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Cross-National Variations in Rural and Socioeconomic Effects on Mathematics Achievement: A Statistical Overview

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March 2004

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Introduction

In the popular view, somehow, rural schools often just do not measure up. The world over, rural schools generally get short shrift in the allocation of resources and prestige, their lack of urbanness often a self-fulfilling indicator of deficiency. As a result perhaps, rural students may perform, on average, less well than others in terms of the expectations and needs of parents and communities as well as on standard measures of achievement. Though every country has rural schools—schools that are often identified as troubled—little research has examined rural schooling across nations. Even the most basic descriptive information is lacking: How prevalent are rural schools in different countries? What percentage of students live in rural areas? How do rural students perform relative to their non-rural counterparts? Are patterns of achievement by rural students consistent across countries? Of particular interest are the poor. How well do poor rural students perform relative to other groups of students? How big a role do family characteristics play in conditioning academic performance in rural areas? What are the value and the values of rural education? Such questions are especially salient for mathematics, for mathematics competence is essential to full participation in the economic, political and social life of the community and the nation. In addition, rural children, it is commonly thought, suffer particular disadvantage in mathematics.

This initial descriptive analysis and statistical overview are intended to begin a larger analysis of these issues. I use data from the 2000 administration of the Programme on International Student Assessment (*PISA 2000*; OECD, 2001).

PISA is among the latest in a series of international comparisons of student achievement dating back some 40 years. These studies include the IEA studies

(International Assessment of Achievement) and the TIMSS studies (Trends in International Mathematics and Science Studies), which examined the mathematics and science achievement of US students compared with that of students in other countries. TIMSS was administered in 1995 (grades 4, 8, final year), 1999 (grade 8), and 2003 (grades 4, 8). TIMSS includes a number of components: assessments; student, teacher, and school questionnaires; benchmarking, video and curriculum studies as well as a series of case studies. 50 countries participated in the 2003 study, compared with 42 and 38 in 1995 and 1999, respectively. TIMSS is explicitly linked to acquisition of critical concepts taught in mathematics and science curricula.

PISA, by contrast, aims to understand the broader notion of literacy in three domains of reading, mathematics, and science. It assesses the knowledge and skills of 15-year-olds, beginning in 2000 with a stratified random sample of 265,000 students from 32 countries. The survey plans to collect data every three years, with a primary focus on reading, mathematics, or science each year. The 2000 survey emphasized reading, while the 2003 survey emphasized mathematics. Students are 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. PISA attempts to measure students' capacities to apply knowledge and skills in reading, mathematics, and science, as opposed to mastery of a particular curriculum. PISA tests students at a particular age, 15, rather than students at a particular grade. PISA data have not, to the best of my knowledge, previously been examined in relation to rural-urban locale.

In the U.S., rural issues have been examined most extensively using data from the National Assessment of Educational Progress(NAEP). NAEP has provided a series of assessments since 1978, permitting examination of trends over time. NAEP assesses performance of school children at points throughout their school career. In contrast to the expectation of rural deficiency, few differences have been found between the mathematics performance of rural and non-rural children in the United States (Howley, 2002). Instead, scores are remarkably similar and consistent over time.

Other U.S. studies have also found little evidence of a rural deficit. Fan and Chen, using NELS data, found no effective difference between scores of rural and non-rural children of similar ethnic and socioeconomic status (1999). Lee and McIntire (2000) used NAEP data to find, instead, a positive difference favoring rural students over non-rural students. Lee & McIntire considered a variety of conditions of schooling to explain differences in rural/non-rural achievement across states. Conditions of schooling in some states favored learning on the part of rural children, whereas conditions in other states had a disadvantaging effect.

Essentially, this first paper seeks to answer six interrelated questions:

1) How prevalent are rural students, and how does prevalence vary across industrialized nations?

2) How does students' mathematics performance vary across rural-urban locales?

3) Is there a rural disadvantage, how big is it, and how consistent is it across countries?

4) How large a role does socioeconomic status (SES) play in determining (or at least predicting) mathematics achievement?

5) Does the relationship between SES and mathematics performance vary across nations, and if so, how?

6) Does the relationship between SES and mathematics performance vary between rural and non-rural students, and if so, how?

Subsequent analyses will extend the current study into cross-national models and determinants of rural student performance in mathematics.

Perhaps the key findings of this analysis, elaborated in the text that follows, are that:

1) rural students generally, but not universally, score lower than their non-rural counterparts, and
2) the effects of SES, while nearly universal in direction and significance, vary *widely* in magnitude.

Simply put, SES matters a great deal more in some countries than in others. Similarly, rural location matters more in some countries than others, and in different ways.

Operationalizing "Rural"

One of the perpetual problems facing cross-national research is definitional, assessing meaning within and across contexts. Within a given nation, it might be argued and is usually assumed, meaning is consistent enough across members to carry out analysis. I would argue that most research faces similar issues of meaning; cross-national research simply highlights them. It is easy to see how the assumption of shared meaning might be problematic even within countries. Consider the issue of school-community relations, for example. Is the meaning of “community” widely enough shared across different groups within the United States, for example, to compare attitudes and policies toward community?

In addressing this problem, cross-national researchers have traditionally proceeded in one of three ways: The first is to proceed with analysis regardless of potential threats to the validity of research, for example, in which community is understood differently enough in different contexts, often in unknown ways, to question the truth of findings. If one group understands community to mean the people living in geographic proximity, whereas another understands community to be people linked closely by family and history, regardless of current domicile, one might question whether the same variable is being examined. The second strategy for cross-national researchers is to focus on a very small number of national cases, and to look deeply both within each case and across cases. Such analyses produce very useful results, but they do not provide a view of the whole. The third approach, the one 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 explain these differences? In these ways, cross-national analysis helps to place within-country analysis within a broader international, possibly human, 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.

In this analysis, PISA asks school principals to identify the population of the community in which the school is located, and this is the measure used here as proxy for 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 million); City centre (more than 1 million); and Metropolitan (more than 1 million elsewhere outside of cities). Again with full awareness that the meaning of communities of different sizes may vary across (and possibly within) nations, it is useful, I believe, to take an initial look at how nations compare in terms of these fixed categories. Initially, I look at all six. Later, in order to gain a more precise view of rural schooling, I collapse the six into three categories: (Rural; Medium-Sized, and Large Cities) and then two, Rural (including Village and Small town) and Non-Rural (including Town, and the various sizes of City). In all cases, "rural" is defined as communities with populations of 15,000 or less. Appendix A shows the classification. I use the term *community size* to denote these variables.

For purposes of presentation, results are presented as propositions, initial statements of findings, subject to verification, refutation, or modification.

Overall Patterns

1. All countries have rural students, but countries vary greatly in the proportions of 15-year olds in rural schools.

Table 1 shows the distribution of 15-year-olds across communities of different sizes in PISA countries. Countries are ranked from high to low in terms of the percentages of 15-year-olds in rural areas. (The table also indicates the percentage of cases missing and the population of cases, with the sample weighted to reconstitute the population. Weighted figures are used throughout this paper, except when otherwise indicated.)

The smaller countries in northern Europe have the highest proportion of rural students, ranging from 100 percent in Liechtenstein to two thirds in Norway, to more than half in Ireland, Switzerland, and Denmark. The only geographically large country in the sample with a large rural population is Russia, at 43 percent. The US is in the middle of the distribution, with one-third of its 15-year-olds in rural areas, similar to Mexico and Germany. In contrast, less than one in six school-going 15-year-olds live in rural areas in Korea, the Netherlands, Australia, Japan, and Brazil.

Table 1. Percentage distribution of 15-year old school population by community size.

