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Cross-National Variations in Rural Mathematics Achievement: A Descriptive Overview

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Using PISA 2000 data, this article examines cross-national variation in rural mathematics achievement among 15-year-olds in 24 industrialized nations. Rural mathematics scores were significantly lower than scores in urban and medium-size communities in 14 of 24 countries. However, patterns were complex. Most commonly, a linear relationship obtained between community size and average math score. In some countries, however, students in medium-size communities scored highest, followed by urban then rural locales. In some countries, such as the U.S., students in urban communities scored lowest. U.S. rural mathematics scores sit squarely in the middle of the distribution. One explanation for lower rural achievement is lower SES. Consistent with other studies, the U.S. showed a marginal raw rural achievement gap, which disappeared when SES was controlled. Once SES was controlled, rural locale predicted mathematics scores in only 4 of 24 countries. Only in Russia was rural locale a statistically significant negative predictor of mathematics achievement, net of socioeconomic status. However, the U.S. showed a substantial gap in urban achievement. Further analysis suggested positive interaction effects in the U.S. between school SES and both urban and rural location.

Rural education is often associated in the public discourse with disadvantage. An Internet search reveals a number of examples. Somewhat typical is a discussion of rural schools by the League of Rural Voters (2004), which claims: “Challenges posed by size, declining enrollment and geographic location put rural schools at an economic disadvantage, making it difficult to generate funding, recruit and retain teachers, and maintain school facilities.” “Rural schools at a disadvantage in the current education-reform climate,” says a headline in the February 18, 2003 *Christian Science Monitor* (Belsie, 2003). Washington Kids Count (2003) issued a press release entitled, “Washington’s rural schools at a disadvantage: Rural children face more problems, perform worse in school and have less support and resources than urban children.” In West Virginia, the Education Alliance claims, “Despite the national attention on improving student achievement emerging from the *No Child Left Behind Act*, many rural schools continue to face a host of challenges. Poverty, insufficient funding, isolation, and inadequate pool of qualified teachers, and high turnover among teachers and administrators continue to be major issues” (2004, p. 2).

Despite these perceptions, nationwide research in the U.S. has found a few differences in the mathematics achievement of children in rural and nonrural areas as measured, for example, by the National Assessment of Educational Progress (NAEP) and the Longitudinal Survey of American Youth (LSAY) (see Fan & Chen, 1999; Howley, 2002; NCES, 1991). At the state level, however, Lee and McIntire (2001) found substantial variations in average achievement levels on NAEP in rural versus nonrural schools. Interestingly, achievement gaps did not necessarily favor nonrural students. In some states, rural students scored significantly higher than nonrural students, whereas in other states, rural students scored significantly lower. These findings challenge a monolithic view of rural achievement as necessarily lower than nonrural achievement. Indeed, both Lee and McIntire and Howley find that students in rural schools frequently outperform students in nonrural schools.

This article looks beyond the U.S. to understand in an international context the extent of rural achievement gaps in mathematics among 15-year-olds in 24 mostly industrialized nations of the Organisation for Economic Co-operation and Development (OECD). Using the PISA (Programme in International Student Assessment) dataset, I ask: To what extent is there an international pattern of rural disadvantage in mathematics achievement? How do mathematics scores differ between rural and nonrural locales in each of the countries for which comparable data are available? Are there

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distinct national patterns of rural/nonrural achievement? Are locale-dependent patterns of mathematics achievement best understood in terms of a locale dichotomy (i.e., rural/nonrural) or a trichotomy (i.e., rural/medium-size communities/large urban centers)? To what extent can differences in rural achievement be explained by differences in the socioeconomic levels of rural versus nonrural students? Where does the U.S. reside in these global patterns?

Rural Mathematics Achievement in the U.S.

As suggested, a compelling series of research studies find little evidence of an overall rural achievement gap in the U.S. Achievement among rural children has been examined most extensively using data from NAEP, which assesses the performance of school children at different points throughout their school career. With assessments carried out since 1978, NAEP also permits the examination of trends over time. Using NAEP data, Howley (2002) found little change in the mathematics achievement of rural students from 1978-2000. Moreover, he found no current difference in the performance of rural students as compared with national averages. The largest historical difference was in 1982, when "extreme rural" eighth grade students scored 10 points lower than the national average, an effect size of -.25. Howley found no statistically significant differences between rural scores and the national average after 1986.

Fan and Chen (1999) analyzed nationally representative data from the National Education Longitudinal Study of 1988 (NELS: 88) to see if 8th, 10th, and 12th graders in rural and metropolitan areas differed in math, science, and social studies achievement. Their literature review identified five limitations of previous research—sampling issues, inconsistent or unclear definitions, socioeconomic status (SES) as a confounding variable, ethnicity as a potential confounding variable, and sector as a potential confounding variable (p. 33). Designing their study to overcome these limitations, the authors compared reading, math, science, and social studies scores (adjusted for SES) across rural, suburban, and urban locales—by ethnic group, public and private school sector, and region. Fan and Chen found that students from rural schools performed as well as their peers in suburban and urban areas in the four subject areas.

Like most researchers, Fan and Chen (1999) measured SES at the individual level, conceptualizing SES as a confounding variable that stands in the way of understanding the true relationship between locale and achievement. Accordingly, they used statistical controls to assess the net effects of rural locale independent of SES.[1] However, they did not explore the effects of school-level SES, which typically has an independent "contextual" effect on school performance over and above that of individual-level SES (Willms, 2002).

Intriguingly, Fan and Chen's (1999) review suggests that SES may have less of an effect on student achievement in rural schools than in urban schools (see Alspaugh, 1992). This is consistent with findings from others (e.g., Howley & Bickel, 1999; Lee & Smith, 1996), in which low SES students are found to perform better, on average, in smaller schools, which are more commonly found in rural areas. In smaller schools, the relationship between SES and student achievement is weaker, leading the authors to speculate that smaller schools provide less opportunity for differentiation among students, expose more students to academically challenging classes, and foster a greater sense of community than do larger schools. Lee and Smith's analysis identified 500-700 students as an ideal size for secondary schools in terms of achievement. Students in large schools were disadvantaged (especially in urban areas), as were students in small schools. SES was strongly and positively associated with achievement in all schools. But the effect of SES was weaker in small schools.

The relative disadvantage of both large and small schools (Howley & Bickel, 1999; Lee & Smith, 1996) raises the question of whether locale is better understood as a dichotomous variable—rural versus nonrural, or as a three-category variable of rural/medium-size communities/urban. Research and the popular view suggest that students in large U.S. inner cities are disadvantaged and likely to score lower, on average, on tests of academic achievement. Conflation of large urban centers, presumably including many low-scoring students, with suburban communities and smaller cities, where average student scores are likely higher, is likely to mask real achievement gaps among students in rural schools.

