**Reassessing Urban-Rural Education Disparities: Evidence from England**

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# Reassessing Urban-Rural Education Disparities: Evidence from England

Rural-urban disparities in education in developed countries have received limited attention in recent years, and whether rural schools face additional disadvantages is controversial. There is some evidence that underlying inequalities appear to be overlooked. This study examines the differences between urban and rural education in England using data from the 2019 Trends in International Mathematics and Science Study (TIMSS) for eighth-grade students, involving a sample of 3,365 pupils across 136 schools. Employing descriptive statistics and multiple linear regression, the research delves into the complexities often overlooked in rural education within developed countries. Findings indicate the existence of hidden inequalities, particularly evident in the educational resources and sustainability of teaching teams of rural schools in England. Moreover, the study challenges previous assertions suggesting the disappearance of educational attainment gaps between urban and rural areas, revealing a negative association between attending rural schools and academic achievement in England, notably in mathematics. Despite modest explanatory power, this correlation remains after controlling for contextual variables, underscoring the additional barriers faced by disadvantaged students in rural settings. The implications of these findings necessitate renewed attention to rural education at research, policy, and practice levels, advocating for enhanced resources, sustainable teaching teams, and policy support.

Keywords: Rural Urban Differences; Rural Education; Achievement Gap; TIMSS

## Introduction

As global urbanisation advances, growing socio-economic inequality between and within countries and regions has become a major challenge in the twenty-first century (Winthrop, 2018). Over the past two decades, developing countries have been able to increase enrolment in primary and secondary education, but many students are still not learning (Klees et al., 2019). Within countries, some children learn more than others and geography seems to widen the learning gap (Banerjee & Duflo, 2011). When gaps caused by geographic factors are found, the results tend to be that urban students perform better academically than their rural peers (Curtis et al., 2017). Studies in developing countries have been more consistent in this conclusion.

Such cases have been rare in developed countries in recent years. Echazarra and Radinger (2019) have argued that differences in academic performance may not be as pronounced in economically developed countries. This has been confirmed by many studies, which indicate that in many of the OECD countries there are no academic differences between rural and urban students. In some cases, such as in the United States and the United Kingdom, students in rural schools have even outperformed their urban peers. Rural schools in developed contexts may benefit from smaller class sizes, closer-knit communities, and more students from relatively advantaged backgrounds, all of which could contribute to improved educational outcomes (Cherry, 2021; Echazarra & Radinger, 2019).

Despite these positive findings, some studies continue to identify challenges that may place rural schools at a disadvantage position. Rural schools are more likely to lack technical educational resources (Farrington et al., 2015). There is also the risk of not being able to retain qualified teachers because of the environment and transport (Ovenden-Hope & Passy, 2015). Effective collaboration and resource sharing between schools in rural areas is limited due to geographic isolation and dispersed populations (Muijs, 2015). Competition and cooperation between schools could have a positive effect on students' academic performance, but students in rural areas do not have access to the same resources and opportunities as their peers in urban areas. The existence of these issues indicates that the circumstances of rural schools may be underestimated. In addition, some evidence reveals possible hidden disadvantages of rural students in developed countries (Davies et al., 2021; Midouhas & Flouri, 2015). However, such evidence is relatively limited.

These conflicting findings reflect an important gap in the literature. The differences may partly stem from variations in data sources, analytical methods, and socio-economic contexts, which can influence how rural-urban disparities are measured and interpreted. As a result, it remains unclear whether rural schools and students in developed countries, such as England, continue to face educational disadvantages.

Therefore, it is meaningful to understand the characteristics of rural pupils in developed countries and to re-explore the issue of urban-rural differences using more recent large-scale data. Based on the Trends in International Mathematics and Science Study (TIMSS) 2019 Grade 8 data from England, this study aims to answer the following research questions:

- Are there any notable disadvantages in the characteristics of rural students and schools in England?
- Is there a correlation between school geography and student achievement in England, after controlling for known factors in the dataset?

Understanding rural-urban disparities in education requires examining both student and school-level characteristics and academic outcomes. By identifying structural and contextual disadvantages in rural schools, the first research question aims to highlight potential educational inequalities that may limit opportunities for rural students. Meanwhile, the second research question focuses on academic achievement itself, seeking to determine whether geographic location has an independent association with student performance. This dual focus allows the study to provide a more comprehensive assessment of urban-rural educational disparities in England.