	Village	Small Town	= RURAL	Town	Small City	City	Metro	%Missing/NA	Population (sample, weighted)
LIECHTENSTEIN	20	80	100	0	0	0	0	0	326
NORWAY	40	27	67	21	11	0	0	4	49,809
IRELAND	28	32	60	13	8	12	7	1	55,724
SWITZERLAND	13	45	58	25	17	0	0	3	72,326
DENMARK	30	25	55	26	7	7	5	5	48,433
SWEDEN	23	27	49	33	11	4	3	2	94,916
LATVIA	23	21	44	26	25	5	0	13	29,509
RUSSIAN FEDERATION	31	12	43	20	24	8	5	0	1,971,107
AUSTRIA	8	34	42	26	15	4	12	1	71,305
PORTUGAL	5	36	41	37	14	7	1	2	99,850
FINLAND	17	22	39	33	7	15	6	0	62,750
MEXICO	15	21	36	24	27	6	6	2	961,637
UNITED STATES	**8**	**28**	**36**	**34**	**20**	**4**	**5**	**23**	**3,115,078**
GERMANY	7	28	35	41	18	2	5	11	822,854
LUXEMBOURG	0	32	32	18	50	0	0	7	4,148
CZECH REPUBLIC	8	23	32	38	18	2	11	0	126,028
BELGIUM	5	25	30	49	21	1	100	4	110,842
UNITED KINGDOM	9	21	29	35	20	9	7	8	641,494
FRANCE	7	22	29	52	15	1	3	11	730,642
NEW ZEALAND	13	11	24	30	17	13	16	0	46,929
GREECE	5	16	21	46	17	9	7	2	142,033
SPAIN	2	19	21	33	37	4	6	0	396,086

POLAND	3	17	21	40	31	6	2	0	528,798
HUNGARY	2	16	18	40	22	11	9	1	107,963
ITALY	2	16	18	52	18	12	100	0	510,677
BRAZIL	2	14	16	27	35	13	9	1	3,047,475
AUSTRALIA	6	9	14	25	16	21	23	0	228,543
JAPAN	0	14	14	27	47	9	4	4	1,447,801
NETHERLANDS	0	12	12	59	29	0	0	6	155,411
KOREA, REPUBLIC OF	2	7	8	10	36	15	30	0	580,917

2. Math scores vary substantially according to community size, in almost every country examined.

Whether by itself or as proxy for some other factor, location appears to make a substantial difference in some countries in average scores on the Mathematics assessment. Table 2 summarizes these differences. The weighted average is calculated for each level of community size and country.

To obtain a rough estimate of the relative "effect" of location on mathematics scores, the highest average score was subtracted from the lowest average score, and the difference divided by the standard deviation for the country (see the last column on the right). A one-way analysis of variance was then conducted (on the unweighted scores) to test for statistical differences across groups. In all cases but two (Luxembourg and Sweden) there were statistically significant differences in math scores across levels of community size. Some of these effects were relatively modest: one fifth of a standard deviation in Norway, and one fourth in Italy. In two thirds of the countries examined, the effects were greater than one half a standard deviation, and in four countries, including the U.S., differences were greater than one standard deviation. These preliminary results suggest a substantial "location effect" on mathematics achievement.

In most, but not all cases, students in rural areas had the lowest average scores. Interestingly, in the United States, the greatest differences were between students in towns (highest average scores) and cities of 1 million or more population in the city centre, which scored, on average, the lowest. The rural effects in the U.S., as measured here, were moderate. Still, that the scores of any group of students should differ substantially from others, simply because they live in a smaller or larger community, suggests a substantial failure of equity.

Table 2. Average Math Scores by Community Size & "Effect" of High-Low Differences

	Village	Small Town	Town	Small City	City	Metropolitan	StdDev	High-Low	Effect (H-L/SD)
NO (STATISTICALLY SIGNIFICANT) EFFECT OF COMMUNITY SIZE									
LUXEMBOURG	--	*446*	**452**	449	--	449	91.5	6	-0.07
SWEDEN	508	*504*	515	507	**523**	502	93.1	19	-0.21
LOW EFFECTS									
NORWAY*	497	*490*	**510**	503	--	--	90.8	20	-0.22
ITALY*	467	449	461	**469**	--	*448*	89.7	21	-0.24
MODERATE EFFECTS									
SWITZERLAND***	*509*	523	537	**540**	--	--	98.9	31	-0.31
NETHERLANDS***	--	563	**572**	*538*	--	--	88.5	35	-0.39
UNITED KINGDOM***	536	539	528	524	*512*	**549**	91.6	36	-0.40
UNITED STATES* (Rural vs High)**	*476*	484	**519**	487	421	466	94.9	42	-0.44
JAPAN***	--	*523*	561	**562**	554	555	87.3	39	-0.45
AUSTRALIA***	517	*514*	526	531	**556**	535	89.5	42	-0.46
NEW ZEALAND***	*521*	532	536	**568**	542	524	98.9	47	-0.47
FINLAND***	541	529	538	548	**550**	*508*	80.1	42	-0.52
IRELAND***	499	509	**522**	510	*477*	490	84.4	45	-0.53
RUSSIAN FEDERATION***	*451*	455	490	502	503	**509**	103.8	58	-0.56
AUSTRIA***	*475*	514	**530**	526	512	498	92.2	55	-0.59
DENMARK***	508	515	520	503	**543**	*491*	86.4	52	-0.60
PORTUGAL***	*427*	435	461	468	**483**	483	90.7	56	-0.62
LARGER EFFECTS									
POLAND***	*426*	439	467	**494**	490	477	102.5	69	-0.67

SPAIN***	476	*466*	470	481	**527**	485	90.1	61	-0.67
BELGIUM***	*465*	**535**	524	513	413	--	104.1	70	-0.67
KOREA, REPUBLIC OF***	513	*497*	517	556	554	**558**	84.4	61	-0.72
CZECH REPUBLIC***	*457*	494	503	499	**526**	512	95.9	69	-0.72
GERMANY***	469	487	506	487	**522**	*444*	102.4	78	-0.76
LIECHTENSTEIN***	*453*	**529**	--	--	--	514	97.8	75	-0.77
BRAZIL***	*299*	316	319	338	**374**	333	96.7	75	-0.77
GREECE***	*408*	450	444	460	433	**492**	107.5	84	-0.78
LATVIA***	*418*	466	468	489	**506**	--	104.1	89	-0.85
LARGE EFFECTS									
UNITED STATES (HIGH-LOW)**	476	484	**519**	487	*421*	466	94.9	97	-1.03
FRANCE***	*487*	493	525	526	**602**	567	88.3	115	-1.30
MEXICO***	*335*	363	389	412	**449**	410	81.9	114	-1.39
HUNGARY***	*363*	457	481	516	**532**	491	98.5	168	-1.71

- p <.05; ** p < .01; ** p < .001

Its particular focus being on rural communities, the remainder of this paper will compare rural and non-rural children and schools. Comparison would be simpler if rural communities were always the lowest scoring, and if larger communities always scored higher, on average, than smaller communities. In fact, the picture is more complex; sometimes the largest cities do not show the highest average scores.

In fact, three general patterns are identified, each with variants. Because of the non-linear effects of community size, I use three categories for comparison: rural (village and small town), medium-size communities (town and small city); and large cities (cities and large metropolitan areas).

3. Rural students are disadvantaged in mathematics achievement in most industrialized countries as well as in the developing countries examined.

Analysis of PISA data suggests that in most countries examined students in rural communities perform worse, on average, than do students in medium-sized communities and large cities.[1] To quantify this, Table 3 shows rural disadvantage, calculated in much the same way as it was in Table 2 above: the average mathematics score for medium-sized communities (and for large cities) is subtracted from the rural average, and the results are divided by the standard deviation for each country. Of 54 such calculations, 44 were negative, meaning that rural students scored lower than students in medium-sized communities (or large cities). Analysis of variance was carried out to test for statistical significance among these differences. Table 3 ranks countries from less to greater rural disadvantage, in comparison with average math scores among students in

[1] Note that "Rural" in Table 3 and subsequent tables refers to a consolidated category of "village" and "small town" as detailed in Appendix A. As a result the average scores will differ somewhat from the figures shown in Table 2.

medium-sized communities. Many of the differences are even greater when rural areas are compared with large cities. Note that in the United States, rural areas are disadvantaged relative to medium-sized communities but advantaged relative to large cities. The final column gives the comparison with cities, which are, in some countries (by no means all), the locale exhibiting the lowest average test scores.

