Rural/Urban Disparities in Science Achievement In Post-Socialist Countries: The Evolving Influence of Socioeconomic Status

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Abstract

Disparities in educational outcomes exist between students in rural areas as compared to students in urban settings. While there is some evidence that these rural disparities are present in eastern Europe, little is known about young peoples' lives in the rural areas of this region. This paper presents an analysis of science achievement by location (rural v. urban) using all available waves of the Trends in International Mathematics and Science Study (TIMSS). We examined the eighth grade data from five countries: Lithuania, Romania, the Russian Federation, Hungary, and Slovenia. Findings demonstrated that students attending rural schools had significantly lower science scores and that the rural disadvantage grew between 1995 and 2011 in some countries, but became non-significant in others. Overall, family socioeconomic status played an important role in determining the educational outcomes of rural students. The implications of these findings are explored in relation to the United Nations Educational, Scientific and Cultural Organization (UNESCO) 2015 Education for All goals.

Keywords

rural education, eastern Europe, science achievement, socioeconomic status

Introduction

Regional disparities in educational outcomes existed in eastern Europe between rural and urban areas during communist rule (Gerber & Hout, 1995). However, since the fall of communism, opportunity gaps between rural and urban areas in eastern Europe have substantially widened (Gerber, 2000; Gerber & Hout, 2004). In most cases, large urban centers experienced high levels of growth and development while rural areas have experienced

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little change (Heyns, 2005). Despite evidence of a rural disadvantage in this region, little is known about how social exclusion and limited access to educational opportunities shape young people's lives in rural areas of eastern Europe. In the past few decades, the countries of central and eastern Europe (CEE) have performed increasingly well on international assessments. According to a report released by the United States Department of Education regarding education in post-socialist countries, "the quality of education in certain fields, especially math and sciences, was, and remains, exceptional" and recent studies show that a number of central and eastern European countries rank among the top countries internationally in eighth grade science and math (Laporte & Ringold, 1997, p. 1). While educational quality in central and eastern Europe appears to be high overall, little is known about the differences that exist between rural and urban educational outcomes in this region.

Given what we know about the educational and social disadvantages associated with rural location in other countries, this paper examined disparities in science achievement between rural and urban areas in countries in post-socialist transition. The purpose of this study was to gain a better understanding of the relationship between rural location and educational achievement in the region. This paper presents an analysis of science achievement by location (rural v. urban) using all available waves of TIMSS (1995, 1999, 2003, 2007, and 2011). We examined the eighth grade data from five post-socialist countries: Lithuania, Romania, Russia, Hungary, and Slovenia.

We start with a discussion of the overall differences in science achievement between urban and rural students. Then, we model these differences while accounting for family socioeconomic status (SES) and gender. We included SES in our model because of the well-documented relationship between rural areas and pervasive poverty. This is also the case in rural regions within eastern Europe, where high poverty is a defining characteristic of many rural communities (European Commission, 2008; Zichy, 2000). In addition to contributing to the literature on the rural/urban dichotomy in educational achievement, we also address implications these findings have with respect to UNESCO's 2015 Education for All (EFA) goals two and six. In light of our findings, we discuss the usefulness of EFA as a framework for measuring educational equity based on geographic location, gender, and socioeconomic status in transition countries.

The Rural Context

In order to understand the relationship between living in a rural area and science achievement, we first explored the rural context as it is represented in the literature. Below is a discussion of the rural context more broadly as well as an overview of what was found in the literature about rural areas and rural education in eastern Europe. Rural areas are diverse spaces and how rural is observed and defined varied across the literature (Cuervo & Wyn, 2013). Some researchers relied on conceptual definitions that define rural spaces based on cultural characteristics and historically defined constructs, specifically occupational, ecological, and sociocultural constructs (Bealer, Willits, & Kuvlesky, 1965). Often, conceptual definitions of rural are based on meaningful differences that exist between rural and urban areas, such as the presence of traditional values and attitudes in rural areas in order to establish whether a place is rural (Willits, Bealer, & Crider, 1973). Other research utilized empirical definitions of rural. Empirical definitions determine what is rural and what is not rural based on measures such as population density or distance from urban areas (Isserman, 2005). Whether one utilizes a conceptual or empirical definition, rural spaces are difficult to define and to capture.

There are characteristics of rural spaces that are consistent across definitions and regional contexts. First, there are differences between urban and rural education, including differences in quality (Giroux, Jah, & Eloundou-Enyegue, 2010; Agrawal, 2014), early education opportunities (Miller & Votruba-Drzal, 2013), and post-secondary outcomes including participation in higher education (Byun, Meece, & Irvin, 2012; Provasnik, Kewal-Remani, Coleman, Gilbertson, Gerring, & Xie, 2007; Koricick, 2014; Chankseliani, 2013; MacTavish & Salamon, 2006; McIlveen, Morgan, & Bimrose, 2012), as well as differences in parents' level of education (Iannelli, 2002).