In a further challenge to a monolithic view of low rural achievement, Lee and McIntire (2001) used 1992 and 1996 NAEP data to assess differences in rural and nonrural student mathematics achievement across states. They found considerable interstate variation, with rural students scoring lower than nonrural students in some states but higher in others. These variations could be predicted by differences in the following factors: instructional resources, professional training, the availability of algebra classes, progressive instruction, a safe and orderly climate, and the extent of "collective support." Together, these factors explained 69% of the variation in nonrural math achievement and 84% of the total variation in rural math achievement. Instructional resources, safe/orderly climate, and collective support were statistically significant predictors of math achievement in rural schools. Interestingly, students in rural schools also

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[1] This makes analytic sense if one is attempting to assess the independent effect of location. Of course, in actual communities and schools, student socioeconomic status is more difficult to "control," and students and their socioeconomic status are not so easily distinguished.

showed greater improvement between 1992 and 1996 than did students in nonrural schools.

The notion that rural students are not disadvantaged simply by location is supported by other studies (e.g., Haller, Monk, & Tien, 1993; Stern, 1994). And so, U.S. research suggests the lack of a general rural achievement gap in mathematics. For the country as a whole, rural children achieve at levels similar to those of nonrural children. Still, there are likely to be substantial differences across states, but with no general pattern of rural disadvantage. At the same time, the rural/nonrural dichotomy may not be the most informative way to understand location-specific differences in achievement. Individual SES has been identified as a major confounding variable. Some research suggests, however, that the strength of the SES-achievement relationship may vary in rural schools.

To a comparativist, these findings raise questions about rural achievement in other countries. To the best of my knowledge, no research has examined rural math achievement gaps in an international context. This article reports the results of such an analysis. Examination of the patterns of rural achievement gaps across countries, it is hoped, will provide a larger context for understanding patterns of rural achievement in the U.S.

Comparative research must always ask whether comparison makes sense. One of the continuing problems facing cross-national research is definitional—assessing meaning within and across contexts. Within a given nation, it is usually assumed that meaning is consistent enough across constituent units and members to carry out meaningful analysis. But rural is likely to mean something quite different in different countries, perhaps even more different than rural New England and rural Utah. Nonetheless, failure to look across multiple contexts runs a parallel risk of missing the big picture in favor of the small.

In facing this problem, comparativists have traditionally proceeded in one of three ways. The first is to proceed with analysis regardless of potential threats to the validity of research. The second strategy is to focus on a small number of national cases and to look deeply both within and across cases. Such analyses produce useful and often insightful results, but they do not provide a view of the whole. The third approach, adopted here, is to look across a range of countries with full awareness of the problems of meaning, but to continue looking for a view of the whole and of the extent to which it is useful to look more deeply within particular contexts. It is useful to see, for example, whether the patterns observed in a particular country are seen elsewhere or whether they represent the particular social, political, economic, and cultural forces in one national context. If true everywhere, to what extent do such patterns vary across countries, and where along a continuum of experiences is "our" country located? If true in some contexts and not others, what factors might explain these differences? In these ways, cross-national analysis helps to place within-country analysis in a broader international context. At the same time, it is important to present a complete picture of analytic methods and results, including ambiguities, unknowns and possible over-generalization.

And so, I ask: Is there a more or less universal pattern of rural disadvantage across countries, or is rural disadvantage characteristic of some countries and not others? How large are these differences? Where does the U.S. stand in relation to other countries in terms of rural and nonrural student performance? To what extent do differences in socioeconomic status explain differences in achievement? Accordingly, four sets of questions guide the analysis:

1. For each country in the sample, do mathematics scores of 15-year-olds vary according to location? If so, how do scores vary, and how big are the differences?

2. Across countries, are there distinct patterns of differences in score by location? In other words, do differences in scores vary as a linear function of location in all countries (e.g., the larger the community, the higher the average score), or are there different patterns of variation across countries (e.g., in some countries do students in large cities score lowest)? Related is the question of whether it is useful to talk in terms of a two-level variable (rural/nonrural), or whether a three-level variable is more appropriate for capturing observed variation.

3. Within each country, do differences in mathematics scores by location remain after SES is controlled at individual and school levels?

4. Does the relationship between individual- or school-level SES and math score vary by location? Does SES have less of an "effect" on student achievement in rural areas? How does this vary across countries?

Methods

Data

The data source is PISA 2000, the Programme in International Student Assessment 2000, collected by the Organisation for Economic Co-operation and Development (OECD). First administered in 2000, PISA is a survey developed jointly by participating countries and designed to assess the knowledge and skills of 15-year-olds in reading, mathematics, and science. PISA focuses on age 15, which

Table 1
Definitions of Location/Community Size

PISA	NAEP
Rural < 15,000	Rural/small towns < 25,000
Medium-size 15,000-1,000,000	Urban fringe/large towns 25,000 or more
Urban > 1,000,000	Central cities Metropolitan statistical areas

is near the end of compulsory schooling in all participating countries. PISA is designed to complement other assessments such as TIMSS (Trends in Mathematics and Science Studies) and NAEP by measuring the broader notion of "literacy" skills in the domains of reading, mathematics, and science. PISA attempts to measure students' capacities to apply knowledge and skills, using assessment tasks involving multistep reasoning and real-world situations, as opposed to mastery of a particular curriculum. PISA has planned a new round of data collection every 3 years.

PISA 2000 data were collected from nationally representative samples of students and their principals in a two-stage, stratified, cluster design. Students were given a battery of academic tests and asked a number of questions about themselves, their attitudes and approaches to learning, and their schools. Principals completed questionnaires about their schools, facilities, instructional processes and climate, and resources. Student- and school-level data are linked, so it is possible to identify each student's school and associated characteristics. PISA 2000 collected data in 32 countries, with national student samples ranging from 300 to 10,000 students for a total of 265,000 students. See OECD (2001) and the Adams and Wu (2002) for further details.

For purposes of this analysis, data were examined for 24 countries. Data for other countries were not available by locale or were missing in one of the three categories of location.

Variables

Outcome: Mathematics score (MATH). The primary variable of interest is mathematics performance, a mathematics scale score (MATH), measured at the individual level and estimated with five "plausible values (PV1MATH . . . PV5MATH)." Plausible values use IRT scaling to estimate scores, in this case mathematics proficiency, when, as in PISA and many large-scale assessments, each student receives a subset of the total set of items. These procedures enable test designers to include a substantially larger number of items than would be feasible for individuals to complete.

Predictors: Location (LOCATION). The primary predictor of interest is community size, or location. In the school questionnaire, PISA asks school principals to identify the population of the community in which the school is located (SC01Q01), and this is the measure used here to measure rural. Six categories are provided: Village (less than 3,000); Small town (3,000-15,000); Town (15,000-100,000); City (100,000-1,000,000); City centre (more than 1,000,000); City elsewhere (more than 1,000,000). The present analysis uses a three-category variable (LOCATION) of Rural (<15,000 inhabitants); Medium-size (15,000-1,000,000), and Urban (>1,000,000). Dummy variables for RURAL (<15,000) and URBAN (>1,000,000) also were constructed from LOCATION, with Medium-size cities serving as the reference group.