Table 3. Average Math Scores by Community Size & Rural Disadvantage

					Rural Difference	
	Rural	Medium Size	Large Cities	Standard deviation	vs Medium	vs City
RURAL ADVANTAGE						
LIECHTENSTEIN	514			98		
UNITED KINGDOM	538	527	529	85	0.14	0.11
NETHERLANDS	563	561		78	0.03	
BELGIUM ***	523	521	413	109	0.02	1.01
LITTLE RURAL DISADVANTAGE						
LUXEMBOURG	446	450		90	-0.04	
DENMARK *	511	516	521	85	-0.06	-0.11
FINLAND ~	534	540	537	76	-0.07	-0.04
SWEDEN	506	513	515	91	-0.08	-0.10
GREECE **	440	449	460	109	-0.08	-0.18
MODERATE RURAL DISADVANTAGE						
SPAIN ***	467	476	500	89	-0.10	-0.37
ITALY *	451	463	448	87	-0.14	0.03
AUSTRALIA ***	515	528	545	86	-0.14	-0.35
NORWAY *	494	507		90	-0.15	
IRELAND ***	504	518	482	84	-0.16	0.27
GERMANY ***	483	500	466	93	-0.18	0.18
CZECH REPUBLIC ***	484	501	514	96	-0.18	-0.32
BRAZIL ***	313	330	357	85	-0.19	-0.51

					Rural Difference	
	Rural	Medium Size	Large Cities	Standard deviation	vs Medium	vs City
SUBSTANTIAL RURAL DISADVANTAGE						
SWITZERLAND ***	520	538		95	-0.20	
NEW ZEALAND ***	526	547	533	96	-0.22	-0.07
AUSTRIA ***	507	529	502	93	-0.23	0.06
UNITED STATES ***	483	507	446	89	-0.27	0.42
PORTUGAL ***	434	463	483	91	-0.32	-0.54
LATVIA ***	441	478	506	99	-0.38	-0.66
FRANCE ***	492	525	572	83	-0.40	-0.97
POLAND ***	437	479	487	101	-0.42	-0.50
RUSSIAN FEDERATION ***	452	497	505	103	-0.43	-0.51
JAPAN ***	523	562	555	87	-0.45	-0.36
HUNGARY ***	446	493	513	101	-0.47	-0.66
KOREA, REPUBLIC OF ***	501	547	557	80	-0.58	-0.70
MEXICO ***	352	401	429	73	-0.68	-1.07

Key: ~ p<.100, * p<.050, ** p<.010, *** p<.001

4. Three patterns are apparent in the distribution of scores by community size: rural disadvantage, urban-rural disadvantage, urban disadvantage.

There appear to be three general patterns of variation. The first, which might be called *rural disadvantage*, shows a clear linear relationship between community size and mathematics performance. Figure 1 shows this pattern, using the case of Australia.

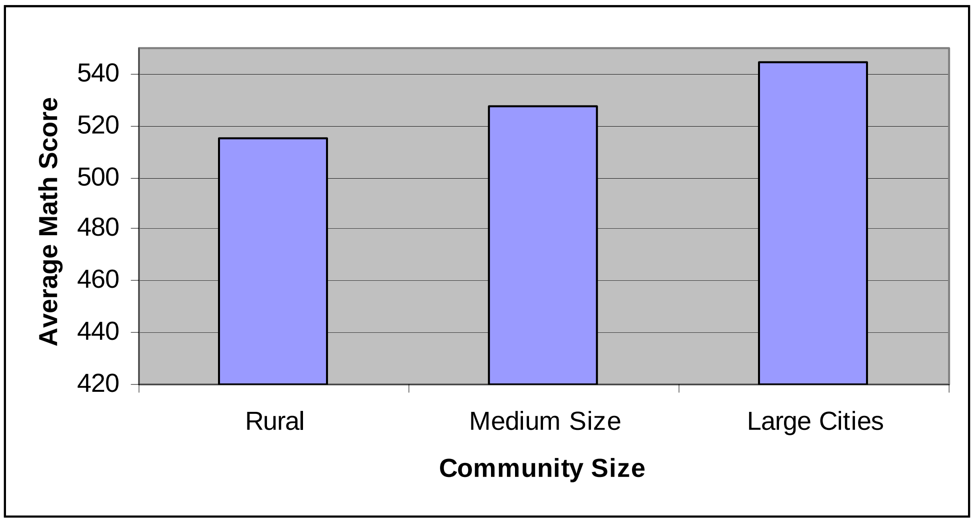

Figure 1. Rural Disadvantage: Average Mathematics Scores, by Community Size, Australia

There were variations in this pattern of linear increases in average scores with larger community size. In Denmark, for example, students in both rural areas and medium-sized communities scored lower than those in large cities. In another variant, Korean students in medium-sized communities and large cities scored well above those in rural areas. And Japan shows a slight urban disadvantage. In all of these variants, however, students in rural areas scored lowest.

A majority of countries fell into this pattern, as listed in Table 4.

A second pattern might be termed *urban-rural disadvantage*. In this pattern, rural schools score lower than medium-sized communities, as with the rural disadvantage pattern. However, students in large cities score lower, often dramatically so, than do students in either rural areas or medium-sized communities.   The U.S. is a good example of urban-rural disadvantage, as shown in Figure 2.

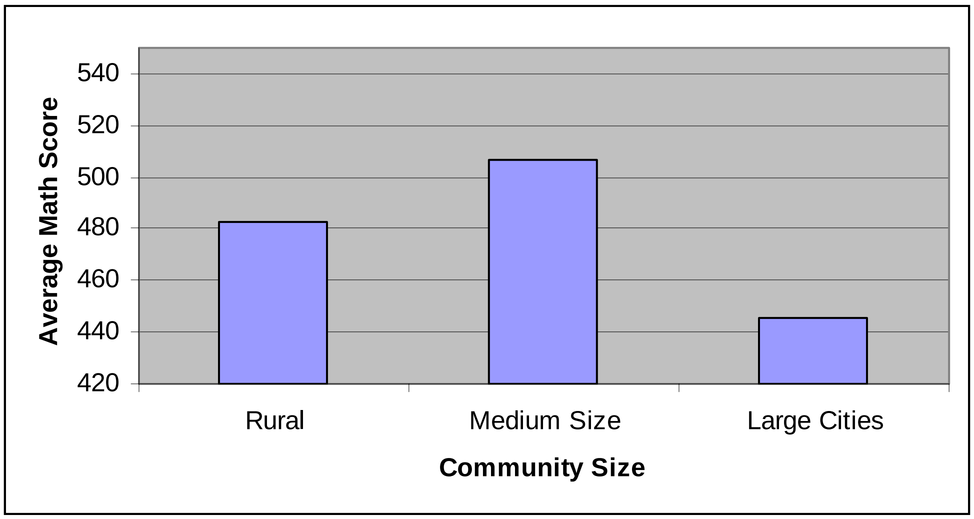

Figure 2. Urban-Rural Disadvantage: Average Mathematics Scores, by Community Size, United States

This pattern was observed in the U.S., Austria, Germany, Ireland, and Italy.

The third pattern, termed *urban disadvantage*, was observed only in Belgium, the United Kingdom, and the Netherlands. See Figure 3.