Second, poverty is a defining characteristic of many rural communities, and is often found in higher levels in rural areas compared to urban areas (Tickamyer & Duncan, 1990; Zichy, 2000; Miller & Votruba-Drzal, 2013; Bailey, Jensen, & Ransom, 2014,). The presence of poverty in rural areas has implications for the educational outcomes of rural youth. Last, several studies have explored the relationship between rural areas and access to technology, specifically the lack of technology related courses in rural schools (Lee & McIntire, 2000), as well as disadvantages rural youth experience accessing technology at home compared to their peers in urban areas (Li & Ranieri, 2013; Chen & Liu, 2013).

Educational inequality between rural and urban contexts is global and widespread. There are vast differences between rural educational quality and access to opportunity as compared to urban, and suburban school settings (Giroux, Jah, & Eloundou-Enyegue, 2010; Agrawal, 2014). Rural children enter school with less advanced academic skills than children in small urban and suburban areas (Miller & Votruba-Drzal, 2013). These lower levels of preparation are partially attributed to a lack of early education opportunities in rural areas, as well as overall lower levels of parental education (Khattri, Riley, & Kane, 1997; Hardre & Hennessey, 2010). The deficits in educational quality and opportunity encountered by rural students have long-term effects on their life outcomes, influencing access to higher education and employment (Chankseliani, 2013; MacTavish & Salamon, 2006). Across countries, fewer numbers of rural students pursue post-secondary education compared to their counterparts in urban and suburban areas (Byun, Meece, & Irvin, 2012; Provasnik, Kewal-Remani, Coleman, Gilbertson, Gerring, & Xie, 2007; Koricick, 2014).

One explanation for the rural disadvantage in post-secondary attainment is the high instance of poverty. Poverty is rampant in rural areas and it has implications for education, as well as long term individual and community consequences (Bailey et al., 2014). Poverty in rural areas leads to limited opportunities for social and economic development, as well as decreased mobility, stable employment, investment in the community, and limited variation in industry or career options (Tickamyer & Duncan, 1990). In fact, the lower educational achievement of rural children is often attributed to less advantaged home environments – including, as was mentioned before, parents with lower levels of education, as well as decreased access to basic human needs relative to non-rural children, such as cognitive stimulation in the form of books and activities, as well as parental warmth, responsiveness, and emotional support (Miller & Votruba-Drzal, 2013). Thus, the association between poverty and educational outcomes deserves special attention in rural settings.

Rural Context in Central and Eastern Europe

Since the beginning of the post-socialist era, there have been increasing inequalities between rural and urban areas in central and eastern Europe (CEE) (Gerber, 2000; Gerber & Hout, 2004). Research using TIMSS and the Programme for International Student Assessment (PISA) data suggest the existence of disparities between urban and rural education systems in the post-socialist countries of CEE (Geske, Grinfields, Dedze, & Zhang, 2006). While regional disadvantages in educational opportunity existed under communism (Gerber

& Hout, 1995), opportunity gaps between rural and urban areas have widened (Gerber, 2000; Gerber & Hout, 2004). Heyns (2005) documented increasing inequalities between urban and rural areas, citing that while large urban centers have experienced high levels of growth and development in the post-communist world, rural areas have experienced little change.

Educational achievement in rural areas of CEE was lower than in urban areas. Typically, the educational level achieved by residents in rural areas within CEE countries was below the national average for that country (Zichy, 2000), and lower than in urban areas (Davis & Pearce, 2000). Based on several papers published on learning achievement in central and eastern Europe in 2006, results consistently demonstrated that children in urban schools scored higher on average than students in rural areas (Willms, Smith, Zhang, & Tramonte, 2006). Much of the available data also showed that educational outcomes were highly correlated with socioeconomic status. Low SES was often a characteristic of children in rural areas. One important correlate of socioeconomic status was parental education. This was particularly true in eastern Europe where parental educational level was found to have a stronger impact on students' educational and early occupational outcomes as compared to western European youth, who were more likely to achieve the same educational level as their parents (Iannelli, 2002). In all CEE countries, socioeconomic status was a significant factor in determining the level of education students will achieve (Strakovam, Tomasek, & Willms, 2007).

Recent research using TIMSS and PISA data hinted at the existence of disparities in science achievement between urban and rural education systems in this region (Geske, Grinfields, Dedze, & Zhang, 2006). In Romania, TIMSS 2003 showed that rural students had lower science achievement scores, lower levels of parental education, and fewer educational resources at home as compared to urban students (Istrate, Noveanu, & Smith, 2006). However, it is possible that TIMSS data underestimated the effect of poverty, since there was no specific measure for socioeconomic status. It is difficult to measure educational outcomes in rural areas where high numbers of the population still do not attend school. For example, in Romania, over half of rural youth ages 15-24 do not attend any type of school (European Commission, 2008).