Since 1996, NAEP has used a somewhat similar classification system based on the U.S. Census with "central cities" (central cities as defined by Metropolitan Statistical Areas); "urban fringe/large towns," a category combining towns of 25,000-50,000 inhabitants and metropolitan areas near central cities of 250,000 or more; and "rural/small towns" of less than 25,000. "Rural" is defined by the U.S. Census as areas with populations less than 2,500 (see Table 1).

Individual/student SES (HISEI). SES is measured using the PISA International Socio-Economic Index of Occupational Status, derived from student responses to questions about parental occupations. The index is designed to optimize equivalence in occupations across countries. Values on the index range from 16 to 90, with higher values representing higher socioeconomic status. PISA variable, HISEI, represents the higher of parental occupations. (For details on methodology, see Ganzeboom, De Graaf, & Treiman, 1992.)

School-level SES (HISEISCH). School-level SES is the average school SES based on the weighted sample mean of HISEI for each school.

Sample weights and replicate weights. Due to the complex sample design, it is necessary to use final sampling weights (W_FSTUW) to accurately represent the population and a series of replicate weights (W_FSTR1-W_FSTR80) to accurately estimate variance. These replicate weights were used with the WESTVAR software to develop correct estimates of standard errors, which analytic techniques such as ordinary least squares regression (based on an assumption of simple random sampling) tend to underestimate when analyzing data collected with complex, multistage sample surveys such as PISA.

Analytic Strategy

Analysis of data from a complex sample design is facilitated by use of WESTVAR, which can calculate accurate descriptive statistics, compare means, and carry out multiple regression analyses with plausible values, sample weights, and replicate weights. Analyses are carried out within and across countries. Initially, descriptive statistics are generated and examined for all variables within each country (see Table 2).

Question 1 asks whether, for each country in the sample, mathematics scores of 15-year-olds vary by location. Further, if there are differences, how do scores vary and by how much? In order to answer this question means were calculated within each country for MATH on each level of LOCATION, and a one-way ANOVA was carried out to test the null hypothesis of no differences among means. For presentation purposes, differences were calculated between rural and medium-size communities (Table 4) and between rural and large cities (Table 5) and expressed as a proportion of the pooled standard deviation.

Question 2 asks whether across countries there are distinct patterns of score differences by location. In other words, do differences in scores vary as a linear function of location in all countries (the larger the community, the higher the average score, for example), or are there different patterns of variation across countries (e.g., in some countries do students in large cities score lowest)? In order to answer this question, the patterns of mean scores by location were examined and countries grouped into patterns. Table 6 presents the results of this grouping.

Question 3 asks whether differences in mathematics scores by location remain statistically significant after SES is controlled. To answer this question, MATH was regressed on RURAL, URBAN, HISEI (student SES), and HISEISCH (school SES), in each country. Results are presented in Table 7.

Question 4 asks whether the relationship between individual- or school-level SES and math scores varies by location. This question gets at whether SES has less (or more) of an effect on student achievement in rural or urban areas, and how this effect varies across countries. To examine this question, MATH was regressed on RURAL, URBAN, HISEI, and HISEISCH as well as on interaction terms involving location and student SES for each country and then for school-level SES.

Findings and Discussion

Table 2 presents descriptive statistics. (The Appendix presents the *n* for each country and community size.)

Community Size and Mathematics Performance

The overarching question is whether mathematics performance varies according to location. Examination of simple differences in average scores suggests that mathematics performance does vary by community size (see Table 3). The U.K. shows the highest average achievement of rural students in this sample, followed by Finland, New Zealand, Japan, Belgium, and Australia. The U.S. ranks 15th of 24 countries.

To get a more precise understanding of these differences, Table 4 compares average mathematics scores in rural and medium-size communities. The relative size of gaps was estimated by dividing the differences (between average math scores in rural and medium-size locales) by the pooled standard deviation. Countries are presented in descending order of rural "effect." The U.S. ranks 16th of 24 countries, with a moderate to small effect of -.28. These differences in the U.S., however, are only marginally significant statistically ($p = .068$). Rural-medium size achievement gaps were statistically significant in 12 of the 24 countries. In all countries except the U.K., rural achievement scores were lower in rural areas than in medium-size communities. The uncontrolled effects of rural location ranged from +.13 *SD* in the U.K. to -.62 *SD* in Mexico.

Mathematics achievement gaps were more pronounced between rural and urban communities, where 11 out of 24 countries showed statistically significant differences. In three countries—Belgium, the U.S., and Ireland—rural scores were higher, on average, than urban scores. In Belgium in particular, rural scores were one standard deviation higher than urban scores. In the U.S., rural scores were more than one third of a standard deviation higher, though, again, the differences were only marginally significant. More commonly, students in urban areas scored higher than students in rural areas, with significant gaps ranging from +.34 *SD* in Australia to +.98 *SD* in France.

Patterns of Mathematics Achievement by Community Size

Examination of these results suggests a complex and variable relationship between mathematics achievement and location. It is not sufficient to talk simply of rural disadvantage. For example, while 15-year-olds in rural areas score lower, on average, than do their counterparts in medium-size communities in all countries except two, students in seven countries, including the U.S., score even lower in urban areas. Visual inspection of these variations suggests four patterns.

The most common is what might be termed "rural disadvantage, urban advantage." In this pattern, typified by France, for example, the larger the community size, the higher the average score. Fourteen of 24 countries showed this pattern; 11 were statistically significant.

The second most common pattern, where urban students score lowest, is named "urban disadvantage." This pattern characterized mathematics achievement in five countries including Ireland and the U.S., two of which were statistically significant.

A third, intermediate, pattern is referred to as "rural disadvantage, urban disadvantage." This pattern, typified