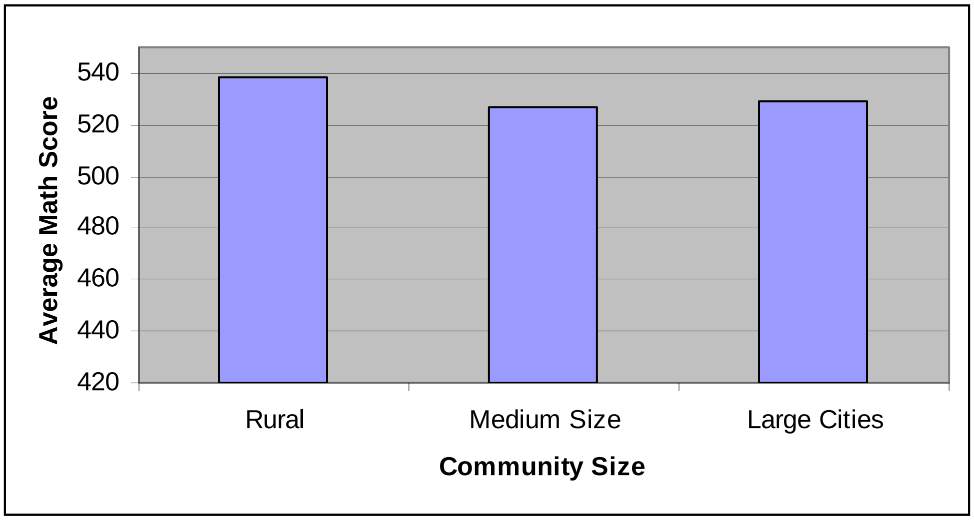

Figure 3. Urban Disadvantage: Average Mathematics Scores, by Community Size, United Kingdom

Figure 4 compares average scores by community size across three countries representing these three types of variation by locale. The differing patterns represented in this figure also illustrate the fact that mathematics scores vary both across countries and by locale within countries. Table 4 summarizes the classifications by locale-related achievement pattern.

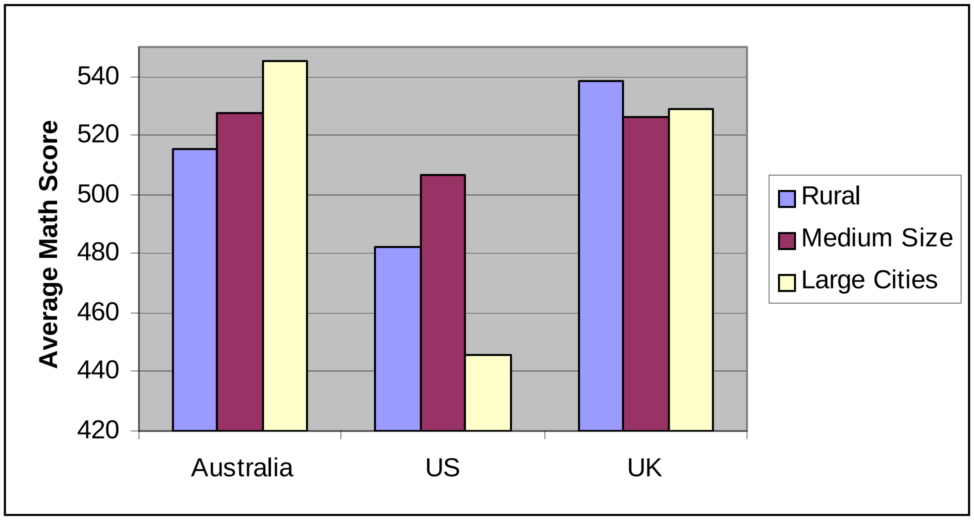

Figure 4. Average Mathematics Scores, by Community Size, Australia (rural disadvantage), US (urban-rural disadvantage), United Kingdom (urban disadvantage)[2]

Table 4. Patterns of Variation in Mathematics Achievement by Community Size

Pattern	Countries
Rural Disadvantage	Australia; Brazil; Czech Republic; Denmark; Finland (or Urban-Rural); France; Hungary; Japan (with slight urban disadvantage); Korea; Latvia; Luxembourg; Mexico; Norway; Poland; Portugal; Russian Federation; Spain; Sweden; Switzerland
Urban-Rural Disadvantage	Austria; Finland (or Rural); Germany; Ireland; Italy; New Zealand; United States (with urban disadvantage)
Urban Disadvantage	Belgium; Netherlands; United Kingdom

Socioeconomic Status and Mathematics Achievement

The preceding discussion examined the variation and distribution of students within and across countries according to a variable I have called *community size*. Countries varied greatly in the numbers and proportions of rural students. Mathematics

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[2] It would be interesting to include Canada in this discussion. However, Canada chose not to make data on community size public, due, perhaps, to concerns about confidentiality.

achievement was found to vary systematically in relation to community size, both within and across countries. Three patterns of results were identified. One represented the majority of countries, in which rural students performed worse than did students in medium-sized communities and large cities. Rural students' scores were lower than those of other groups in 44 of 54 comparisons. Differences in performance varied, but many were quite substantial. Rural students, it would appear, face serious disadvantages.

Observing that rural students score lower on mathematics assessments, of course, says nothing about the reasons for lower performance, whether reasons lie in student and community "background characteristics," the characteristics of schools, availability or utilization of resources, or interactions among these factors. The purpose of this paper is descriptive, to understand the extent of variation in mathematics achievement within and across nations, in relation to community size, especially in rural areas. Nonetheless, I begin to explore one of the possible explanations of lower performance, family socioeconomic status.

At the risk of tautology, socioeconomic status, or SES, refers to the relative social and economic standing of an individual and the family *vis a vis* other individuals and families. SES is usually operationalized through indicators of mother and father's education, parents' occupational status, existence of certain kinds of high-status possessions in the home, and perhaps family income, each of which are imperfect and all of which are highly correlated. In this analysis, I use the PISA developed measure, HISEI, which converted parental occupation (whichever parent was engaged in a "higher" occupation) into a scale comparable across countries.

However it is measured, SES is almost universally and positively related to academic achievement, as well as a number of other desirable social outcomes: the higher the SES, the higher, on average, the achievement. Correlations between SES and achievement are generally higher than those between factors subject to policy manipulation such as teacher qualifications or curricular innovations. As a result, SES seems like a good candidate to understand in its own right and to explain some of the variation in mathematics achievement across countries.

In this overview, I will look at SES in three ways. First, I will see if SES varies, like mathematics achievement, by community size. If so, then SES might be part of the explanation for lower achievement.

What is interesting about the relationship between SES and student achievement is partly that it is robust—found to be statistically significant as it is in (virtually) every study of achievement in which it is examined.[3] In addition, and this fact is virtually never discussed, is that the relationship varies in magnitude—across classrooms, schools, districts, states, and nations, and perhaps even within individuals over time. Little is known about this variation, how it is distributed, what its correlates are, how it changes over time, or how the effects of SES on student achievement can be lessened.

As a result, my second look at SES will be across nations. In which countries is the relationship between SES and mathematics achievement stronger, and in which is it weaker?

Finally, I look at SES gradients, the estimated linear relationship fit between SES and mathematics achievement, for rural and for non-rural students. (For simplicity's sake, I examine only Rural/Non-Rural comparisons.) As above, the purpose of this paper is primarily descriptive, and so these patterns will be classified into types.

Several findings emerge from these analyses.

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[3] In some contexts, a robust correlation between SES and achievement is important to note. In the case of PISA, with its large samples, statistical significance is less surprising, given the sensitivity of pearson correlation coefficients to large samples.

1. Like Mathematics achievement, SES differs according to community size. Students in rural areas are, on average, of lower SES than students in medium-sized communities and in large cities.