The presence of poverty is also an unfortunate reality in rural areas of eastern Europe. Rural regions within CEE are characterized as "desolate and the rural population resigned" (Zichy, 2000, p. 87), where poverty is an unfortunate reality (European Commission, 2008). In Lithuania, the poverty rate in rural areas is three times greater than in the country's largest cities (European Commission, 2008). In Romania, the rate of poverty in rural areas is 42% compared to 18% in urban areas (European Commission, 2008). As such, poverty is highly concentrated in rural areas of eastern Europe.

A variety of school factors influence educational outcomes in rural schools, including a lack of advanced course offerings, instructional resources, progressive instruction, professional training, and a safe/orderly climate (Lee & McIntire, 2000). Access to these resources varies greatly between rural and urban schools and decreased access to technology in particular is a correlate of higher poverty and the less developed infrastructure found in rural areas. In addition to inequities that exist in access to technology between rural and urban students, students in rural areas are also disadvantaged in their ability to use the internet autonomously, the degree of social support they received relative to internet use, and internet use as related to self-efficacy (Li& Ranieri, 2013; Chen & Liu, 2013). The lack of effective use and access to technology in rural areas potentially further exacerbated the rural-urban achievement gap.

Increasingly localized systems of government in post-socialist countries place additional strain on rural education in this region. Prior to the upheaval of the early 1990s and the fall of communism, education systems in eastern Europe and the Soviet Union were highly centralized and controlled, fiscally and systemically through the control of curriculum, personnel, and standards (Micklewright, 1999; Eklof, Holmes, & Kaplan, 2005; Laporte & Ringold, 1997; Amini & Commander, 2012). During the post-socialist transition however, fiscal responsibility for education fell primarily on local governments and families, and the funding responsibility for early education was delegated to families, and private organizations (Laporte & Ringold, 1997). Slovenia and Hungary, for example, have what is considered to be the most decentralized schooling systems in all of eastern Europe (Ammermuller et al., 2005). Because funding for schools is now more closely connected to regional resources and local governments, decentralization poses potential equity issues in this region. Such issues have already been documented in Hungary, where there are indications that educational resources are unequally distributed (Laporte & Ringold, 1997). A greater share of the fiscal burden also falls on families and individuals in this region. In the Czech Republic, schools charged tuition for pre-school and university education, and enrollment in private schools, particularly at the university level, had risen to 9% by 1997. Similarly, in Poland private university enrollment reached 10%, but the largest increase in private university enrollment was in Romania, where 27% of students were paying tuition by 1997 (Laporte & Ringold, 1997). Other financing alternatives are being explored in this region, including partnerships between educational institutions and the private sector (Laporte & Ringold, 1997). This decentralization has special implications for rural schools and communities, which have fewer fiscal resources, school options, and family financial resources to adapt to these changes.

Finally, gender is often considered a significant factor in youths' educational outcomes. The post-Socialist context is a unique frame through which to explore gender, given the high level of gender equality found in socialist education systems, particularly in the area of science. In central and eastern European countries, there is a lack of consensus amongst scholars about the relationship between gender and educational achievement. While demonstrating that students' background characteristics were less impactful on science achievement than they are on math achievement in central and eastern Europe, Ammermuller et al. (2005) reported that in science, female students did have a disadvantage. On the other hand, Heyns (2005) documented increases in educational inequality based on age, education level, and location but noted that the gender gap has declined since 1989. In the post-Socialist region more broadly, Kovaleva (2010) found no gender differences in natural sciences achievement among Russian fourth and eighth grade students. Similarly, Amini and Commander (2012) found mixed results in Russia when examining gender differences in science achievement based on both TIMSS and PISA. More research is needed to clarify the relationships between gender and academic achievement in post-socialist countries.

Considering the rural context and the characteristics that define rural areas and rural education in eastern Europe, this paper will attempt to answer the following research questions:

- Has the rural gap in science achievement changed over time, as captured by TIMSS 1995, 1999, 2003, 2007, and 2011?
- Does computer ownership vary between rural and urban areas?
- Does the rural/urban difference in science achievement hold once we account for gender and family SES?

Data & Methods

This study used data from the Trends in International Mathematics and Science Study (TIMSS). The International Association for the Evaluation of Educational Achievement (IEA) has conducted TIMSS every four years since

1995 and this study utilized data from all five assessments: 1995; 1999; 2003; 2007 and 2011. TIMSS measured student achievement in mathematics and science, and collected information on curriculum and instructional practices for participating countries. For the purposes of this study, we only used TIMSS data on science achievement. TIMSS used a two-stage stratified cluster sampling design in which schools were sampled with probability proportional to their size, and 4th and 8th grade classrooms were randomly selected from those schools. Our study only utilized the 8th grade TIMSS data given our focus on science learning which occurs more during secondary school. The 8th grade data for 1995 actually included a range of students from 6th to 9th grade in some countries, so we restricted the 1995 analysis to only 8th graders as to make it comparable across years.

We restricted our choice of post-socialist eastern European countries based on the availability of the valid data for the countries that participated in all five data collections. As such, we employed data from five eastern European countries: Hungary, Lithuania, Romania, Russia, and Slovenia. TIMMS assigned sampling students weights to ensure the data represented the actual population of schools, classrooms, and students. Using the recommended weights allowed the results to be generalized to target populations of all 8th grade students in each country.