Table 2
Descriptive Statistics

	Math	Location			Student-level SES	School-level SES	
Country	*M* (*SD*)	Rural	Medium-size	Urban	*M* (*SD*)	*M* (*SD*)	*N*
Australia	533.3 (90.0)	14%	41%	45%	52.3 (16.8)	52.2 (4.1)	2,859
Austria	515.3 (92.4)	42%	42%	16%	49.8 (14.0)	49.8 (8.4)	2,640
Belgium	521.1 (106.2)	30%	70%	1%	49.1 (16.7)	48.8 (9.4)	3,784
Brazil	334.3 (97.4)	16%	62%	22%	44.0 (17.2)	43.7 (11.2)	2,717
Czech Republic	497.6 (96.3)	32%	55%	13%	48.2 (13.6)	48.2 (7.0)	3,066
Germany	491.7 (102.5)	35%	59%	6%	49.1 (15.8)	49.0 (8.3)	2,830
Denmark	514.9 (86.6)	55%	33%	12%	49.8 (16.1)	49.6 (8.1)	2,382
Spain	476.3 (90.5)	21%	69%	10%	44.9 (16.5)	44.7 (9.3)	3,428
Finland	536.2 (80.3)	39%	40%	21%	50.0 (16.5)	50.0 (7.3)	2,703
France	516.2 (89.3)	29%	67%	4%	48.4 (16.9)	48.1 (9.3)	2,597
United Kingdom	529.8 (91.7)	29%	55%	16%	51.2 (15.9)	51.0 (7.9)	5,195
Greece	448.1 (108.3)	21%	63%	16%	48.3 (18.1)	48.2 (9.8)	2,605
Hungary	488.5 (97.9)	18%	62%	20%	49.8 (15.9)	49.5 (9.8)	2,799
Ireland	502.8 (83.6)	60%	21%	19%	48.0 (15.2)	47.9 (6.4)	2,128
Italy	457.4 (90.4)	18%	70%	12%	46.9 (16.0)	46.8 (8.6)	2,765
Japan	556.6 (86.9)	14%	74%	13%	50.3 (15.5)	51.0 (6.4)	2,924
Korea	546.8 (84.3)	8%	46%	45%	43.0 (14.4)	42.9 (7.5)	2,769
Mexico	387.0 (82.7)	36%	51%	13%	42.7 (16.8)	42.4 (10.7)	2,567
New Zealand	536.9 (98.7)	24%	47%	29%	52.4 (17.0)	52.3 (8.1)	2,048
Poland	470.1 (102.5)	21%	71%	8%	45.9 (15.4)	45.6 (8.0)	1,976
Portugal	453.4 (91.3)	41%	51%	8%	44.2 (16.0)	44.0 (8.2)	2,545
Russian Federation	478.3 (104.1)	43%	43%	13%	49.8 (17.2)	49.7 (7.8)	3,719
Sweden	509.5 (93.4)	49%	44%	7%	50.3 (16.2)	50.3 (7.3)	2,464
USA	492.4 (98.3)	36%	55%	10%	52.3 (16.3)	51.9 (7.8)	2,135

Note. Full sample student weights used in calculations. Rural = <15,000 inhabitants; Medium-size = 15,000-1,000,000; Urban = >1,000,000.

Table 3
Math Performance by Location and Country: Means (Standard Deviations)

	Location			
Country	Rural	Medium-size	Urban	Overall
United Kingdom	537.7 (85.0)	526.4 (89.2)	526.9 (109.3)	529.8 (91.7)
(Finland)	534.0 (75.9)	538.4 (79.0)	536.1 (88.9)	536.2 (80.3)
New Zealand*	525.0 (96.1)	546.0 (96.7)	532.0 (103.3)	536.9 (98.7)
Japan*	523.1 (86.9)	562.4 (84.2)	551.4 (97.5)	556.6 (86.9)
Belgium*	522.3 (109.1)	521.4 (101.5)	408.1 (96.5)	521.1 (106.2)
Australia*	514.6 (85.6)	526.7 (87.0)	545.5 (91.4)	533.3 (90.0)
(Denmark)	512.5 (84.6)	515.7 (87.0)	523.6 (92.0)	514.9 (86.6)
Austria*	506.6 (93.2)	529.6 (86.8)	501.2 (98.8)	515.3 (92.4)
(Sweden)	505.8 (91.4)	512.8 (95.0)	515.5 (93.0)	509.5 (93.4)
Ireland*	503.9 (84.0)	518.3 (80.1)	481.8 (86.5)	502.8 (83.6)
Korea*	499.1 (79.9)	546.6 (84.8)	556.1 (82.0)	546.8 (84.3)
France*	488.5 (83.2)	524.5 (88.5)	573.0 (68.0)	516.2 (89.3)
Czech Republic*	483.5 (95.6)	501.4 (96.9)	515.9 (88.1)	497.6 (96.3)
(Germany)	483.4 (93.2)	499.5 (105.7)	466.2 (110.9)	491.7 (102.5)
USA	481.3 (88.6)	507.4 (94.5)	447.7 (99.8)	492.4 (98.3)
Spain*	465.6 (89.1)	476.2 (89.6)	500.3 (91.3)	476.3 (90.5)
Russian Federation*	452.7 (103.5)	496.8 (100.8)	502.1 (94.4)	478.3 (104.1)
(Italy)	448.9 (87.1)	461.6 (89.7)	444.8 (91.4)	457.4 (90.4)
Hungary*	446.9 (100.7)	493.5 (96.5)	511.6 (90.5)	488.5 (97.9)
(Greece)	439.6 (109.2)	448.9 (105.1)	456.8 (113.6)	448.1 (108.3)
Portugal*	436.1 (91.3)	462.8 (87.7)	482.4 (87.1)	453.4 (91.3)
Poland*	435.1 (100.7)	478.2 (102.2)	488.6 (90.4)	470.1 (102.5)
Mexico*	351.5 (72.5)	401.8 (81.2)	429.5 (71.5)	387.0 (82.7)
Brazil*	313.5 (85.3)	331.7 (97.5)	356.5 (97.6)	334.3 (97.4)
Overall	448.1 (112.1)	466.7 (123.5)	461.0 (122.5)	460.8 (120.6)

*$p < .05$ (for one or both comparisons of rural and medium-size community or rural and urban).

Table 4
Mathematics Achievement Gaps, Rural and Medium-Size Communities

	Location				
Country	Rural	Medium-size	Difference	Pooled *SD*	Effect Size
United Kingdom	537.7	526.4	11.3	87.9	.13
Belgium	522.3	521.4	1.0	103.8	.01
Denmark	512.5	515.7	-3.2	85.6	-.04
Finland	534.0	538.4	-4.4	77.5	-.06
Sweden	505.8	512.8	-7.0	93.1	-.08
Greece	439.6	448.9	-9.3	106.2	-.09
Spain	465.6	476.2	-10.6	89.6	-.12
Australia	514.6	526.7	-12.1	86.8	-.14
Italy	448.9	461.6	-12.8	89.3	-.14
Germany	483.4	499.5	-16.0	101.5	-.16
Ireland	503.9	518.3	-14.5	83.2	-.17*
Czech Republic	483.5	501.4	-17.8	96.8	-.18
Brazil	313.5	331.7	-18.3	95.4	-.19
New Zealand	525.0	546.0	-21.0	97.0	-.22**
Austria	506.6	529.6	-22.9	90.7	-.25*
USA	481.3	507.4	-26.1	93.0	-.28
Portugal	436.1	462.8	-26.7	90.5	-.29*
France	488.5	524.5	-36.0	88.3	-.41*
Poland	435.1	478.2	-43.1	103.3	-.42***
Russian Federation	452.7	496.8	-44.1	104.6	-.42***
Japan	523.1	562.4	-39.3	85.8	-.46*
Hungary	446.9	493.5	-46.6	99.5	-.47**
Korea	499.1	546.6	-47.5	85.7	-.55**
Mexico	351.5	401.8	-50.3	81.5	-.62***