***Existing evidence on urban-rural Education Gap***

Research on the urban-rural education gap highlights that disparities in educational opportunities and outcomes persist in many contexts, though the extent and primary causes of these differences vary between developing and developed countries. Much of the evidence in the last decade has come from studies in developing countries, which highlights that rural students face substantial educational disadvantages. For example, studies using large-scale datasets from longitudinal surveys confirm the existence of severe achievement gaps in both Peru and India. Castro and Rolleston (2015) use three waves of data between 2002-2009 from the Peruvian dataset of the Young Lives study and verify the existence of a serious urban-rural education gap in Peru. Young Lives is a longitudinal database that is weighted towards tracking the underprivileged, and rural areas are more represented in the data. The results of the study show that there is a large achievement gap between urban and rural Peruvian children aged 5-8 years in the sample, as measured by the Picture Vocabulary Test. Their analysis demonstrated that the influence of the school plays a crucial role (35 to 40 per cent) in this gap, in addition to differences in the children's early environments, which exist before entering school. Also, the disadvantaged characteristics of rural schools are directly related to policy, considering that rural education in Peru is almost publicly provided. Agrawal (2014) analysed the data from household surveys conducted by the National Sample Survey Organisation (NSSO) of India for the period 1993-2009. The results show that based on the education Gini index, the level of educational inequality in India was more than fifty per cent in 2009. Rural-urban inequality remains a large proportion of overall inequality in India, despite the fact that the gap between rural and urban education has been declining gradually. And there is a tendency towards greater inequality within the countryside.

China represents a key case where research on rural-urban education disparities remains ongoing. Zhang et al. (2015) combined data from two large-scale surveys in China, the China Family Panel Survey (CFPS) data in 2010 and the Rural-Urban Migration in China (RUMiC) data in 2009, to study the urban-rural education gap in China. These are two large-scale longitudinal surveys, and the CFPS has the advantage of having standardised mathematical and literacy tests with a nationally representative sample. RUMiC better represents the rural-urban migrant population, but only has self-reported final test scores. Together, the results of the two databases confirm the existence of an urban-rural education gap in China, which remains noticeable after controlling for a range of potential influential factors. More recent data provide useful insight to support their study. Song and Tan (2022), combined data from all five waves of the CFPS tracking from 2010 to 2018 and analysed a sample of 3,043 eligible students. Results from logistic regressions suggest that urban students in China are more likely to enrol in higher education, although this is not associated with enrolment in elite universities.

Other studies adopt alternative approaches, such as direct assessment and parental surveys, to confirm these patterns. Siddiqui et al. (2023), for example, assessed the learning of 1,023 children aged 4-8 years in two provinces of India and Pakistan and surveyed 873 parents. After constructing a linear model to predict children's academic achievement, they found that urban-rural differences contributed as one of the important predictor variables. These findings from developing countries collectively emphasise that rural educational challenges in developing contexts are multi-faceted, and linked with both structural inequalities and local conditions.

In contrast to developing countries, recent research in developed contexts has been relatively limited, with conflicting findings on the extent of rural educational disadvantage. The idea that there is no disparity between urban and rural education is supported by some studies. Analyses based on the Programme for International Student Assessment (PISA) 2015 and the Teaching and Learning International Survey (TALIS) 2013 show that in all OECD countries, once socio-economic status (SES) is taken into account, the gap between urban and rural pupils is almost non-existent (Echazarra & Radinger, 2019). Many studies believe that the main reason why rural students lag behind their urban peers in academic performance is because of their relatively less privileged family background, and has little to do with geographical factors (Byun et al., 2012; Reeves, 2012; Roscigno & Crowle, 2001).

England is often included in these studies that conclude rural-urban disparities are negligible, for example, Echazarra and Radinger (2019) believed rural students in England outperform their peers. However, some evidence makes a different claim. Graham (2024) analysed several national databases from England, arguing that rural disadvantage is hidden by the mean, particularly those in the most extreme percentile ranges. Although this study highlights inequalities among socio-economically disadvantaged rural students, it does not assess to what extent geographic location itself is linked to academic performance. Furthermore, Davie et al. (2021) analysed administrative data from the UK over a 10-year period by using multilevel modelling and the Geographic Information System method. Their results highlight the important association between geographic location and access to elite universities. Whilst rural areas exhibit higher rates of progression to elite universities at the overall level, disadvantaged groups in rural areas are less likely to attend elite universities than those in urban areas at the individual level. Analysis using data from the UK's

Millennium Cohort Study has also demonstrated that there is an urban-rural gap in cognitive ability at the primary school level that remains unexplained after controlling for observable variables (Midouhas & Flouri, 2015). The findings of these studies suggest that, at least in England, the urban-rural education gap does not appear to be a topic that can be ignored.

Although these studies in England provide valuable insights, most focus on educational outcomes other than academic achievement, such as university access and early cognitive development. Academic achievement, however, is crucial for understanding rural-urban disparities, as it captures both current educational opportunities and future prospects.

### *The Current Tendency of Disclaiming the Urban-Rural Distinction*

During the review of the literature, we found that there has been a gradual decline in the study of the rural-urban gap in the field of education, especially in developed countries. Rural areas are increasingly less studied as a distinct setting or sector in educational research, defined by Thier et al. (2021) as “research deserts”. From Biddle and Azano's (2016) review of rural education research in the United States over the last century, it was found that scholars and institutions in the United States were much less interested in rural education as early as the mid to late 20th century. Even though complex changes in the economic situation led to a resurgence of interest in rural education research at the end of the 20th century and the beginning of the 21st century, research is still restricted to a small number of journals of specific types. Moreover, the belief once present that rural areas were a distinct educational context "is clearly no longer in evidence". Rural areas, as an educational sector, are widely recognised as not being distinguished. According to Bæck (2016), education research tends to ignore the difference between rural and urban schools, which is evident in both Europe and North America. Most empirical studies on rural areas, while involving rural education, do not treat rural education as an issue to be explored in depth, but only as a variable to be controlled for. Policies and practitioners have also paid much less attention to this group, even though rural students and schools are a very important part of the education system in most countries (Lavalley, 2018).