Summary statistics were produced for each country for all five years, but we elected to only present the first and last years in text.[1] We utilized TIMSS 1999 data on computer ownership for Lithuania because this data was not available in TIMSS 1995. To answer the first research question, we conducted a bivariate regression analysis of science achievement by country and location, rural and urban, using TIMSS 1995, 1999, 2003, 2007, and 2011. To answer the second research question we used bivariate logistic regression to analyze if there was a statistically significant difference in the average ownership of computers between rural and urban students in each country.[2] Third, we conducted multivariate ordinary least squares (OLS) regressions for each year in order to estimate how rurality, gender and socio-economic background were related to science achievement. Again, we only reported the findings based on the first and last waves. Due to the sampling strategy, the usual ordinary least squares (OLS) regression assumption of completely independent observations may be violated, since students in the same school tend to be similar on unmeasured variables. In order to obtain correct standard errors, we used the recommended jackknife repeated replication (JRR) technique.

Our dependent variable was **performance scores in science** in four content domains (biology, chemistry, physics, and earth science) and three cognitive domains (knowing, applying, and reasoning). TIMSS uses item response theory (IRT) method to map proficiency on a scale with an international mean of 500 with a standard deviation equaling 100. Since TIMSS uses multiple imputation to create five plausible values (PV) for science achievement, we used specific PV commands in STATA to sum the plausible scores and to account for the additional standard error associated with PVs.

Our main variable of interest was a binary variable for whether a student **attended a rural school**. Since TIMSS altered the way they measured rural status between 1999 and 2003, we coded the variable to be consistent over time. For 1995 and 1999, rural was defined categorically as living in a geographically isolated or village area. We used this as our measure for rural when analyzing the 1995 and 1999 waves of TIMSS. In subsequent years, rural was defined numerically indicating an area with less than 3,000 people. We utilized this definition of rural when analyzing the 2003, 2007, and 2011 waves. We compared descriptives as well as UNESCO data to ensure the rural measure captured the population of interest.

We also include other variables in the multivariate model, specifically gender and family socioeconomic status. **Gender** was measured using a dichotomous scale (0=male and 1=female). **Family socioeconomic status** was captured by using two variables: parental education and a composite of home possessions.[3] One of the variables in home possessions, **computer ownership**, was also used in the analysis comparing rural and urban ownership of a computer. Parental education is a dummy variable indicating that one of the parents has received a BA degree or higher. Home possessions was a standardized variable that was used as a proxy for family wealth. It was a composite measure of home possessions including ownership of a calculator, desk, dictionary, and computer, as well as access to internet in the home. The number of books in the home was also included. The measure was standardized for each year so that it showed the relative position of a student's family.

Results

Table 1 presents descriptive statistics for the variables used in the analysis for the first wave (1995) by country. Table 2 presents descriptive statistics for the variables used in the analysis for the last wave of TIMSS (2011) by country. In TIMSS 1995 we see that only Lithuania and Romania scored below the international mean, at approximately 463 and 470 respectively. In the 2011 wave, Romania is the only country in our study that remained below the international mean at 465. Between 1995 and 2011, Hungary's overall eighth grade science score decreased by 2.7%, Lithuania had a 10.88% increase, Romania a 1.2% decrease, the Russian Federation a 3.7% increase, and finally Slovenia saw a 0.3% increase in science score between 1995 and 2011.

Table 1. Descriptive statistics by country for TIMSS 1995

	Hungary	Lithuania	Romania	Russian Federation	Slovenia
Mean Science Achievement	536.75	463.56	470.93	522.58	540.98
Percentage of Rural Students	0.35	0.32	0.31	0.23	0.33
Percentage of Female Students	0.51	0.55	0.50	0.53	0.51
SES (Standardized Home Possessions)	0.33	0.13	-0.83	0.21	0.23
Parental Education (BA or higher)	0.27	0.51	0.12	0.40	0.21
Percentage with a computer	0.37	0.16[i]	0.19	0.35	0.47
N	2912	2525	3725	4022	2708

Table 2. Descriptive statistics by country for TIMSS 2011

	Hungary	Lithuania	Romania	Russian Federation	Slovenia
Mean Science Achievement	522.39	513.87	464.69	542.46	542.82
% Students Rural	0.20	0.27	0.24	0.16	0.29
% Female	0.49	0.49	0.48	0.49	0.49
SES (Standardized Home Possessions)	0.19	-0.19	-0.48	-0.24	0.24
Parental Education (BA or higher)	0.29	0.28	0.22	0.57	0.34
% with a computer	0.95	0.96	0.84	0.88	0.99
N	5176	4735	5523	4891	4403

In 1995, from 19% of students (Romania) to 47% of students (Slovenia) owned a computer. Within all five countries, there were significant disparities between rural and urban students in terms of computer ownership (see Table 3). For instance, only a quarter of rural students in Hungary possessed computers while 43% of urban students possessed computers. By 2011, computer ownership had rapidly increased for students in all countries, but important differences remained between rural and urban computer ownership. The disparity between rural and urban computer ownership had narrowed substantially in Hungary and Lithuania and had disappeared completely in Slovenia. Conversely, the Russian Federation had the widest difference between rural and urban ownership with urban areas approaching universal ownership (93%) while only about two-thirds of rural students owned computers.