$^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Table 5

Mathematics Achievement Gaps, Rural and Urban Communities

	Location				
Country	Rural	Urban	Difference	Pooled *SD*	Effect Size
Belgium	522.3	408.1	114.2	109.6	1.04***
USA	481.3	447.7	33.6	92.5	.36
Ireland	503.9	481.8	22.1	84.2	.26**
Germany	483.4	466.2	17.2	96.9	.18
United Kingdom	537.7	526.9	10.7	94.8	.11
Austria	506.6	501.2	5.4	94.7	.06
Italy	448.9	444.8	4.1	88.9	.05
Finland	534.0	536.1	-2.1	80.1	-.03
New Zealand	525.0	532.0	-7.0	100.5	-.07
Sweden	505.8	515.5	-9.7	91.0	-.11
Denmark	512.5	523.6	-11.1	87.0	-.13
Greece	439.6	456.8	-17.2	112.1	-.15
Japan	523.1	551.4	-28.4	91.1	-.31
Australia	514.6	545.5	-30.9	91.4	-.34**
Czech Republic	483.5	515.9	-32.4	95.2	-.34**
Spain	465.6	500.3	-34.8	91.0	-.38*
Brazil	313.5	356.5	-43.1	97.1	-.44***
Russian Federation	452.7	502.1	-49.4	103.5	-.48***
Portugal	436.1	482.4	-46.3	92.6	-.50
Poland	435.1	488.6	-53.5	100.2	-.53
Hungary	446.9	511.6	-64.7	101.3	-.64***
Korea	499.1	556.1	-57.0	83.2	-.69***
Mexico	351.5	429.5	-78.0	80.4	-.97***
France	488.5	573.0	-84.5	86.3	-.98***

$^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Table 6
Patterns of Mathematics Achievement Gaps

Pattern of Gap	Countries
Rural Disadvantage-Urban Advantage	Australia, Brazil, Czech Republic, (Denmark), France, (Greece), Hungary, Korea, Mexico, Poland, Portugal, Russia, Spain, (Sweden)
Rural Disadvantage-Urban Disadvantage	Japan, (Finland), New Zealand
Urban Disadvantage	Austria, (Germany), Ireland, (Italy), USA
Rural Advantage	Belgium, United Kingdom

Note: For countries in parentheses, there were no statistically significant differences between rural and medium-size communities or rural and urban communities.

by Japan, shows rural students scoring lowest, on average, followed by students in large urban areas.

A final pattern, named “rural advantage” and found in this sample only in the U.K. and Belgium, shows the highest average scores in rural areas. Table 6 lists countries by pattern, and Figure 1 provides a visual representation of the four patterns.

Thus, it is clear that rural students score lower in mathematics than nonrural students in most, but not all, countries. At the same time, there are different patterns of achievement. In some countries, the lowest average scores are among rural students; in other countries, the lowest scores are among urban students. Only in Britain do rural students score highest, although the margin is not great. The U.S. also shows marginally significant differences between the mathematics scores of students in rural and medium-size communities and between urban and rural students, with urban students scoring the lowest. Figure 2 shows average U.S. scores by location in comparison with the several “Anglo” systems, Australia, New Zealand, and the U.K. Although there is substantial within-location variation, and differences across location in the U.S. are only marginally significant, U.S. averages do not compare well with those of other Anglo systems. Indeed, there would seem to be a general tendency for countries with large rural gaps to have lower overall mathematics scores.

Controlling for Individual- and School-Level SES

In order to confirm the presence of a rural effect, it is useful to control for socioeconomic status at individual and at aggregate school levels. Rural populations are often poorer than more urban counterparts, due to lack of economic opportunities and development and a variety of other factors associated with rural life. For these reasons, it is useful to see whether the effects of rural location on mathematics achievement remain significant once the effects of individual- and school-level SES have been removed. To this end, I regressed, for each country in the sample, PISA’s five plausible values of mathematics on dummy variables for rural and urban location and on individual- and school-level SES. The results are presented in Table 7. Countries are listed alphabetically in two groups: an initial set of seven countries, where rural location is a significant or marginally significant predictor of mathematics scores once SES was controlled, and the remaining 17 countries, where rural location was not associated with variations in mathematics scores.

As expected, the SES variables, both individual student and especially school-level SES, are strong predictors of mathematics scores. Indeed, individual-level SES is a significant predictor of mathematics in all countries except Japan, and school-level SES predicts mathematics scores in all countries except Finland. Rural and urban location are much less consistent. Once SES is controlled, rural location predicts mathematics scores in only 4 of 24 countries. And the effects are complex: In Germany, Greece, New Zealand, and Sweden, rural location is positively associated with mathematics, once urban locale and SES are controlled. In Mexico, Russia, and Hungary, rural location is negatively associated with mathematics, net of SES and urban controls. Interestingly, in Germany, Sweden, and Greece, rural assumes significance only after SES and urban locale are controlled. In the U.S., rural is not a significant predictor of variation in mathematics scores once SES is controlled.

Urban location independently predicts mathematics scores in 7 of 24 countries, with all net effects negative. Once SES and rural locale are controlled, urban location has a net negative effect on mathematics performance in one third to one half of those countries. And in most cases (only Korea is significant), the negative net effect of urban location is greater than the effects—positive, negative, or insignificant—of rural locale.

Table 7

Regression of Mathematics on Rural Locale, Urban Locale, Student SES, and School SES

Country	Intercept	Rural	Urban	Student SES	School SES	*F*	R^2
Germany	127.7^{a}	15.5*	-26.1	0.7***	6.7***	109.3***	.36
	(17.7)^{b}	(7.3)	(15.4)	(0.1)	(0.4)		
Greece	173.4	24.4	-30.9	0.7***	5.0***	42.6***	.23
	(27.7)	(13.0)	(16.6)	(0.2)	(0.6)		
Hungary	173.0	-14.3	-19.9*	0.6***	6.0***	146.4***	.39
	(15.8)	(8.2)	(7.7)	(0.1)	(0.3)		
Mexico	235.6	-13.1	13.8	0.4***	3.3***	62.5***	.28
	(14.6)	(7.7)	(10.1)	(0.1)	(0.3)		
New Zealand	310.5	13.1*	-16.6**	1.4***	3.1***	54.2***	.15
	(21.2)	(6.2)	(5.5)	(0.2)	(0.4)		
Russian Federation	293.2	-28.4***	-9.4	0.8***	3.3***	56.3***	.14
	(25.8)	(8.5)	(9.6)	(0.1)	(0.6)		
Sweden	337.1	14.7**	-4.2	1.7***	1.7***	56.1***	.12
	(21.4)	(4.6)	(11.4)	(0.1)	(0.4)		
Australia	351.1	7.6	4.7	1.2***	2.3***	57.51***	.15
	(19.8)	(8.2)	(6.2)	(0.2)	(0.4)		
Austria	229.9	-0.3	-33.3**	0.5***	5.3***	54.1***	.23
	(22.9)	(9.0)	(10.2)	(0.1)	(0.4)		
Belgium	245.7	1.9	-16.6	0.9***	4.9***	102.5***	.27
	(22.2)	(8.4)	(12.7)	(0.1)	(0.4)		
Brazil	160.2	2.1	1.6	0.7***	3.3***	45.5***	.21
	(13.9)	(8.4)	(7.6)	(0.2)	(0.3)		
Czech Republic	124.5	-0.2	-30.4***	1.1***	6.8***	82.5***	.29
	(25.9)	(7.7)	(8.6)	(0.1)	(0.6)		
Denmark	369.2	9.1	-3.7	1.2***	1.7***	33.0***	.10
	(20.4)	(5.6)	(7.6)	(0.1)	(0.4)		
Finland	471.5	1.4	-9.2	1.2***	0.1	38.0***	.07
	(20.3)	(4.5)	(5.7)	(0.1)	(0.4)		
France	312.7	-9.0	1.4	0.6***	3.8***	51.5***	.21
	(22.7)	(8.2)	(14.7)	(0.1)	(0.5)		
Ireland	342.8	-0.4	-21.6**	1.2***	2.3***	43.0***	.12
	(20.9)	(5.0)	(7.2)	(0.1)	(0.4)		

