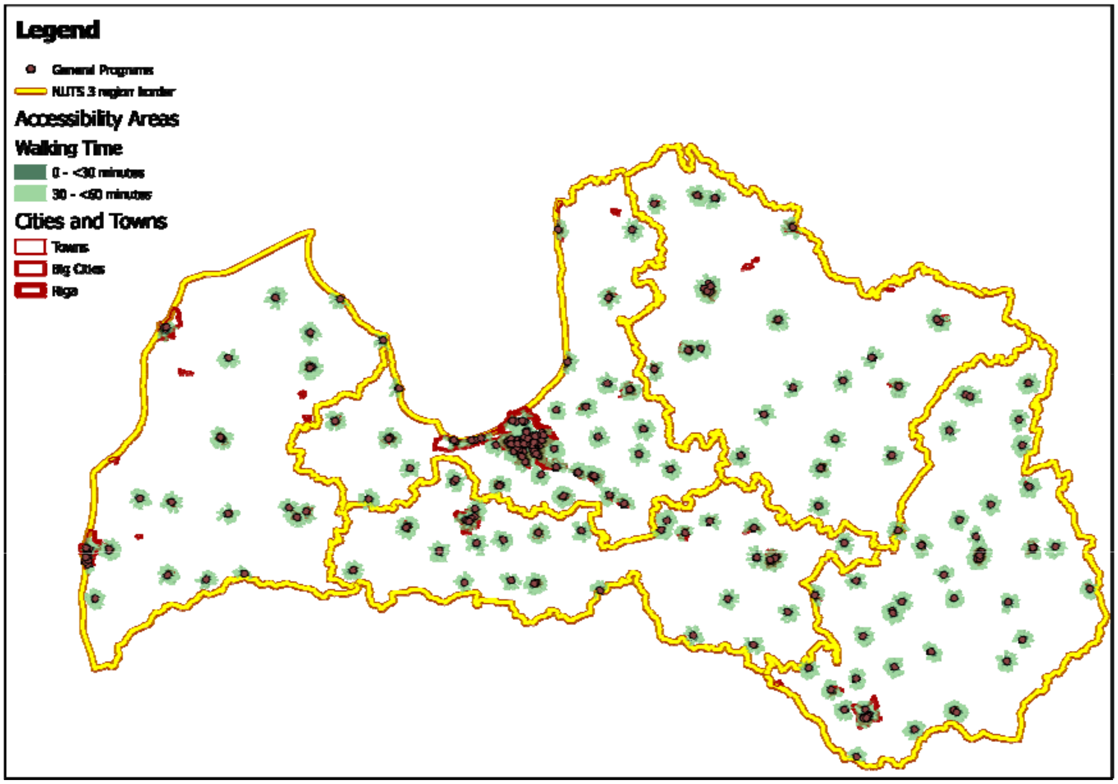


Figure D2. Accessibility of general secondary education programs by walking time. Latvia, end of 2021.

Sources: Calculation using *ArcGIS Pro 2.9 Network Analyst* tool "Service Area" and State Education Information System data

Appendix E. Additional tables

Table E1. Average and median monthly earnings vs secondary education walking access time, by program type. Latvia, 2021.

	Dependent variable: Average gross monthly earnings, log							
	Average gross monthly earnings, log				Median gross monthly earnings, log			
	Program type				Program type			
	Gymn.	STEM	General	All	Gymn.	STEM	General	All
Time/10	-0.007*	-0.001	0.005*	-0.001	-0.005	-0.006[*]	-0.004*	-0.005***
(minutes)	*0.003*	*0.005*	*0.002*	*0.002*	*0.003*	*0.003*	*0.001*	*0.001*
Program (vs. General)								
STEM				0.003				0.004
				0.005				*0.004*
Gymnasium				0.019*				0.019***
				0.007				*0.005*
_cons	7.010***	6.976***	6.966***	6.992***	6.710***	6.698***	6.691***	6.711***
	0.009	*0.005*	*0.004*	*0.007*	*0.007*	*0.004*	*0.004*	*0.005*
N	12	12	12	36	12	12	12	36
R2	0.365	0.002	0.305	0.166	0.193	0.300	0.330	0.349

Notes. The table reports regression coefficients with robust standard errors (in *Italic*). Observations correspond to walking accessibility areas (AAs) with access time 0-5, 5-10, …, 55-60 minutes, weighted by the number of residents aged 15 to 18. Each AA has at least 690 residents aged 15-18 and at least 7000 employees. Earnings are total earnings from all jobs. The independent variable (Time) is the average walking access time for the given AA and program type (e.g., 2.5 minutes for the 0-5 minutes AA, 7.5 minutes for the 5-10 minutes AA, etc.). Legend: (*) $p < 0.10$; * $p<0.05$; ** $p<0.01$; *** $p<0.001$. *Sources*. Calculation with State Education Information System, State Revenue Service data and experimental population statistics.

Table E2. Estimated urban-rural gap in socio-economic status.
Baltic and Nordic countries, 2017 – 2020.

	Dependent variable: European socio-economic group (1 - highest, …, 9 - lowest)						
	EE	LV	LT	DK	SE	FI	NO
	A. Without education level controls						
Type of settlement (vs. Towns and suburbs)							
Cities	-0.539***	-0.170**	-.0602***	-0.246***	-0.263***	-0.390***	-0.247***
	0.029	*0.058*	*0.024*	*0.015*	*0.010*	*0.027*	*0.032*
Rural	0.180***	0.442***	0.336***	0.270***	0.240***	0.166***	0.253***
	0.029	*0.048*	*0.024*	*0.014*	*0.010*	*0.027*	*0.027*
Other controls	Sex, age and age-squared, age at immigration (zero for natives), region, year fixed effects.						
N	68494	20677	140732	221662	450336	54595	60426
R2	0.0624	0.0609	0.1084	0.1213	0.1428	0.1111	0.1005
	B. With education level controls						
Type of settlement (vs. Towns and suburbs)							
Cities	-0.182***	0.051	-0.142***	0.064***	-0.027**	-0.161***	-0.018
	0.027	*0.049*	*0.021*	*0.013*	*0.009*	*0.024*	*0.029*
Rural	0.075**	0.179***	0.124***	0.103**	0.102***	0.002	0.097**
	0.026	*0.042*	*0.021*	*0.012*	*0.009*	*0.024*	*0.024*
Other controls	Sex, education level (three categories), age and age-squared, age at immigration (zero for natives), region, year fixed effects.						
N	68494	20677	140732	221662	450336	54595	60426
R2	0.2383	0.3147	0.3735	0.3348	0.3052	0.3012	0.289

Notes: Robust standard errors in italic. Legend: * p<0.05; ** p<0.01; *** p<0.001.
Sources: Calculation with EU Labour Force Survey microdata (2017 to 2020).