Using the terms created earlier to describe the distribution of Mathematics scores, SES is distributed according to the pattern of rural disadvantage. All countries in the sample, except Belgium, Germany, Ireland, and the United States, showed a pattern of increasing average SES with each level of community size. In all cases but Belgium, rural areas showed the lowest average SES. The typical pattern, that of Japan, and that of the United States, is illustrated in Figures 5 and 6. (For the sample as a whole, the mean SES was 46.3, the standard deviation 17.4)

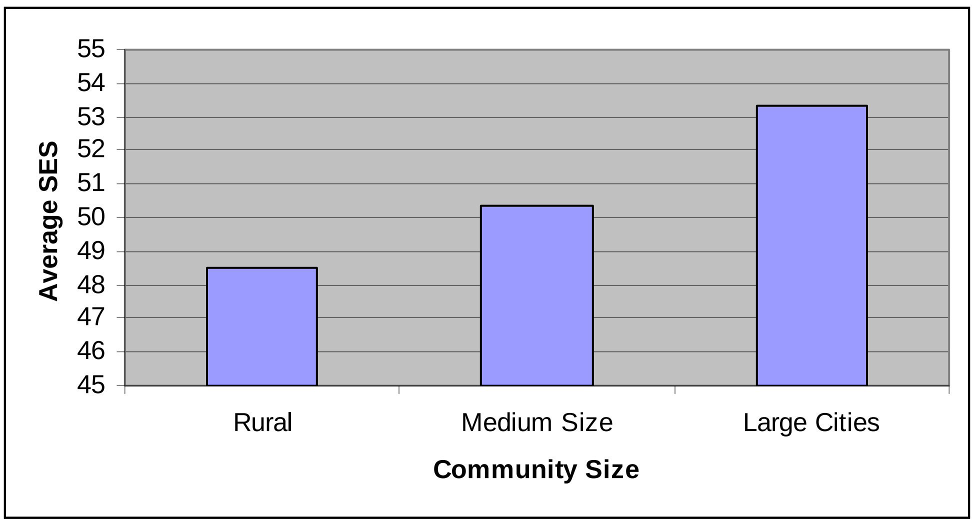

Figure 5. Rural Disadvantage: Average SES by Community Size, Japan

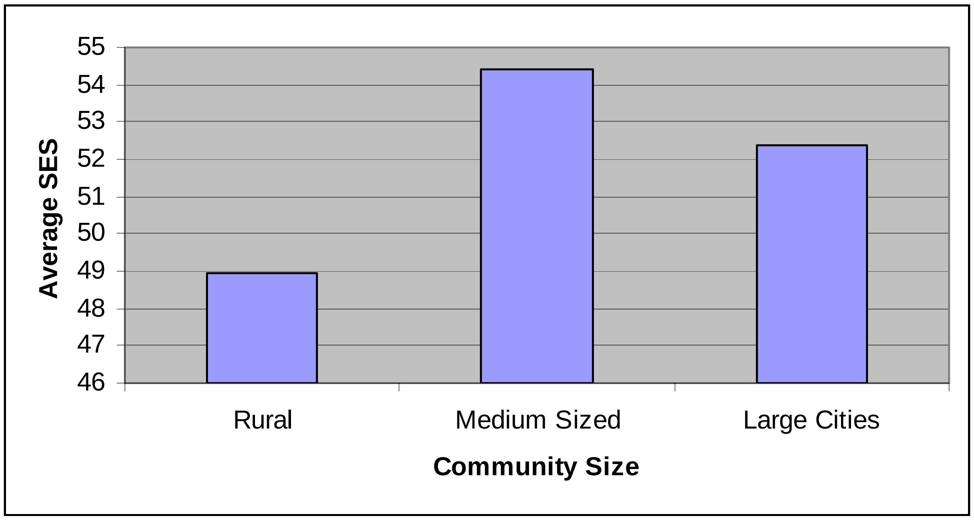

Figure 6. Urban-Rural Disadvantage: Average SES by Community Size, U.S.

2. The relationship between individual level SES and Mathematics achievement is not fixed but varies greatly across countries.

Table 6 presents pearson correlations for the SES and Math, classified, somewhat arbitrarily, into low, moderate, higher, and high inequality countries. In all cases, SES is positively associated with Mathematics achievement: the higher the SES, the higher, on average, math scores. In every country, the association is statistically significant, though statistical significance is not surprising given the sample size, even in the case of low inequality countries such as Japan, where one would not expect a low p-value. Nonetheless, the correlation is positive and significant in all cases. Countries vary a great deal, however, in the degree of association. In some countries, such as Japan, it would be difficult to predict math scores from an individual's SES. In other countries, such as the U.S., for example, or Germany, SES would provide a much better fix on an individual's likely math score. SES in the U.S. has *ten times* the predictive power it has in Japan (r^2 = .137 as compared to r^2 = .014), suggesting, that family background has a great deal more effect in the U.S. system than in Japan's. By this measure, Japan's school system is among the most equitable among industrialized nations, and the U.S. and German systems among the least. That claim might be overstating the case, of course, based as it is, on a single measure, but the comparison clearly suggests the need for further study within and across a few possibly instructive cases. It is interesting to note that the Japanese income distribution is comparatively more equitable than most.

3. The effects of SES vary in rural and non-rural environments.

A final purpose of this analysis is to portray the differential effects of SES in rural and non-rural environments. To examine this question, correlation coefficients were calculated between SES and MATH by rural and non-rural locale for each country, also shown in Table 6.

In all cases but two, Japan and Korea, SES is highly predictive of Math scores in rural (as well as non-rural) locales. It would be interesting to try to understand why SES was not associated with rural Math scores only in those two countries—confounding variables, cultural conditions, different policies and practices, funding strategies? We cannot be certain, but the answer(s) could make a great deal of difference.

In 22 of 29 countries examined, SES had less of an influence in rural locales than in non-rural locales. In seven countries, including the US, SES had a greater effect in rural areas than urban, though not greatly so. Differences in the magnitude of the effect of SES were greater in the countries where SES had a greater effect in non-rural areas. Differences between non-rural and rural “SES effects” were especially large in Mexico and Brazil, but also in Denmark, Korea, Poland, and Spain.

Interestingly, the US ties Belgium for the third and fourth highest correlation between SES and Math in rural areas. Mathematics scores are more closely tied to SES in rural US communities than in most industrialized nations. In subsequent research, I hope to learn more about why.

In all cases, the influence of country was greater than the influence of locale. Except for rural Korea and Japan, SES was significantly associated with mathematics scores, though the magnitude of these effects varied substantially. This variation, in some cases by a factor of 3 or more, suggests that the effects of SES are somewhat predictable, possibly even subject to policy intervention.

Table 5. Zero-order correlations between SES and Mathematics scores

	$r_{SES, MATH}$		
	Overall	Non-Rural	Rural
LOW INEQUALITY			
JAPAN*	0.12	0.11	0.15[x]
LATVIA*	0.16	0.15	0.17
MODERATE INEQUALITY			
ITALY	0.22	0.24	0.14
KOREA, REPUBLIC OF	0.24	0.23	0.09[x]
FINLAND	0.25	0.27	0.22
RUSSIAN FEDERATION*	0.25	0.22	0.24
NORWAY	0.26	0.30	0.22
AUSTRIA	0.28	0.30	0.24
IRELAND	0.28	0.34	0.25
DENMARK	0.29	0.36	0.22
HIGHER INEQUALITY			
FRANCE	0.31	0.30	0.24
NETHERLANDS*	0.31	0.32	0.34
SPAIN	0.31	0.33	0.21
GREECE	0.32	0.32	0.31
NEW ZEALAND	0.32	0.32	0.30
POLAND	0.33	0.34	0.21
SWEDEN	0.33	0.37	0.27
AUSTRALIA	0.35	0.34	0.32
SWITZERLAND	0.35	0.34	0.32
CZECH REPUBLIC*	0.36	0.34	0.39
BRAZIL	0.37	0.38	0.24
LUXEMBOURG	0.37	0.39	0.34
UNITED KINGDOM	0.37	0.39	0.32
UNITED STATES*	**0.37**	**0.31**	**0.35**
BELGIUM	0.38	0.38	0.35
GERMANY	0.38	0.41	0.32
MEXICO	0.38	0.37	0.13
PORTUGAL	0.38	0.37	0.33
HIGH INEQUALITY			
HUNGARY*	0.43	0.41	0.44

N.B. With the exception of rural locales in Korea and Japan, all correlations were statistically significant, $p < .01$.