Continued on page 12

Table 7 *(continued from page 11)*

Country	Intercept	Rural	Urban	Student SES	School SES	F	R^2
Italy	268.6	6.8	-16.9	0.3*	3.8***	21.7***	.15
	(20.5)	(12.1)	(9.4)	(0.1)	(0.5)		
Japan	301.9	-1.3	-17.3	0.0	5.5***	5.7***	.14
	(60.1)	(20.3)	(30.0)	(0.1)	(1.2)		
Korea	349.6	-19.5	-11.0*	0.2*	4.6***	33.5***	.17
	(23.2)	(18.1)	(5.5)	(0.1)	(0.6)		
Poland	144.4	6.6	-20.9	0.4*	6.9***	45.2***	.33
	(28.3)	(12.1)	(11.6)	(0.2)	(0.6)		
Portugal	252.2	9.2	6.6	1.2***	3.4***	59.9***	.21
	(21.0)	(8.4)	(10.8)	(0.1)	(0.5)		
Spain	338.6	5.4	9.4	1.1***	2.0***	37.8***	.13
	(15.8)	(6.7)	(11.3)	(0.2)	(0.4)		
United Kingdom	284.3	-1.7	-4.3	1.2***	3.7***	85.1***	.22
	(15.2)	(4.3)	(7.1)	(0.1)	(0.3)		
USA	220.8	-0.1	-44.8**	1.2***	4.3***	37.8***	.21
	(30.2)	(9.0)	(17.1)	(0.2)	(0.5)		

[a] Unstandardized coefficient. [b] Standard error.
$^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Thus, it would appear that across nations, a great deal of the rural achievement gap can be explained by SES. Once SES is held constant, rural location has, if anything, only a modest relationship with mathematics scores. In half of the countries where a marginal or statistically significant relationship was found between rural location and mathematics scores, the relationship was positive. Only in the Russian Federation was a statistically significant rural achievement gap identified independently of SES.

Of course, the lack of an independent rural location effect does not negate the differences in rural and nonrural mathematics achievement observed in 16 countries. What it does mean is that differences in socioeconomic status of rural students and their schools explain these differences. Further research is necessary to assess whether socioeconomic differences between rural and nonrural students are paralleled by differences in school inputs and characteristics that may also explain differences in achievement.

Interactions between Rural Locale and SES

To assess the possibility of a greater or lesser effect of SES in rural (or urban) areas, I added an interaction term to each of the country regression models above (Rural x Individual SES and Urban x Individual SES). Then, I substituted similar interaction terms involving school-level SES. Interactions between rural or urban location and individual-level SES were not significant. However, interactions with school-level SES were significant in a number of cases (see Table 8).

Each of the four possible sets of interaction effects were statistically significant in at least one country (see Table 9), in addition, of course, to countries in which one or both interaction effects were not statistically significant. Interaction effects with student and school SES need to be understood in the context of their positive and statistically significant main effects. Thus, a negative interaction between school SES and rural, for example, suggests that in a particular country, school SES, while strongly associated with mathematics performance net of the effects of other variables, has less of an effect on mathematics scores in rural areas in that country.

Take, for example, the case of Australia, shown in Figure 3. Figure 3 plots three estimated within-group regression lines for mathematics as predicted by school SES. The top line represents the estimated mathematics scores for

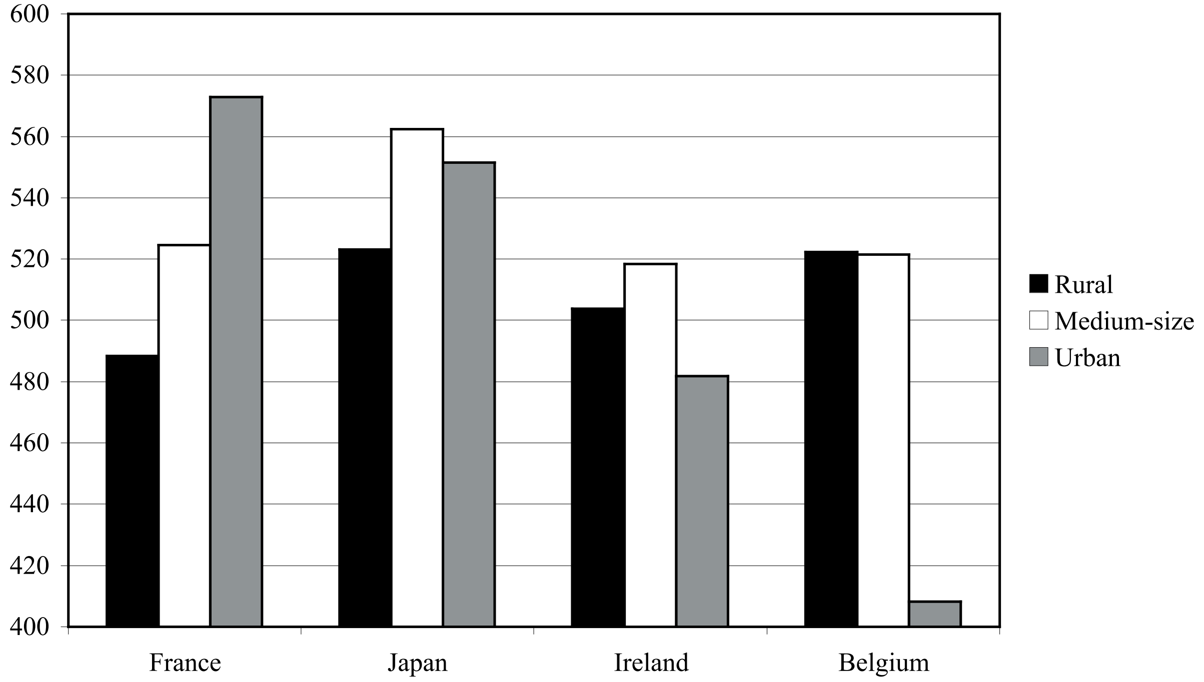

Figure 1. Four patterns of variation in mathematics achievement and community size