In most countries, rural students were less likely to own a computer as compared to students in urban areas. This trend was consistent across waves with little variation and in most cases the relationship was statistically significant. While this comparative analysis is descriptive in nature, it nonetheless sheds light on how differential access to technology may act as a stratifying mechanism between rural and urban students.

Table 3: Mean differences in computer ownership by rural-urban status for TIMSS 1995 and 2011

	1995		2011	
	Rural	Urban	Rural	Urban
Hungary	0.25	0.43***	0.90	0.97***
Lithuania[4]	0.09	0.19***	0.91	0.98***
Romania	0.10	0.24**	0.73	0.86**
Russian Federation	0.24	0.38***	0.66	0.93***
Slovenia	0.38	0.50***	0.99	0.99

Note: * p<.05, ** p <.01, *** p<.001

In 1995, rural school children in CEE performed worse than their urban counterparts in the area of science (see Table 4). As indicated in our bivariate model, rural schools had significantly lower scores in four of the five countries. The rural deficit was largest in Hungary (b=-30.94; p<.001) and the Russian Federation (b=-37.06; p<.001). No significant differences in rural scores were found in Romania. Once gender, home possessions, and parental education were controlled for, rural disadvantage remained significant in Hungary (b=-12.44; p<.0.05) and the Russian Federation (b=-25.50; p<.001). Family socioeconomic status, measured as home possessions and parental education, seemed to account for much of the rural deficit.

Socioeconomic status was significantly related to science achievement across all countries, with greater levels of home possessions associated with science scores. Only in the Russian Federation, was the effect of home possessions smaller than the effect of being from a rural area. Finally, parental education had a significant effect on science scores across all countries, with students whose parents held a BA or higher achieving higher science scores. In all countries, significant differences were found between genders, with females, on average, scoring lower than males on science. Notably, we tested a rural gender interaction, but the rural disadvantage did not vary by gender. In sum, students in rural areas fared worse in science than their urban peers, but family socioeconomic explained away the deficit everywhere but the Russian Federation and Hungary.

Table 4. Multivariate ordinary least squares (OLS) regression analysis for Science achievement TIMSS 1995

	Hungary		Lithuania		Romania		Russian Federation		Slovenia	
Rural	-30.94*** (5.78)	-12.44* (5.91)	-20.00* (8.57)	-3.34 (9.66)	-17.40 (13.27)	3.70 (11.95)	-37.06*** (7.37)	-25.50*** (7.20)	-16.38* (6.74)	-4.02 (6.61)
Female		-25.39*** (4.40)		-33.24*** (4.53)		-11.76** (4.23)		-12.36*** (3.33)		-29.87*** (4.15)
SES (Standardized Home Possessions)		28.60*** (2.96)		24.27*** (3.79)		15.33*** (2.82)		14.98*** (3.71)		31.35*** (3.76)
Parental Education (BA or higher)		37.42*** (5.19)		20.09*** (5.06)		27.49*** (9.35)		32.76*** (5.33)		41.12*** (4.93)
Constant	547.37*** (3.47)	547.25*** (4.41)	470.03*** (5.25)	485.30*** (5.85)	476.15*** (6.17)	499.77*** (5.71)	531.16*** (4.19)	523.41*** (6.15)	545.43*** (3.81)	543.88*** (4.22)
R Squared	0.0351	0.1716	0.0132	0.1219	0.0062	0.0755	0.0034	0.0937	0.0099	0.1557
N	2833	1909	2325	1198	3698	2670	4022	3270	2267	1963

Note: * p<.05, ** p <.01, *** p<.001
Standard errors in parenthesis

Rural children continued to perform worse than their urban counterparts in the area of science in 2011 in all countries except for Slovenia (see Table 5). The first model showed that rural school students scored lower on TIMSS 2011 in Hungary, Lithuania, Romania, and the Russian Federation. The rural deficit was largest in Hungary (b=-41.53; p<.001) and Lithuania (b=-37.83; p<.001). In Slovenia, there was no significant difference between rural and urban students.

When gender and family socioeconomic status were controlled for, significant negative differences in science achievement between rural and urban students remained in Hungary (b=-25.47; p<.001) and Lithuania (b=-23.33, p<.001). Socioeconomic status via home possessions and parental education seem to explain away much of the rural deficit in Romania. Controlling for SES had the greatest impact on the magnitude of the rural effect in Romania and Hungary. Notably, in Lithuania the effect for home possessions was smaller in magnitude than the effect of being from a rural area. In Slovenia, family socioeconomic status, specifically the standardized measure for home possessions, partially explained the rural deficit in science achievement.