While rural education issues common to developing countries, such as higher dropout rates among rural girls in Pakistan (Siddiqui & Gorard, 2017), have rarely been observed in developed countries, some common challenges remain prevalent. These include teacher shortages, inadequate financial support, student segregation, and associated consequences. Logan and Burdick-Will (2017) analysed all public schools in the US using data from the National Centre for Education Statistics (NCES) 2010-2011 and found that rural schools may have higher rates of ethnic segregation. Poverty and lower test scores, like those typically focused on disadvantaged schools in large cities and suburbs, were also found to be problematic in rural public schools. School choice systems designed for densely populated areas cause distress in rural settings, where parents have to pay extra to send their children to more distant schools, which in turn adds additional pressure on families suffering from poverty (Beach et al., 2019; Lavalley, 2018). Meanwhile, The poor transport network creates "isolation" in rural schools, and limited access to transport creates multiple difficulties in recruiting highly qualified labour, getting staff to work and students attending school. (Ovenden-Hope & Passy, 2019). Ongoing issues of population loss and lower population densities make teacher recruitment more difficult. Rural schools need to find ways to allocate limited resources to deal with complex difficulties, while risking greater budget cuts (Lavalley, 2018).

In the Nordic region, many districts have closed small schools with low enrolment, mostly in rural areas, for cost-cutting purposes (Lehtonen, 2021). Critics argue that such decentralisation and neoliberal market-based reforms have exacerbated inequality, and that the effects of this inequality are uneven between urban and rural areas (Bæck, 2016). Empirical evidence also shows a clear link between school closures and local population loss. In rural areas with sparse school networks, the implementation of such policies has a clear impact on children's accessibility to schools and the financial burden on families (Lehtonen, 2021). The small size of schools is usually one of the main characteristics of rural education (OECD, 2016a, 2016b). The relationship between school size and educational outcomes has been a long-debated topic in research and policy (OECD, 2016a). Some scholars have argued that small school sizes are beneficial for educational outcomes, as teachers being responsible for fewer students improves the quality of their teaching (Solheim and Opheim, 2018). In this context, teachers in more urbanised schools tend to be less supportive than those in rural schools (OECD, 2016a). In addition to this, the small size allows for stronger relationships between the school, parents and local religious institutions, meaning that such rural schools are often perceived to have higher social capital and resources (Israel et al, 2001). Higher social capital and resources often predict better academic performance.

However, some researchers have argued that small school size is detrimental to school management (Bagley & Hillyard, 2019). Because of their small size, teachers are fewer in number and therefore have to face the situation of "everyone wearing 27 hats" (Bagley & Hillyard, 2019). Some teachers may even have to teach subjects for which they have no specialised training, which has a negative impact on students' academic performance (Barter, 2008). Meanwhile, the probability of providing shadow education is also higher in urban than in rural areas (Bray & Lykins, 2012). This is partly due to the business choices made by institutions offering shadow education, it is more likely to profit from opening an institution in an area with a higher population density. Another aspect is due to the size of the school, which is usually larger in urban schools than in rural areas, and the perception by some parents that larger schools will cause a lack of individual attention for their children, so they will send their children to additional shadow education after school (Bray & Lykins, 2012).

These complex factors, many of which are unique to rural schools, suggest that the challenges faced by rural education should not be underestimated. Moreover, evidence also suggests that rural-urban differences are not necessarily non-existent, as some studies have claimed (e.g. Davies et al., 2021; Graham, 2024). Therefore, the issue of educational gaps between rural and urban areas should be considered more carefully. Arbitrarily assuming that rural areas are not an educational setting with unique differences and characteristics may be biased.

## Method

The research gaps described above imply the necessity for updated and more powerful analyses of whether there are urban-rural differences in student achievement. This study uses data from TIMSS 2019 to analyse the mathematics and science achievement of urban and rural students. It explores the differences in educational resources and outcomes between urban and rural areas and attempts to find out whether urban-rural differences in student achievement are still notable after controlling for other variables.

### *Dataset*

The dataset used in this study is TIMSS 2019. TIMSS is conducted every four years and provides nationally representative data through a stratified two-stage sampling method, which ensures a balanced representation of both school and student populations across different regions (Department for Education, 2020). The dataset contains detailed school-level and student-level variables, making it suitable for examining rural-urban disparities. Unlike many other datasets, it captures key educational challenges like instructional hours, resource shortages, and teacher experience, all of which are critical to understanding geographic inequalities in education.