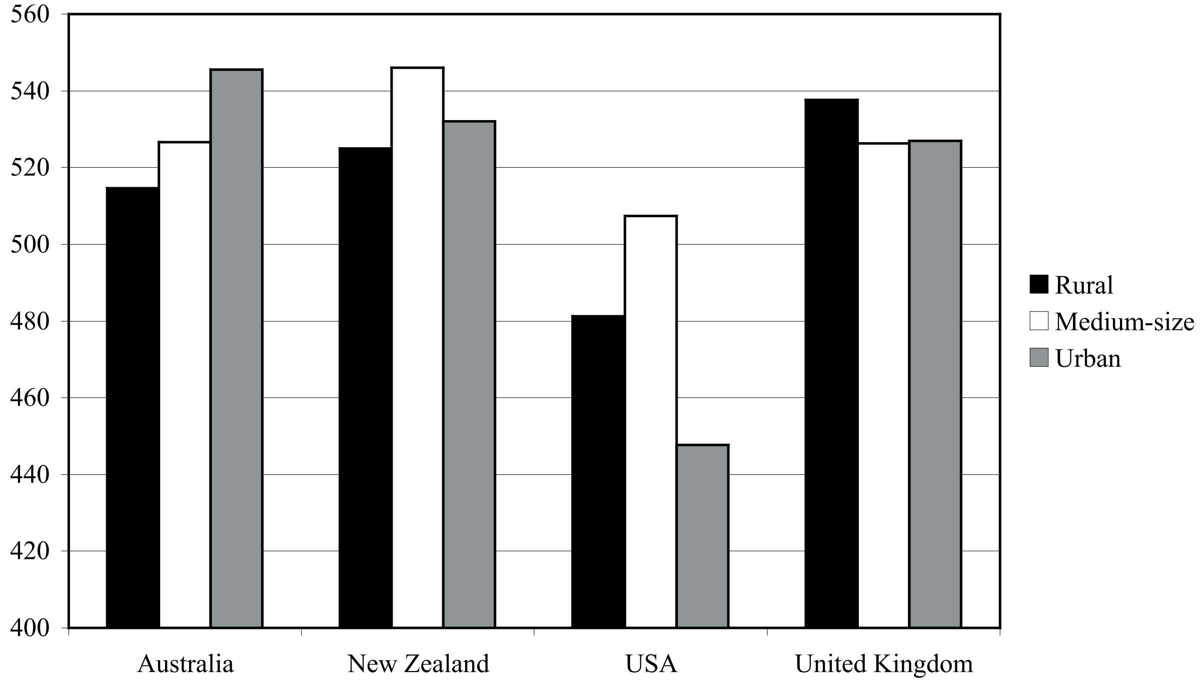

Figure 2. Four patterns of variation in mathematics achievement by community size, U.S., and three anglophone systems

Table 8

Interaction Effects between Locale and School SES

	Rural x School SES		Urban x School SES	
Country	Coefficient (SE)	*p*	Coefficient (SE)	*p*
Australia	-.97 (.19)	< .001	-.78 (.20)	< .001
Austria	.08 (.23)	.713	.96 (.29)	.002
Brazil	-1.01 (.20)	< .001	.86 (.18)	< .001
Czech Republic	-2.68 (.24)	< .001	-.31 (.35)	.385
Germany	-.53 (.17)	.002	-.63 (.50)	.212
Denmark	-2.24 (.17)	< .001	.75 (.17)	< .001
Spain	-.70 (.26)	.009	1.03 (.26)	< .001
Finland	.16 (.22)	.463	-.69 (.26)	.008
France	.63 (.27)	.021	-2.36 (.47)	< .001
United Kingdom	-.35 (.15)	.022	2.46 (.17)	< .001
Greece	-.73 (.28)	.010	.07 (.26)	.783
Hungary	.63 (.20)	.002	-.73 (.17)	< .001
Ireland	-.30 (.20)	.140	1.50 (.23)	< .001
Italy	-.20 (.42)	.631	2.51 (.28)	< .001
Japan	-1.38 (.78)	.083	10.75 (1.12)	< .001
Korea	-4.69 (.24)	< .001	-.62 (.25)	.017
Mexico	-.97 (.19)	< .001	-.78 (.20)	< .001
New Zealand	-.22 (.23)	.319	1.49 (.21)	< .001
Poland	1.48 (.36)	< .001	1.31 (.36)	< .001
Portugal	.21 (.27)	.439	.23 (.26)	.387
Russia	.78 (.26)	.003	.64 (.30)	.037
Sweden	-.71 (.19)	< .001	-.06 (.34)	.852
USA	.61 (.24)	.014	3.60 (.43)	< .001

Table 9
Cross-National Patterns of Locale x School SES Interactions

Negative rural interaction/Negative urban interaction

- Both Rural & Urban interactions significant:
    - Australia, Korea, Mexico
- Rural interaction significant:
    - Czech Republic, Germany, Sweden

Negative rural interaction/Positive urban interaction

- Both Rural & Urban interactions significant:
    - Brazil, Denmark, Spain, United Kingdom, New Zealand
- Rural interaction significant:
    - Greece
- Urban interaction significant:
    - Ireland, Italy, Japan

Positive rural interaction/Negative urban interaction

- Both Rural & Urban interactions significant:
    - France, Hungary
- Urban interaction significant:
    - Finland

Positive rural interaction/Positive urban interaction

- Both Rural & Urban interactions significant:
    - Poland, Russia, USA
- Urban interaction significant:
    - Austria
- Neither interaction significant:
    - Portugal

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average urban students at different levels of school SES, the bottom line does so for rural students, and the middle line does so for students in medium-size communities. Two points should be made. First is the obvious achievement gaps noted above between students in rural, medium-size, and urban communities. Second, the steepness of the gradient, or predicted linear relationship between school SES and mathematics varies by location. In other words, the effects of the socioeconomic makeup of the school on mathematics performance vary by locale.

In most countries, student SES is a significant predictor of mathematics achievement, but the effect of student SES does not vary systematically by rural or urban locale. In contrast, the effects of school SES on mathematics performance do, in many countries, vary according to location. In some countries, school SES has a greater effect on mathematics performance in rural areas, while in other countries it has a weaker effect in rural areas, and in still other countries, it makes no statistical difference. The implications are that equity effects may vary by rural and urban locale, and across countries. This analysis identifies four patterns of variation (see Table 9). Subsequent analyses will work to explain and account for those differences, using multilevel modeling.