Parental education, as a measure of SES, was associated with science scores in Hungary, Lithuania, Romania, and the Russian Federation, with students whose parents held a BA or higher achieving higher science scores. Markedly, in the Russian Federation, the effect of parental education accounted for the majority of rural disadvantage in science achievement while home possessions was not related to achievement. Finally, significant differences by gender were found only in Hungary and Lithuania. In Hungary, females on average scored lower than males (b=-13.26, p<.001), while in Lithuania (b=6.25, p<.05) females on average scored higher than their male counterparts. As previously stated, we tested a rural gender interaction but found that the gender gap did not vary by type of location. Overall, analysis of the 2011 wave demonstrates that students in rural areas performed less well in the area of science achievement as compared to their urban peers. However, family socioeconomic status explains away the rural deficit in all countries except Hungary and Lithuania.

Table 5. Multivariate ordinary least squares (OLS) regression analysis for Science Achievement TIMSS 2011

	Hungary		Lithuania		Romania		Russian Federation		Slovenia	
Rural	-41.53*** (6.44)	-25.47*** (5.18)	-37.83*** (5.70)	-23.33*** (5.62)	-33.95*** (8.58)	-16.04 (8.83)	-23.37* (10.33)	-7.99 (10.91)	4.30 (5.04)	-3.97 (5.31)
Female		-13.26*** (3.78)		6.25* (3.06)		2.64 (3.50)		-5.12 (3.13)		-4.23 (3.98)
SES (Standardized Home Possessions)		30.80*** (2.65)		15.57*** (2.53)		16.99*** (2.09)		5.97 (2.04)		17.10*** (2.92)
Parental Education (BA or higher)		33.89*** (3.63)		29.03*** (3.73)		26.69*** (5.21)		30.22*** (4.09)		35.30 (4.21)
Constant	531.38*** (3.42)	520.69*** (3.97)	524.28*** (2.83)	516.10 (3.67)	472.66*** (4.04)	481.74 (5.11)	546.25*** (3.30)	536.59*** (4.28)	544.81*** (3.54)	537.71*** (4.73)
R Squared	0.041	0.221	0.0492	0.1268	0.0282	0.1428	0.0127	0.0639	0.0006	0.0912
N	4991	3977	4536	3053	5433	3945	4893	3811	4210	3101

Note: * p<.05, ** p <.01, *** p<.001
Standard errors in parenthesis

In addition, we also ran the analysis using TIMSS 1999, 2003, and 2007.[6] The results of the multivariate analysis using TIMSS 1999, after controlling for gender and family socioeconomic status, found significant negative differences in achievement between rural and urban students in science in Hungary and the Russian Federation. Analysis of TIMSS 2003 found no significant differences between rural and urban students on science achievement after controlling for gender and family socioeconomic status. Results of the TIMSS 2007 analysis show a resurgence of the effect of rural location on science achievement after controlling for gender and family socioeconomic status. In this wave, a significant difference in science achievement between rural and urban students was found in both Hungary and Lithuania. As already stated, this disparity remained in these two countries in 2011.

Attending a school in a rural location was negatively correlated with a students' science achievement across countries with few inconsistencies. The only exceptions appeared to be a lack of a significant effect in Romania in 1995 and in 1999, 2003, and 2011 for Slovenia. Slovenia presents the most inconsistent rural effect on science achievement, demonstrating significant differences between rural and urban science achievement in only in TIMSS 1995 and 2007.

Overall, once we control for gender and family socioeconomic status, the rural effect disappeared in most cases. In 1995, the Russian Federation had a substantial rural-urban disparity, but it declined in subsequent years and eventually disappeared. In 2003, the rural effect on science achievement disappeared for all countries after controlling for gender and family SES. This was followed by the 2007 wave where we see the resurgence of the rural effect in Hungary, as well as the presence of a rural effect in Lithuania, which had not been present in previous waves. The rural effect in Hungary and Lithuania remained through the 2011 wave. Across the multivariate analysis, family socioeconomic status exerted the greatest control over the effect of rural location on science achievement.

Discussion

We employed the 8th – grade data from the Trends in International Mathematics and Science Study (TIMSS) 1995, 1999, 2003, 2007, and 2011 for five eastern European countries – Hungary, Lithuania, Romania, the Russian Federation, and Slovenia. The goal of this analysis was to answer three main research questions: a) Does the rural gap in science achievement change over time, using TIMSS 1995, 1999, 2003, 2007, and 2011? b) Does computer ownership vary between rural and urban areas? c) Does the rural/urban difference in science achievement hold once we account for gender and family SES?

Our findings showed that there were significant differences between rural and urban eighth grade science achievement across waves from 1995 to 2011 in these post-socialist countries. We found that in most countries, students attending rural schools had significantly lower science scores than their urban counterparts and students in rural areas scored lower than urban students across all waves of TIMSS. There were a small number of exceptions to this finding, including no rural/urban difference in Romania in 1995, and in Slovenia in 1999, 2003, 2011. It is evident from our findings that rural student achievement in the area of science has not improved since the fall of communism. Considering these findings both historically, and as characteristics of the post-socialist transformation, the results are significant. Through the course of the last two decades, as measured by TIMSS, rural students continued to perform worse than their urban counterparts in the area of science. The fall of communism and the subsequent political and economic transformations in central and eastern Europe have not had a positive impact on the educational outcomes of rural students in the area of science.