TIMSS was conducted for Grade 4 and Grade 8 students, corresponding to Year 5 and Year 9 in England. This study focuses on Grade 8 students as it represents a critical stage in educational development, where foundational knowledge in mathematics and science has been established. This also focus aligns with most previous studies that have examined rural-urban academic disparities at or beyond the secondary level.

A total of 3,365 pupils from 136 schools in England participated in TIMSS in 2019, of which 24 schools were from urban areas, 17 schools were from suburban areas, 22 schools were from medium-size cities or large towns, 29 schools were from small towns or villages, one school was from remote rural areas. 43 schools did not respond to the school-level questionnaire.

### ***Variables***

[Table 1 insert here]

Table 1 shows the summary of variables used in this study. Among them, seven variables were used to describe student and school characteristics:

Total Instructional Hours per Year: This variable represents the number of hours of formal school teaching and learning that students receive annually. According to the TIMSS 2019 framework, instructional hours cover both core curriculum subjects and additional teaching time that supports student development. Research indicates that greater instructional time is often positively correlated with academic performance, particularly in mathematics and science (Hanushek & Woessmann, 2017).

School Discipline Problems: This variable measures the extent of school discipline issues, including both behavioural problems and disruptions that affect the learning environment. TIMSS defines discipline problems through school reports on factors such as respect between students and teachers, classroom order, and school safety. A positive school climate, characterised by low discipline issues, could potentially be linked to higher student engagement and academic outcomes (Hooper et al., 2015; Konishi et al., 2010).

Instruction Affected by Mathematics/Science Resource Shortages: This variable captures the availability and adequacy of resources essential for mathematics and science instruction, including infrastructure and instructional materials. In TIMSS 2019, resource shortages are defined through responses on items such as the condition of school buildings, the availability of technological equipment (e.g., computers, tablets, and electronic whiteboards), and access to learning materials. Studies have demonstrated that resource availability can significantly influence both the teaching process and student achievement (Hanushek & Woessmann, 2017).

Teacher's Years of Teaching Experience: This variable records the total number of years teachers have been teaching mathematics and science. TIMSS 2019 uses teacher self-reports to gather this information. This variable could reflect the sustainability of the school's teaching team: higher average teaching experience may imply more experienced teachers, but it may also indicate that fewer new teachers have joined the school.

Home Educational Resources: This variable reflects the availability of educational resources in students’ homes, including books, internet access, and participation in preschool education. TIMSS 2019 defines home resources through student questionnaire items that ask about access to educational materials and technology. Home educational resources are frequently used as an indicator of family SES and have been shown to correlate with academic performance (Caponera & Losito, 2016; Wiberg & Rolfsman, 2019).

Highest Level of Parental Education: This variable indicates the highest educational qualification attained by students’ parents, as reported by the parents. In TIMSS, parental education is categorised into levels from “did not go to school” to “postgraduate degree”. In this study, these categories were consolidated into three broader groups- unknown, under secondary and secondary and above. The decision to merge categories was made to simplify the analysis while maintaining sufficient variation between groups. Additionally, this categorisation allows for more stable statistical estimates, particularly given the limited sample size for higher educational levels in rural and urban subgroups. This variable was also used as an indicator of family SES.

Participation in Maths/Science Extra Lessons: This variable tracks whether students participate in extra mathematics or science lessons outside of regular school hours, as reported in the TIMSS student questionnaire. These additional lessons can provide supplementary academic support but may also contribute to academic stress. Research shows that the effectiveness of extra lessons varies based on factors such as lesson quality and student motivation (Bray & Lykins, 2012).

All these variables have been widely used in previous studies on student achievement and educational contexts based on TIMSS data (e.g. Caponera & Losito, 2016; Lee & Stankov, 2018; Wiberg & Rolfsman, 2019).

Besides, new indicators were created. To analyse urban-rural disparities, schools were grouped into two categories. Schools located in densely populated urban areas, suburban areas, and medium-sized cities or large towns were combined into the urban group. Schools in small towns, villages, and remote rural areas were classified as the rural group. This categorisation simplifies the analysis by creating a clear urban-rural distinction, aligning with previous research (e.g. Webster & Fisher, 2000). This grouping also addresses potential sample size limitations in subgroups, such as remote rural.

The dependent variables of the regression models were students' achievement in maths and science. This was obtained using the “plausible values” provided by TIMSS 2019. For Grade 8 students in TIMSS 2019, mathematics and science achievement were measured through selected-response and constructed-response items. The assessment covered algebra, geometry, and data and probability in mathematics, and biology, chemistry, physics, and earth science in science. It also assessed three cognitive domains: knowing, applying, and reasoning, which reflect recall of facts, application of knowledge, and higher-order thinking (Cotter et al., 2019; Department for Education, 2020). TIMSS mathematics and science scores are reliable proxies for academic achievement, with studies showing moderate to strong correlations with national test results in these subjects (Wiberg, 2019; Wiberg & Rolfsman, 2019). Similar large-scale international tests, such as PISA, have demonstrated strong correlations between mathematics, science, and reading performance, suggesting that mathematics and science scores could reflect overall academic ability to some extent (Lee & Stankov, 2018).