The U.S. is an interesting case. Unlike the majority of countries, mathematics achievement is lowest in large urban areas rather than rural areas. Indeed, the gap in mathematics performance between students in rural and medium-size communities is less than that between students in urban communities and others. The positive effects of school SES, while significant for all locales, are particularly pronounced in U.S. urban areas, and less but still significantly so in rural areas. In medium-size U.S. communities, mathematics scores appear to be somewhat less dependent on SES. In rural and particularly in large urban areas in the U.S., however, school SES appears to make a significant difference in mathematics performance of 15-year-olds.

Conclusions

In 14 of 24 countries, rural mathematics scores were significantly lower than scores in urban and medium-size communities. Only in the U.K. and Belgium were average rural math scores higher. Rural math achievement gaps appear to be a common, but not universal, phenomenon. The pattern of variation in locale-specific achievement was complex, however. In some countries, such as Australia, there was a linear relationship between community size and average math score: the larger the community, the higher, on average, the score. This was the most common pattern. In other countries, such as Japan, medium-size communities scored highest, followed by students in urban locales, then rural. Still in some countries, such as the U.S., students in urban communities scored substantially lower than did students in either rural or medium-size communities. Finally, rural students scored slightly higher than students in medium-size communities in Belgium and the U.K., and urban students scored lowest of all, as in the U.S. pattern. Because of these complexities, it appears less useful to talk in terms of a two-level locale variable (rural/nonrural) than a three-level conception of locale.

The literature has suggested that differences in rural/nonrural achievement may be an artifact of lower socioeconomic status of rural residents. And so, regression analyses were carried out for each country in which mathematics

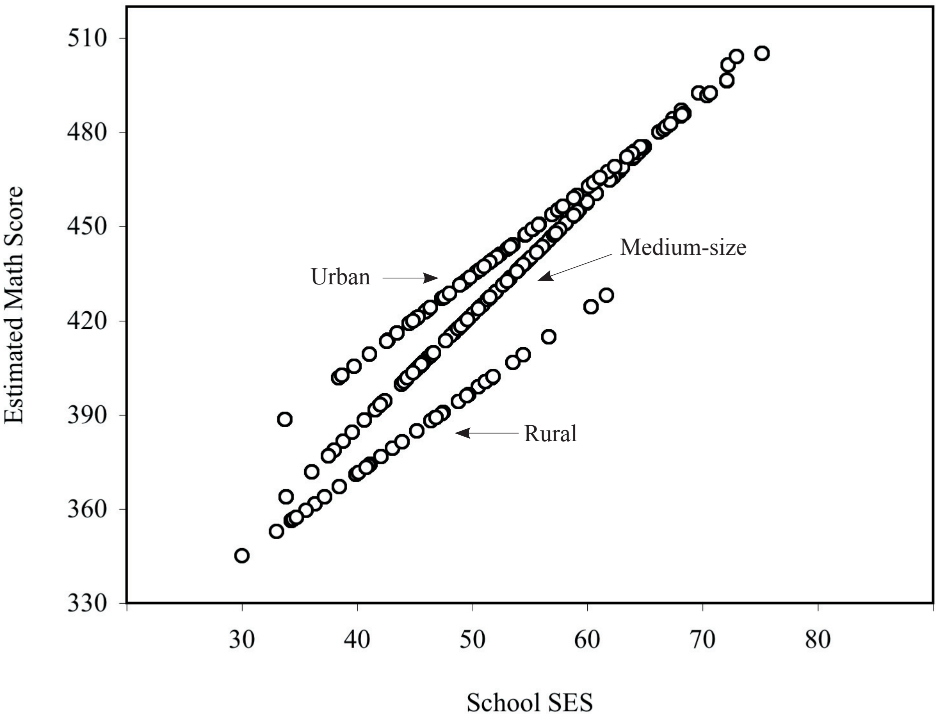

Figure 3. Estimated math scores by school SES and locale, Australia

was regressed on rural locale, urban locale, student SES and school SES. Once SES was controlled, rural locale was a statistically significant predictor of mathematics in only 4 of the 24 countries. Interestingly, rural locale was positively associated with mathematics in three of the four countries (Sweden, Germany, New Zealand). Only in Russia was a statistically significant negative effect of rural location identified, net of socioeconomic status.

Consistent with other studies of rural achievement, the U.S. was found to have only a marginal raw rural achievement gap, a gap that disappeared when SES was controlled. However, the U.S. was characterized by a substantial and persistent urban achievement gap. Further analysis suggested positive interaction effects in the U.S. between rural locale and school SES on the one hand and between urban location and school SES on the other. In other words, the socioeconomic makeup of the school had a greater positive effect on mathematics achievement in rural and urban areas in the U.S. than in medium-size communities. Conversely, the negative effects of low SES schools on mathematics achievement in the U.S. would be expected to be correspondingly greater in rural and urban areas. At the outset, the question was posed as to how the U.S. fit into global patterns. U.S. rural mathematics scores sit squarely in the middle of the distribution of average national rural math scores. While this analysis suggests the lack of an overarching pattern across nations, the U.S. shares with several other countries a relatively minor rural achievement gap, which disappears when SES is controlled, coupled with a quite pronounced and robust gap in urban achievement.

Further research is needed to explain these cross-national differences in locale-specific achievement gaps, as well as locale-specific SES effects. It will be interesting to see if cross-national differences in math achievement can be explained by differential access to resources or other systematic differences in factors measured by PISA, such as Lee and McIntire (2001) did in the U.S. It will also be important to see whether the lower socioeconomic status of rural students and schools that explains rural mathematics gaps is associated with a corresponding lower level of school inputs and characteristics and how individual student characteristics such as SES, the socioeconomic composition of schools, and school inputs and characteristics relate to rural and urban locale in terms of mathematics achievement. At this point, at least, it can be said that there is little cross-national evidence for a systematic rural mathematics achievement gap, beyond the effects of low SES.

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Appendix
Numbers of Respondents by Country and Location

	N			
Country	Rural	Medium-size	Urban	Total
Australia	412	1,452	995	2,859
Austria	1,141	1,087	394	2,622
Belgium	1,037	2,600	20	3,657
Brazil	598	1,534	544	2,676
Czech Republic	917	1,754	395	3,066
Denmark	1,250	754	269	2,273
Finland	1,056	1,081	566	2,703
France	664	1,569	94	2,327
Germany	855	1,538	159	2,552
Greece	680	1,479	402	2,561
Hungary	510	1,729	533	2,772
Ireland	1,239	458	413	2,110
Italy	472	1,960	333	2,765
Japan	307	2,127	354	2,788
Korea	301	1,234	1,234	2,769
Mexico	849	1,317	347	2,513
New Zealand	513	979	556	2,048
Poland	379	1,443	154	1,976
Portugal	952	1,339	202	2,493
Russian Federation	1,527	1,683	509	3,719
Spain	795	2,331	302	3,428
Sweden	1,183	1,070	165	2,418
United Kingdom	1,763	2,636	404	4,803
USA	577	921	180	1,678
Total Sample	19,977	36,075	9,524	65,576