After controlling for gender and family socioeconomic status however, our interpretation of the negative relationship between rural location and science achievement comes into focus. In all but a few cases, the rural disadvantage in science achievement disappeared after controlling for gender and family socioeconomic status. Notably, family socioeconomic status accounted for a greater proportion of the rural disadvantage in science achievement, as compared to gender. Looking at the impact of gender and family socioeconomic status historically, we can see that in 1995, the rural disadvantage only remained in Hungary and the Russian Federation after controlling for these variables. There was no significant rural effect on science achievement for all countries in 2003. By the final wave in 2011, a significant rural effect on science achievement was observed in Hungary and Lithuania even after controlling for our other variables.

What these findings show is that over the course of the post-socialist transition, family socioeconomic status explained much of the difference between rural and urban science achievement. This was especially true for 2003, when there was no significant rural disadvantage after controlling for these variables. However, the resurgence of the rural effect on science achievement in Hungary and Lithuania in the final wave, even after adding control variables was significant. In 2011, rural students in Lithuania scored on average over 23 points lower than urban students even after controlling for gender and family SES. Similarly, in Hungary it was clear that family SES accounted for a significant amount of rural disadvantage in the area of science achievement. Yet, even after accounting for these variables, the rural disadvantage was still present.

In the case of Hungary, being rural appeared to have a unique effect on science achievement. One possible explanation for the persistent rural effect in Hungary is school tracking. Hungary is more highly tracked compared to the other countries in this study and it tracks students early – at age 11 (Woessmann, 2009). Research on the effects of tracking indicate that tracking students into different types of schools increases inequality, and early tracking (before 9th grade) further exacerbates this effect (Woessmann, 2009; Hanushek & Woessmann, 2006). There is also research that points to the effect of early tracking and its impact on the relationship between socioeconomic status and student performance. Essentially, early tracking increases the effect of family background on student performance (Woessmann, 2009; Schuetz, Ursprung, & Woessmann, 2008). Early tracking is one possible cause for the persistent rural effect on science achievement in Hungary after accounting for family socioeconomic status.

Our bivariate analysis of computer ownership also sheds light on an important indicator for socioeconomic status, students' access to technology. Rural students were less likely to own computers than their urban counterparts. This finding was true across all countries included in this study with the exception of Slovenia in 2003 and 2011. While this finding may not have been surprising in 1995, when home PC ownership was less common, in 2011 computer ownership was of greater importance in the field of education and in students' life outcomes. This finding is in line with the literature on the lack of access to technology experienced by students in rural locations and has implications for students' socioeconomic status and ultimately, educational outcomes.

There are some important trends here in the relationship between gender and science achievement. While a significant female disadvantage in science achievement was observed across countries in early waves of TIMSS, by 2011 we observed significant effects for gender only in Hungary and Lithuania. However, the finding in Lithuania was a positive significant effect between gender and science achievement, with female students outperforming male students. By the 2011 wave, gender accounted for little of the rural disadvantage, suggesting an even stronger connection between SES and the educational outcomes of rural youth.

While gender was associated with science achievement, family socioeconomic status played a much larger role in the educational disadvantages of rural youth. Through our analysis, we are able to conclude that the findings related to SES were consistent with literature on rural education, as well as the strong relationship between rural locations and poverty. In each case, family socioeconomic status, as measured through home possessions and parental education played a significant role in accounting for some of the observed disadvantage of rural location on science achievement in post-socialist countries. Ultimately, the rural disadvantage appeared to be more of a SES disadvantage. This again goes back to the strong ties found between rural areas and poverty. These findings demonstrated the challenges that youth in rural areas face, as well as the impact of SES and poverty on the educational outcomes of rural youth.

Through this historical analysis we also observed changes in the effect of gender and family socioeconomic status on educational achievement over time, from 1995-2011. There are many possible explanations for the shifting role these variables play on educational achievement in these countries. As these countries transition out of socialist systems they are influenced by greater global market forces. Consider the analysis of the 2003 wave of TIMSS where the rural effect on science achievement was not significant in all countries after controlling for SES and gender. It was the only wave of TIMSS where there was no rural effect. However, in the next wave the rural effect was again present in two of the five countries, and this effect persisted through 2011. What could have happened to once again bring about a rural effect? One possible explanation could be that the 2003 wave, which was collected approximately 12 years after the end of socialism and the fall of the Soviet Union, was a plateau, after which globalization and market forces impacted the economic and political structures of these transition countries to a greater degree. Twelve years after the fall of the Soviet Union, these countries became greater economic players in Europe and the western world. The 2007 and 2011 waves could also be capturing aspects of the global recession that began in earnest in 2007/2008. Regardless of the origin of this emerging trend, special attention should be paid to the education outcomes of rural youth in post-socialist countries.