In order to understand better the differences between SES-Math relationships in rural and non-rural areas, regression equations were estimated for each country, whereby Mathematics score was predicted by:

HISEI (the measure of individual socioeconomic status),

RURAL (dummy variable denoting rural (1) vs non-rural (0) schools),

RURALSES (interaction between HISEI & RURAL)

Predicted Mathematics scores were then estimated and plotted for average rural and non-rural students at each point of SES. Examination of these plots revealed six patterns; countries are listed in Table 7.

In some countries, there was little difference in rural and non-rural socioeconomic gradients. Such countries tended to show little or no rural disadvantage, though further disaggregation may reveal differences. Such countries have achieved relative equity between rural and non-rural areas, but socioeconomic status still makes a (varying) difference. New Zealand provides a typical example, as in Figure 7.

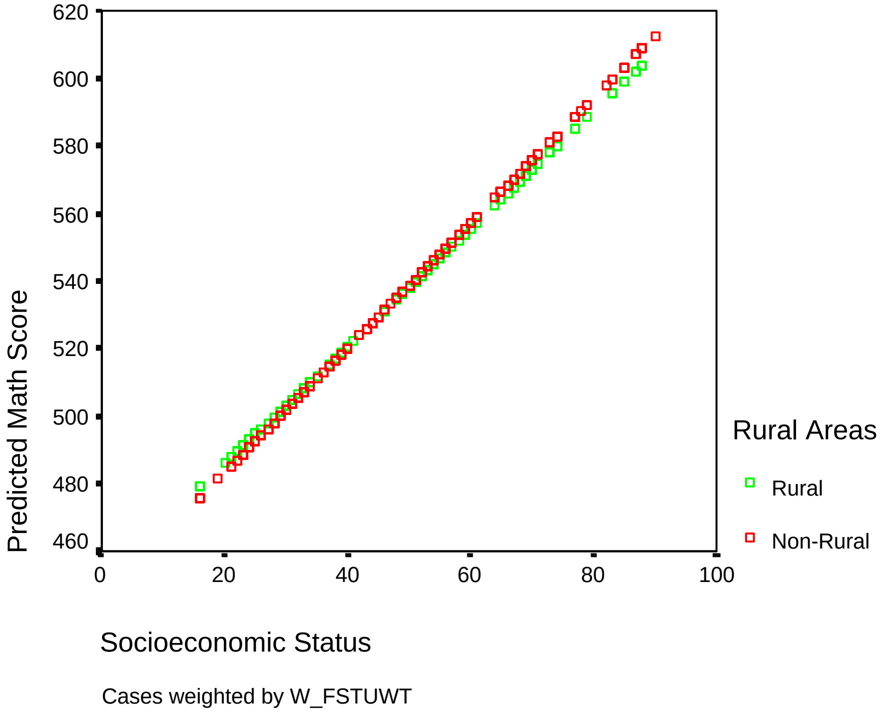

Figure 7. No Rural Disadvantage: Rural/Non-Rural Socioeconomic Gradients for New Zealand

Table 7. Patterns of Rural/Non-Rural Socioeconomic Gradients

Pattern	Countries
1. No Rural Disadvantage: Gradients virtually same in level and slope	Belgium, Luxembourg, New Zealand, Switzerland, United Kingdom (rural a little higher)
2. Divergence: Begin together at low SES then diverge	Australia, Austria, Greece, Brazil (a lot)
3. Further Divergence: Begin apart at low SES & diverge further	France, Korea, Mexico, Poland
4. Disadvantage to Non-Rural Poor: Cross within range of data, with Steeper Non-Rural Slope	Denmark, Finland, Germany, Ireland, Italy, Netherlands, Norway, Spain, Sweden
5. Rural Disadvantage: Convergence at higher SES	Czech Republic, Hungary, Japan, Portugal
6. Parallel but Not Equal: Parallel slopes	Latvia, Russian Federation, US

A second pattern, termed *Divergence*, was identified in which average mathematics scores were roughly the same at low levels of SES. As SES increased, however, the scores of non-rural students increased more rapidly. In these countries, SES made more of a difference in mathematics score among non-rural youth than among rural youth. Scores were more equitably distributed among rural students, but their scores were lower; the differences with non-rural youth increased with higher levels of SES. Australia and Brazil provide examples, as shown in Figures 8 and 9.

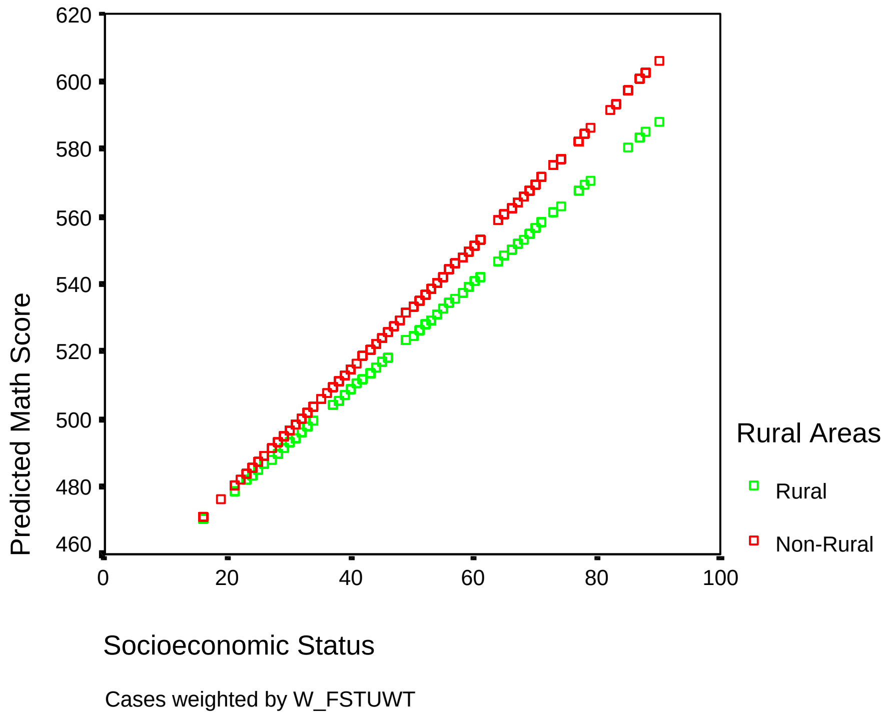

Figure 8. Divergent: Rural/Non-Rural Socioeconomic Gradients for Australia

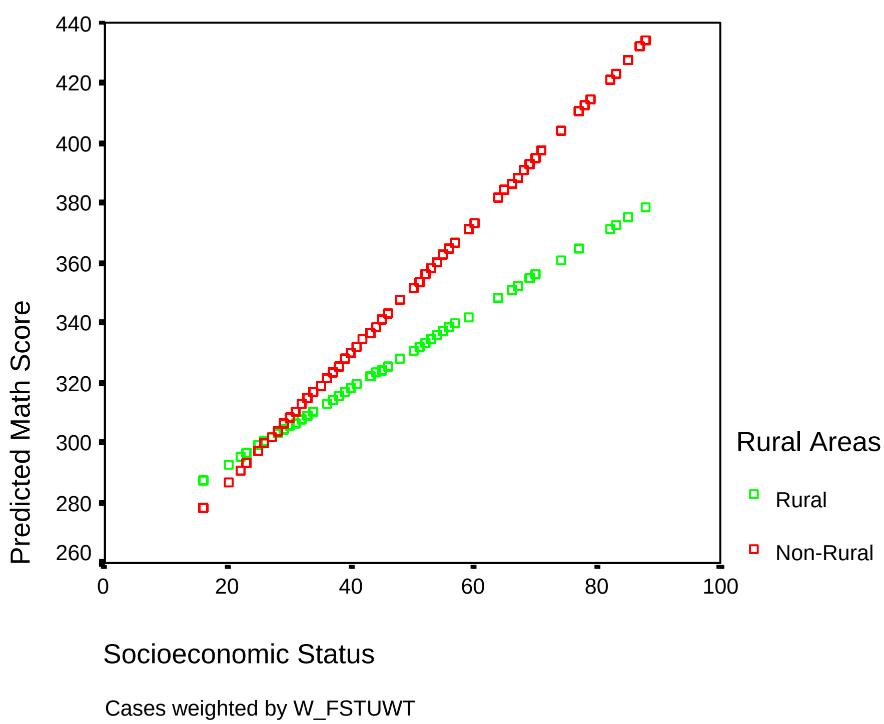

Figure 9: Divergence: Rural/Non-Rural Socioeconomic Gradients
for Brazil

A third pattern, *Further Divergence*, begins with differences between groups at low levels of SES and shows increasing divergence as SES increases. Again, SES has less of a discriminating effect among rural students, but their performance is, on average, lower. Moreover, the higher the SES, the greater the divergence. France provides a good example, in Figure 10.