### *Handling Missing Data*

England has a certain level of missing data in TIMSS 2019. This study follows the recommendations of Gorard (2020) and Gorard et al. (2022), where missing data are treated with caution to maximise information retention. As mentioned earlier, 43 schools in England did not respond to the school-level questionnaire, which resulted in 883 cases with missing values on relevant variables, including the geographical location of the school.

When data were missing on one or more key variables, a new category was added to indicate 'missing'. Therefore, in the descriptive analysis, all cases were divided into three groups: urban, rural and missing. The analysis starts from these three groups to explore the differences in educational resources and students' family backgrounds between urban and rural areas. Missing values of real number variables were explained and replaced by the mean in the model.

There were also considerable missing values for some of the categorical variables, particularly for highest parental education. In England, 1,482 cases reported not knowing the highest level of parental education, in addition to 216 cases missing. This may be attributed to the fact that the question on parents' highest level of education was asked in the student questionnaire, therefore many students were unaware of this information. This is labelled as the unknown group in the descriptive statistics.

***Analysis***

The descriptive analysis mainly uses effect size and odds ratio to evaluate the data, these are more intuitive ways of testing for between-group differences that do not require high-risk assumptions (Gorard, 2006, 2014). Effect size is used to measure the extent of differences between the three groups (Siddiqui & Shaukat, 2021). The odds ratios are calculated on each occasion between groups, to observe the proportion of each group involved in a certain situation (Bland & Altman, 2000). Specifically, for the real variables, we calculate the difference between the means of the two groups (in this study rural group versus urban/missing group) and divide by the total standard deviation. For categorical variables, we divide the odds of an event occurring in the exposed group (rural group) by the odds of the event occurring in the non-exposed group (urban/missing group).

Furthermore, two OLS multiple regression models were constructed in this study to predict the maths and science achievement of English students, respectively. The structure of the models is basically the same and is divided into two steps. The first step of the regression model incorporates sex, home educational resources, parental education, and participation in extra lessons. These variables control for differences in student characteristics, SES, and out-of-school learning opportunities. Controlling for these factors helps isolate the effect of school geography on academic achievement by accounting for variations that might otherwise confound the results. Among them, categorical variables were converted into dummy variables before entering the model. The second step includes a dummy variable on behalf of urban/rural to explore whether school geography is still associated with achievement. Stepwise forward entry was used to exclude variables that were not adding explanation and did not increase the predictive model accuracy (R-Square). For each model, standardised coefficients are presented to show the extent of association between the outcome variable (scores) and predictors introduced in the model. The school-level variables were not included in any of the models, as this is likely to be a result of differences between urban and rural schools.

We tested for multicollinearity, especially between **home educational resources** and **parental education.** The variance inflation factors (VIF) were slightly above 1, and tolerance values were close to 1, indicating low multicollinearity. These values confirm that the regression results are not affected by strong correlations between variables.

The results obtained from the regression analyses are likely to be affected by the large number of missing cases in England in the school location variable. In order to verify the reliability of the results of the regression analysis, four separate models were constructed as an additional sensitivity analysis. We assumed the following two situations: all missing cases are located in rural schools & all missing cases are located in urban schools. Based on these two assumptions, we replaced missing cases and constructed regression models again.

## Findings

### *Descriptive Analysis*

The descriptive analysis explained the differences between urban and rural students' academic performance, the distribution of school resources between urban and rural areas, the diversity of urban and rural students' family backgrounds, the differences in students' participation in extra lessons, and the differences between urban and rural parents' highest educational qualifications.

[Table 2 insert here]

Table 2 shows that there are some differences in the performance of rural and urban students. In England, the results of the urban students are higher compared to their rural peers. The differences between the two groups are more obvious in maths. Meanwhile, the English missing group is weaker in maths and science than the rural group.

[Table 3 insert here]

Table 3 presents a summary analysis of the key school-level factors, where effect size represents the difference between urban and rural areas. It can be seen that urban schools have far more total instructional hours than rural schools. In the variable School Discipline Problems, higher scores indicate better school discipline, in which the urban-rural gap is not large. The higher the value of the Instruction Affected by Mathematics or Science Resource Shortages variable, the less it is affected by resource shortages. In England, urban schools are much less affected than rural schools in both mathematics and science. This means that urban schools are still better resourced than rural schools.

[Table 4 insert here]

Table 4 shows that students in rural areas of England have more home educational resources than those in urban areas, which reflects that more students in rural areas of England may come from more wealthy families than those in urban areas. When comparing the rural group with the missing group, the effect size is -0.24. This means that students in the missing group have much lower home educational resources than those in the rural group, and also lower than those in the urban group, who may have a less privileged background.

[Table 5 insert here]

Table 5 shows that after-school tutoring is more prevalent in urban England, with urban pupils 1.72 times more likely to attend after-school tutoring in maths and 1.78 times more likely to attend it in science than their rural peers. This may be due to the fact that the city has more established after-school tutoring organisations. It is also possible that because schools are generally larger in urban areas than in rural areas, some parents believe that this leads to a lack of attention for their children, so they choose to enrol their children in extracurricular tutoring. The missing group also has a much higher participation rate in after-school tutoring than the rural group.