Implications: Education for All

The implications of our findings are explored in relation to the goals set forth in the United Nations Educational, Scientific, and Cultural Organization's (UNESCO) Education for All goals. These internationally agreed upon goals regarding the achievement of youth all over the world were set to be achieved by 2015. Critiques of the EFA goals center on the challenges associated with numerical goals in education, as well as the negative consequences these goals can have for educational quality in poor countries (Goldstein, 2004; Jansen, 2005). We explored the EFA goals as a framework for measuring educational equity in eastern Europe based on geographic location (rural/urban), gender, and socioeconomic status in transition countries. Specifically, we focused on two goals. These goals are focused on children in difficult circumstances having access to quality education, eliminating gender disparities, and improving all aspects of education including achieving measurable learning outcomes and gaining essential life skills (www.unesco.org).

EFA goal number two is to ensure that children in difficult circumstances have access to quality primary education. Our findings here, which focused on eight grade science achievement have implications related to this goal, considering that eighth grade in most countries is the final year before secondary school begins and TIMSS captures knowledge students have learned by eighth grade. Our findings suggested that rural students lag behind their urban counterparts in science achievement in all countries, and that they lag behind them in Hungary and Lithuania even after controlling for family socioeconomic status and gender. These findings imply that there is still work to be done to ensure that children in poor rural areas have access to quality education.

EFA goal number six is important to consider in light of the findings we have presented here about technology. One of the tenets of goal six is to improve educational quality and ensure that children achieve essential life skills. In the 21st century, owning and regularly operating a computer is absolutely an essential life skill. However, our findings showed that rural children are far less likely to own a computer than their urban peers. Having access to technology in the home has implications for educational achievement, as well as the achievement of essential life skills.

Eliminating the effect of socioeconomic background on educational achievement is a major aim of EFA (Goldstein, 2004). Considering our analysis, it appears that family socioeconomic status continues to play a significant role in the educational achievement of youth. What we have uncovered through this analysis is that it is not necessarily rural location that affects educational outcomes, but rather the characteristics that define rural locations, such as persistent poverty, low parental education, and lack of quality educational resources. The Education for All movement's ultimate goal is to ensure that all children have access to education in order to help reduce poverty and improve the human condition worldwide (Miles, 2008). There is still work to be done in this regard and as demonstrated here, this work is particularly important in countries in post-socialist transition.

Notes

1. Analyses based on TIMSS 1999, 2003, and 2007 are available in Appendix A.
2. While a Chi-Square test could have been performed, the logistic regression was chosen so that the weights and replication procedure could be applied as recommended by TIMSS manual.
3. Variable was standardized around the mean for home possessions for all 5 countries.
4. Since 1995 survey lacked data on computer ownership for Lithuania, we substituted 1999 data here.
5. See Appendix A.

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Appendix A

Descriptive Statistics by country for TIMSS 1999, 2003, and 2011

Table A1. Descriptive statistics by country for TIMSS 1999

	Hungary	Lithuania	Romania	Russian Federation	Slovenia
Mean Science Achievement	552.38	488.15	471.87	533.25	520.01
Percentage of Rural Students	0.30	0.30	0.39	0.36	0.38
Percentage of Female Students	0.50	0.52	0.49	0.52	0.52
SES (Standardized Home Possessions)	0.42	-0.17	-0.85	-0.04	0.47
Parental Education (BA or higher)	033	0.40	0.25	0.44	0.21
Percentage with a computer	0.50	0.16	0.14	0.22	0.66
N	2339	3166	3393	4329	3086

Table A2. Descriptive statistics by country for TIMSS 2003

	Hungary	Lithuania	Romania	Russian Federation	Slovenia
Mean Science Achievement	542.76	519.38	469.60	513.62	520.50
Percentage of Rural Students	0.20	0.27	0.30	0.23	0.30
Percentage of Female Students	0.50	0.50	0.52	0.49	0.50
SES (Standardized Home Possessions)	0.49	-0.001	-0.88	-0.11	0.43
Parental Education (BA or higher)	0.48	0.43	0.19	0.51	0.29
Percentage with a computer	0.75	0.48	0.32	0.30	0.86
N	3302	4964	4104	4667	3578

Table A3. Descriptive statistics by country for TIMSS 2007

	Hungary	Lithuania	Romania	Russian Federation	Slovenia
Mean Science Achievement	539.03	518.56	461.90	529.57	537.54
Percentage of Rural Students	0.20	0.24	0.27	0.24	0.26
Percentage of Female Students	0.50	0.50	0.49	0.52	0.50
SES (Standardized Home Possessions)	0.22	0.46	-0.78	-0.45	0.38
Parental Education (BA or higher)	0.32	0.23	0.18	0.50	0.35
Percentage with a computer	0.90	0.85	0.64	0.61	0.97
N	4111	3991	4198	4472	4043