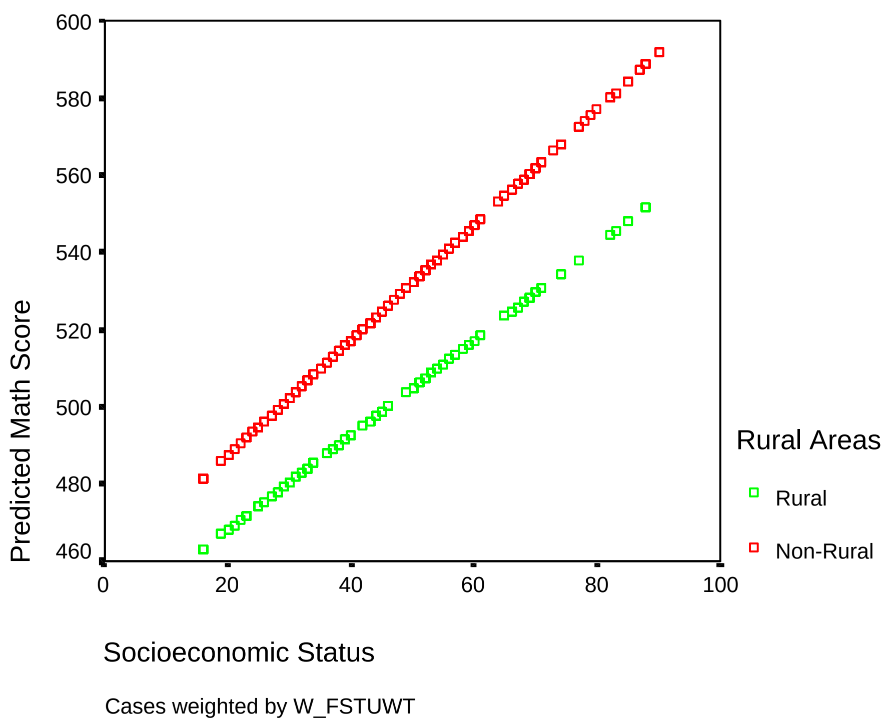

Figure 10: Further Divergence: Rural/Non-Rural Socioeconomic Gradients
for France

The fourth pattern, *Disadvantage to Non-Rural Poor*, is more complex, with the estimated regression lines crossing within the range of observed data. The non-rural slope is steeper, but starts, at low levels of SES, at a lower initial math score. This suggests that poor students score, on average, lower in non-rural areas than do poor students in rural areas. The higher the SES, however, the more likely non-rural students are to score higher than rural youth. Again, the effect of SES is greater in non-rural areas, and scores are generally higher. Italy provides a good example of this pattern, in Figure 11.

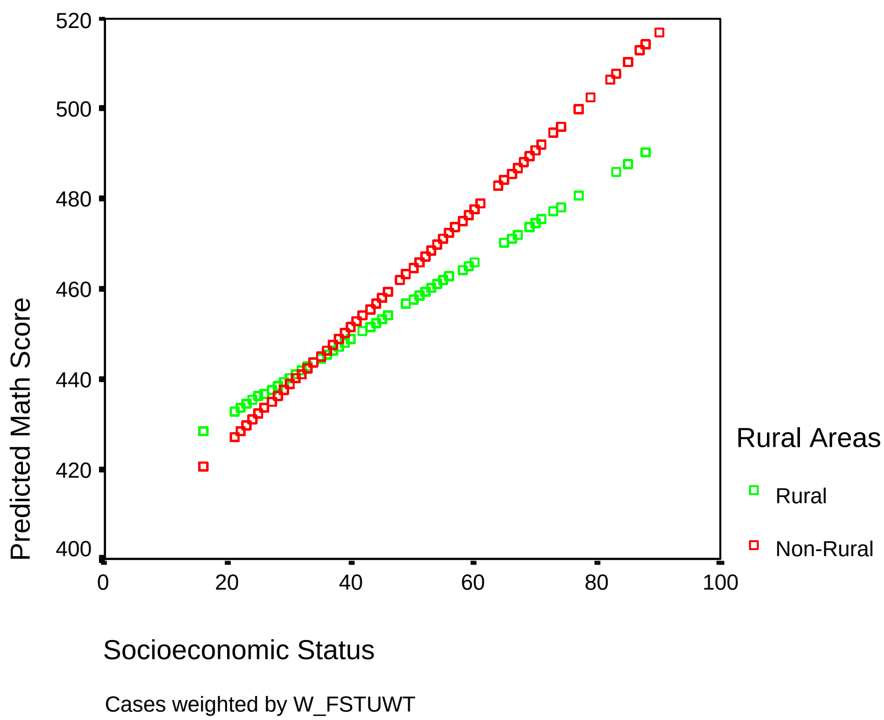

Figure 11. Disadvantage to Non-Rural Poor: Rural/Non-Rural Socioeconomic Gradients for Italy

The fifth pattern is termed *Rural Disadvantage*. At low levels of SES, rural students score substantially lower than their non-rural counterparts. At higher levels of SES, however, the scores are nearly the same. Portugal, in Figure 12, provides an example of this pattern.

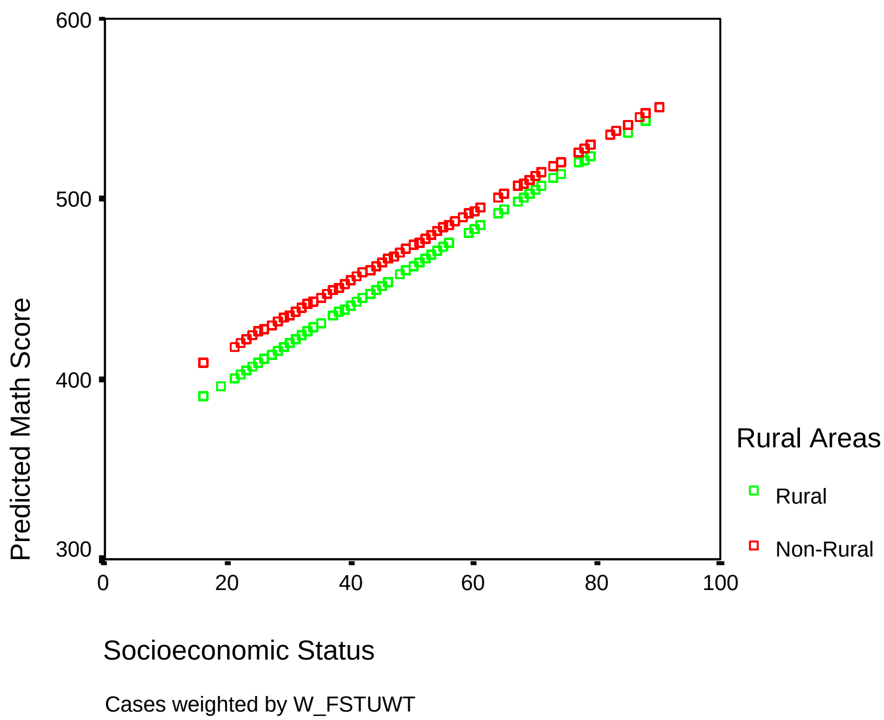

Figure 12. Disadvantage to Rural Poor: Rural/Non-Rural Socioeconomic Gradients for Portugal

Finally, the sixth type, *Parallel but Not Equal*, reveals parallel lines at different levels of math performance. In most cases, rural students score lower than non-rural students. The similar slopes, however, suggest that SES has the same (inequitable) effect in both rural and non-rural areas. The United States provides a good example of this pattern, in Figure 13.