[Table 6 insert here]

Table 6 shows that, except for unreported cases (unknown), the highest level of education of urban parents is generally higher than that of rural parents. Compared to rural parents, parents in the missing group have a higher overall educational level.

[Table 7 insert here]

Table 7 shows the years of working experience of teachers. Teachers in the rural areas of England are generally more experienced than those in the urban areas. However, this could also reflect that fewer young teachers in England work in rural areas. The missing group has the longest duration of experience.

In summary, urban students generally outperform their rural peers, particularly in maths, and benefit from better-resourced schools with more instructional hours. Also, after-school tutoring is far more prevalent in urban areas. Urban parents also tend to have higher educational qualifications. However, rural students tend to come from wealthier families with more home educational resources. Interestingly, rural teachers are more experienced than their urban counterparts, reflecting different workforce demographics.

*Linear Regression Models Predicting Performance in Math and Science*

Results from regression models show that studying in a rural school is negatively correlated with both Math and Science scores.

[Table 8 insert here]

Table 8 shows the results of the model used to predict maths scores. It shows that family background, represented by home educational resources and parental education, provides the strongest prediction of maths attainment. Also, boys are more likely to achieve higher grades in maths than girls. After-school tutoring is negatively associated with children's maths achievement.

Most importantly, the model clearly shows that geographic location is still associated with maths performance. Even after controlling for background and inter-school factors, the location of the school in a rural area still explains 0.7 per cent of the maths score. The coefficient shows that students in rural schools are more likely to have lower maths scores.

[Table 9 insert here]

Table 9 shows the results of the regression model predicting science scores, which uses the same variables as the above model. It can be seen from the model that family background still has the greatest contribution to the model. Similarly, after-school tutoring is still negatively related to students' science achievement. Boys are more likely to achieve higher science scores. After controlling for all background variables, studying in a rural school still correlates with student achievement in science. The R square change remains small, indicating that the strength of the residual correlation is weak.

*Sensitivity Test*

Finally, as described in the analysis, we conducted an additional sensitivity analysis. We attempted twice to replace missing-case school locations with either rural or urban locations, and in the models with the replacements, being located in a rural school still caused meaningful R-square changes (See Appendix). This suggests that the results of the maths attainment model for England should not be attributed to missing cases.

## Discussion

There are certain limitations in this study that should be acknowledged before interpreting the findings. The cross-sectional data used do not provide causal evidence, but rather correlations within the data. Additionally, the limitations inherent in the TIMSS dataset restrict our ability to identify hidden factors related to student achievement. Specifically, the lack of detailed geographic characteristics limits the exploration of nuanced rural-urban patterns. Also, the inclusion of schools from "small towns" in the rural category may introduce biases due to the socio-economic diversity within these areas. While TIMSS employs stratified sampling to achieve a nationally representative sample, missing data may compromise this representativeness. Time and resource constraints also prevented the use of a national sample for further validation; future research might benefit from utilising comprehensive national datasets such as the National Pupil Database.

Despite these limitations, the findings indicate a negative correlation between rural school attendance and lower academic achievement, particularly in mathematics.

Although the differences observed could also result from omitted variable bias, measurement error, or other unobserved factors, these associations endure even after controlling for known factors. This underscores the need for further investigation into the additional challenges faced by disadvantaged rural students, which remain underexplored in existing research.

In recent years, there seems to be an underestimation of the complexity of rural education in developed countries, with the belief that villages are less likely to be affected by social problems such as poverty, ethnicity, and so on (Fargas-Malet & Bagley, 2022; Hargreaves, 2009; Midouhas & Flouri, 2015; Muijs, 2015). Such deeply held perceptions cover up hidden inequalities, and the findings of this study demonstrate that such inequalities do exist. This study found clear differences between rural and urban schools in England, many of which should be seen as manifestations of inequality and have been identified and emphasized in previous studies. Rural schools in England were more likely to report being struggling with educational resources in the teaching and learning process. Calls for a lack of resources in rural schools have long existed but do not appear to have received sufficient attention (Muijs, 2015). Meanwhile, teachers in rural schools in England are on average staying in their jobs longer, meaning fewer young teachers are present. A sustainable teaching force is an important factor in ensuring the quality of teaching and learning activities in schools (Tran et al., 2020). Case studies of rural schools, especially those in remote areas with poor transport links, often observe difficulties in recruiting qualified staff due to geographical factors (Ovenden-Hope & Passy, 2019; Webb et al., 2004).