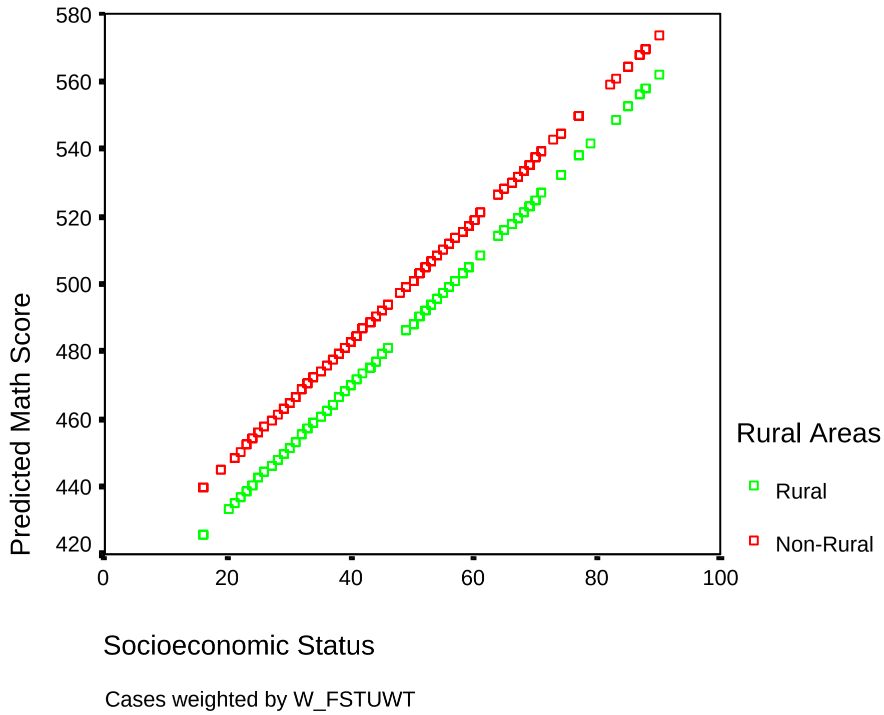

Figure 13. Parallel but Not Equal: Rural/Non-Rural Socioeconomic Gradients in the United States

<u>Performance and Equity in Rural Locales</u>

Equity and performance are sometimes portrayed as tradeoffs in policy discussions. In order to compare relative performance of students in rural areas in terms of average mathematics score and the relative effect of SES on mathematics, I calculated average Math scores for rural students in each country, classified countries by quartile, from low (1) to high (4). I then classified countries by quartile according to the correlation coefficient in rural areas between SES and Math, again from low to high. Ideally, a country would score high in Math and low in SES effect. Countries are grouped according Results are shown in Table 8. Higher and lower refer to a country's position in the top or bottom half of scores on each measure.

Several countries score high on both performance and equity measures in rural areas. Some countries, including the US, score relatively low on both measures. Each grouping contains roughly equivalent numbers of countries, suggesting no easy relationship between high performance and high equity in rural areas. Eight countries scored in the top half of countries in terms of both performance and equity.

Table 8. Classification of Sampled Countries according to Quartile of Average Rural Math Score and Quartile of SES-MATH Correlation in Rural Areas

	Average Math Score	r: SES, Math (rural)	Quartile Rural Math Score	Quartile Rural SES Effect
HIGHER PERFORMANCE; GREATER EQUITY				
FINLAND	534	0.25	4	1
JAPAN	523	0.12	4	1
KOREA, REPUBLIC OF	501	0.24	3	1
DENMARK	511	0.29	3	2
AUSTRIA	507	0.28	3	2
IRELAND	504	0.28	3	2
NORWAY	494	0.26	3	2
FRANCE	492	0.31	3	2
HIGHER PERFORMANCE; LOWER EQUITY				
NEW ZEALAND	563	0.32	4	3
UNITED KINGDOM	538	0.37	4	3
SWITZERLAND	520	0.35	4	3
AUSTRALIA	515	0.35	4	3
NETHERLANDS	563	0.31	4	4
BELGIUM	523	0.38	4	4
SWEDEN	506	0.33	3	3
LOWER PERFORMANCE; GREATER EQUITY				
SPAIN	467	0.31	2	1
ITALY	451	0.22	2	1
RUSSIAN FEDERATION*	452	0.25	2	2
LATVIA*	441	0.16	1	1
POLAND	437	0.33	1	1
MEXICO	352	0.38	1	1
BRAZIL	313	0.37	1	2
LOWER PERFORMANCE; LOWER EQUITY				
GERMANY	483	0.38	2	3
CZECH REPUBLIC	484	0.36	2	4
UNITED STATES	**483**	**0.37**	**2**	**4**
PORTUGAL	459	0.38	2	4
GREECE	440	0.32	1	3
LUXEMBOURG	446	0.37	1	4
HUNGARY	446	0.43	1	4

Initial Conclusions

This paper has sought to provide a descriptive and science. PISA overview of rural students and mathematics achievement in 30, mostly industrialized countries. To do this, I analyzed the PISA 2000 dataset, for which a random sample of 15-year-olds were assessed on their "knowledge and skills" in reading, mathematics, was developed to test academic competences needed for life, at the age when most students are deciding whether to continue their schooling or leave for work.

The paper has examined the distribution of rural students in the 30 countries. "Rural" was defined as communities of 15,000 or less (combining categories of village (population <3,000) and "small town," 3,000-15,000). Average math scores were compared across countries in terms of the six community size categories offered in the survey.

Rural students, as a group, generally but not always, scored lower than students from larger communities. In some cases, the lowest scoring youth were from large cities. Nonetheless a consistent rural disadvantage was found, sometimes coupled with an urban disadvantage.

Rural is not one thing. Dare we say—having examined no context whatsoever—that rural is contextual? While rural students generally score lower than non-rural youth, this is not always or necessarily true. In a few countries, rural students outperformed non-rural students. In a number of countries, *poor* rural students scored higher, on average, than non-rural students of similar socioeconomic status.

Rural students and schools may perform better, relative to student SES, than non-rural schools. The distribution of SES appeared visually to be more tightly associated with community size than did mathematics achievement. This would be an interesting point to examine in future analyses.

SES was associated with achievement among all groups, but the effects varied. In some national contexts, SES was less tightly predictive of mathematics performance than in others. Several of these countries were characterized by high levels of achievement and high levels of equity, especially in rural areas.

This analysis, while attempting to provide an overview, has left many holes. Future analyses will need to control for the various factors known to affect student achievement, in order to get a more precise fix on the role of SES and the relative extent of rural disadvantage.

Future analyses will need to examine the ways in which rural disadvantage works in different countries. Do rural students score lower because they are poorer, because they lack the cultural resources of urban dwellers, because of fewer school resources, or less effective utilization of those resources? Does the relatively low status of rural schools translate into lower self-efficacy on the part of rural students? Conversely, does the relative socioeconomic equity among rural students, as compared with non-rural counterparts, translate into more effective learning environments or less (positive) pressure to achieve? Why does PISA find a rural disadvantage, even in the US, as compared to studies using NAEP and NELS data, which find few differences? How robust will these differences be, once SES is controlled?

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