Furthermore, some studies believe that differences in educational attainment between urban and rural areas in most developed countries essentially disappear after controlling key factors (Byun et al., 2012; Reeves, 2012; Roscigno & Crowle, 2001), and even report that rural students in England outperform urban students (Echazarra & Radinger, 2019). This is inconsistent with the findings of this study. At least in England, studying in a rural school is negatively associated with student's test scores, mainly in mathematics. These results align with some other existing evidence, which suggests that disadvantages in rural education are masked below the mean and points to the existence of disadvantages in outcomes such as cognitive ability and higher education access (Davies et al., 2021; Graham, 2024; Midouhas & Flouri, 2015). This study builds on these studies by directly highlighting urban-rural inequalities in the maths and science achievement of Grade 8 pupils.

Some may contend that this discovery does not warrant attention owing to its relatively modest explanatory power. However, the enduring negative correlation between attending a rural school and academic achievement persists even after controlling for various contextual variables, especially for SES. This indicates that in England, children from relatively disadvantaged backgrounds in rural schools are more likely to encounter additional obstacles to their academic success compared to their peers in urban schools. This is concerning, and holds meaningful implications for highlighting the potential disadvantage faced by relatively disadvantaged students in rural schools, emphasizing the necessity for closer examination of this overlooked demographic, potentially impacted by geographical factors.

Although not the primary focus of this study, these findings raise additional concerns regarding the way educational disparities are assessed. In England, the geographic education gap is typically measured at the level of Local Authorities (LAs), which can provide valuable insights into regional differences. However, there is a possibility that disadvantaged rural schools may be overshadowed by the overall performance of their respective LAs, particularly in regions where urban and rural areas coexist. In such mixed LAs, the stronger performance of urban schools could mask the challenges faced by rural schools, leading to an inaccurate portrayal of educational inequalities. This is particularly concerning given that the Department for Education's school assessments rely heavily on LA averages, which may overlook the specific needs of rural schools and contribute to a misrepresentation of the actual educational landscape.

An important consideration is that this study's conclusions were drawn using a binary classification of urban and rural areas, due primarily to the limitations of the TIMSS dataset. This does not suggest that all rural schools in England face widespread inequalities. On the contrary, given the complexities of rural areas in England, these findings hold even greater significance. Rural areas vary significantly, including affluent villages, remote farming communities, and economically struggling coastal regions. Affluent villages often benefit from better access to resources due to their proximity to urban areas, while coastal regions, especially in the north and southwest, may experience challenges linked to economic decline, such as reduced school funding and higher unemployment. These differences can influence the quality of education and student outcomes. Despite this diversity, the study reveals clear disadvantages in rural schools even within a binary classification. These appear both in student and school characteristics and in how school location relates to academic performance. More detailed research on rural subtypes may uncover further disparities requiring targeted policy measures.

We argue that a renewed focus on rural education is urgently needed at the research, policy and practice levels. The over-optimistic view of research on rural education deserves consideration, calling for more robust and comprehensive evidence, particularly the use of large-scale datasets with more detailed information to look for subtle patterns. Rural schools need more teaching resources and more sustainable teaching teams, and this should be supported at the policy level. Overall, the disadvantages of rural schools need to be identified, recognised and taken seriously. Fortunately, although the potential harm of geography on academic achievement was found, the correlation was not very strong. This suggests that while such inequalities exist, they may be minor and manageable. Therefore, we call for timely interventions to address these disparities, which should require only modest efforts and manageable policy adjustments.

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**Disclosure Statement**

The authors report there are no competing interests to declare.

**Data Availability Statement**

The data that support the findings of this study are openly available on TIMSS & PIRLS International Study Center website at https://timssandpirls.bc.edu/timss2019/international-database/, reference number 2021930389.

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**Tables**

Table 1: Participant Characteristics.

| **Characteristics** | |
|---|---|
| Urban | 1,669 |
| Rural | 813 |
| Urban-Rural Missing | 883 |
| Girls | 1,715 |
| Boys | 1,492 |
| Missing | 158 |
| Science score (Average) | 516.01 |
| Maths score (Average) | 517.72 |
| Total instructional hours (Average) | 998.33 |
| School discipline problems (Average) | 10.62 |
| Instruction affected by mathematics resource shortages (Average) | 10.46 |
| Instruction affected by science resource shortages (Average) | 10.57 |
| Home educational resources (Average) | 10.73 |
| Maths teacher's teaching experience (Average) | 13.06 |
| Science teacher's teaching experience (Average) | 11.91 |
| **Parental Education** | |
| Under post-secondary | 520 |
| Post-secondary and above | 1,147 |
| Unknown | 1,698 |
| **Maths extra lesson** | |
| Attend | 428 |
| Did not attend | 2,320 |
| Missing | 617 |
| **Science extra lesson** | |
| Attended | 257 |
| Did not attend | 2,533 |
| Missing | 575 |

Table 2: Effect Size – Academic Performance

| | Effect size (urban v/s rural) | Effect size (missing v/s rural) |
|---|---|---|
| Maths | 0.15 | -0.04 |
| Science | 0.05 | -0.09 |

Table 3: Effect Size - School-Level Factors (Urban v/s Rural)

| Total Instructional Hours per Year | School Discipline Problems | Instruction Affected by Mathematics Resource Shortages | Instruction Affected by Science Resource Shortages |
|---|---|---|---|
| 0.18 | 0.04 | 0.13 | 0.16 |

Table 4: Effect Size - Home Educational Resources

| Effect size (urban v/s rural) | Effect size (missing v/s rural) |
|---|---|
| -0.09 | -0.24 |

Table 5: Percentage of Students Participating in Extra Lessons or Not

| | Math extra lessons | | Science extra lessons | |
|---|---|---|---|---|
| | Did not attend | Attend | Did not attend | Attend |
| Urban | 82.6% | 17.4% | 89.0% | 11.0% |
| Rural | 89.1% | 10.9% | 93.5% | 6.5% |
| Missing | 83.4% | 16.6% | 91.7% | 8.3% |

Table 6: Percentage of Parents' Highest Educational Level

| | Under post-secondary | Post-secondary and above | Unknown |
|---|---|---|---|
| Urban | 14.8% | 36.8% | 48.4% |
| Rural | 16.6% | 35.3% | 48.1% |
| Missing | 15.6% | 27.9% | 56.5% |

Table 7: Effect Size - Teacher's Years of Teaching Experience.

| | Effect size (urban v/s rural) | Effect size (missing v/s rural) |
|---|---|---|
| Maths Teachers | -0.30 | 0.08 |
| Science Teachers | -0.14 | 0.20 |

Table 8: Regression Model Predicting Maths Scores

| Step | Predictors | Adjusted R Square | Coefficient |
|---|---|---|---|
| 1 | Home Educational Resources | 0.154 | 0.372 |
| | Parental Education = Unknown | 0.177 | -0.161 |
| | Sex = Male | 0.184 | 0.092 |
| | Maths Extra Lessons | 0.191 | -0.093 |
| 2 | School Location = Rural | 0.198 | -0.083 |

Table 9: Regression Model Predicting Science Scores

| Step | Predictors | Adjusted R Square | Coefficient |
|---|---|---|---|
| 1 | Home Educational Resources | 0.171 | 0.417 |
| | Parental Education = Unknown | 0.188 | -0.196 |
| | Science Extra Lessons | 0.199 | -0.114 |
| | Sex = Male | 0.202 | 0.061 |

| | | | |
|---|---|---|---|
| | Parental Education = Post-Secondary and Above | 0.204 | -0.083 |
| 2 | School Location = Rural | 0.206 | -0.050 |

**Appendix. Summary of Sensitivity Analysis Models**

Table A1. Regression Model Predicting Math Scores with **All Missing School Locations Replaced as Rural**

| Step | Predictors | Adjusted R Square | R Square Change | Coefficient |
|---|---|---|---|---|
| 1 | Home Educational Resources | 0.154 | 0.154 | 0.366 |
| | Parental Education = Unknown | 0.177 | 0.023 | -0.161 |
| | Sex = Male | 0.184 | 0.008 | 0.092 |
| | Math Extra Lessons | 0.191 | 0.008 | -0.091 |
| 2 | School Location = Rural | 0.196 | 0.005 | -0.073 |

Table A2. Regression Model Predicting Science Scores with **All Missing School Locations Replaced as Rural**

| Step | Predictors | Adjusted R Square | R Square Change | Coefficient |
|---|---|---|---|---|
| 1 | Home Educational Resources | 0.171 | 0.171 | 0.413 |
| | Parental Education = Unknown | 0.188 | 0.017 | -0.196 |
| | Science Extra Lessons | 0.199 | 0.012 | -0.114 |
| | Sex = Male | 0.202 | 0.003 | 0.061 |
| | Parental Education = Post Secondary and Above | 0.204 | 0.002 | -0.083 |
| 2 | School Location = Rural | 0.206 | 0.002 | -0.043 |

Table A3. Regression Model Predicting Math Scores with **All Missing School Locations Replaced as Urban**

| Step | Predictors | Adjusted R Square | R Square Change | Coefficient |
|---|---|---|---|---|
| 1 | Home Educational Resources | 0.154 | 0.154 | 0.372 |
| | Parental Education = Unknown | 0.177 | 0.023 | -0.161 |

| | | | | |
|---|---|---|---|---|
| | Sex = Male | 0.184 | 0.008 | 0.092 |
| | Math Extra Lessons | 0.191 | 0.008 | -0.093 |
| 2 | School Location = Rural | 0.198 | 0.007 | -0.083 |

Table A4. Regression Model Predicting Science Scores with **All Missing School Locations Replaced as Urban**

| Step | Predictors | Adjusted R Square | R Square Change | Coefficient |
|---|---|---|---|---|
| 1 | Home Educational Resources | 0.171 | 0.171 | 0.417 |
| | Parental Education = Unknown | 0.188 | 0.017 | -0.196 |
| | Science Extra Lessons | 0.199 | 0.012 | -0.114 |
| | Sex = Male | 0.202 | 0.003 | 0.061 |
| | Parental Education = Post Secondary and Above | 0.204 | 0.002 | -0.083 |
| 2 | School Location = Rural | 0.206 | 0.002 | -0.050 |