REL MIDWEST
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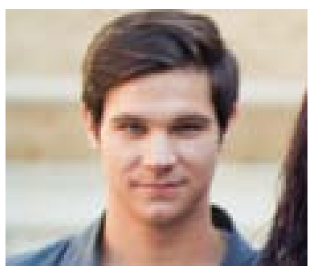
Differences in spending in school districts across geographic locales in Minnesota



NATIONAL CENTER FOR EDUCATION EVALUATION AND REGIONAL ASSISTANCE
Institute of Education Sciences

ISSUES & ANSWERS

REL 2012–No. 124

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Differences in spending in school districts across geographic locales in Minnesota

February 2012

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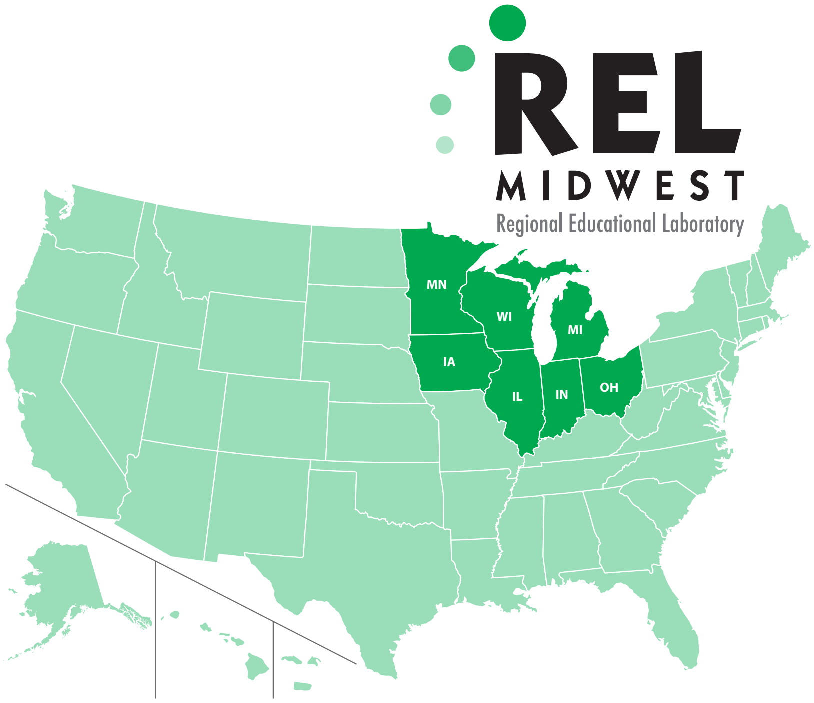

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February 2012

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Summary

REL 2012–No. 124

Differences in spending in school districts across geographic locales in Minnesota

This study examines differences in spending in school districts across geographic locales in Minnesota and factors that might contribute to these differences. The study finds that district spending per student in 2008/09 varied across locale types in Minnesota. These differences are largely accounted for by differences in regional characteristics and level of student need.

State leaders must make policy decisions about the funding of public school districts across settings with different needs and costs. This study focuses on differences in spending in school districts across geographic locales in Minnesota, exploring factors that may contribute to these differences.

Whether the state's funding formula adequately accounts for cost differences in districts in different geographic locales has been a topic of interest among Minnesota legislators and other stakeholders. A proposed 2009 Minnesota Senate bill directed the state commissioner of education to seek assistance from Regional Educational Laboratory Midwest in studying the cost of operating school districts in different regions of the state, taking into account demographic, geographic, and economic differences. The proposed bill, along with additional needs assessments in the state and the region, indicated a need for research on spending patterns of districts across geographic areas with different needs.

This study examines the relationship between school district expenditures and district characteristics, including regional features (enrollment size, student population density, labor costs, and geographic remoteness) and level of student need (percentages of students eligible for free or reduced-price lunch, of special education students, and of English language learner students). Prior research has found that each of these factors has been associated with differences in expenditures across districts.

This study examines five types of district spending per student for prekindergarten–grade 12: general fund expenditures, instruction and instruction-related expenditures, administration expenditures, student support expenditures, and transportation expenditures.

The study addresses two research questions:

- How do district expenditures per student, regional characteristics, and level of student need differ across geographic locales?

- To what extent do regional characteristics and level of student need account for differences in expenditures per student across geographic locales?

The first research question was investigated through a comparative descriptive analysis of Minnesota's regular noncharter public school districts, using 2008/09 data. Districts were classified into seven locale types—rural–remote, rural–distant, rural–fringe, town–remote, town–not remote, suburb, and city—using urban-centric locale codes established by the National Center for Education Statistics based on Census Bureau data (U.S. Department of Education 2010). For each locale type, this analysis provides a detailed description of the district expenditures, regional characteristics, and level of student need.

The analysis finds that during the 2008/09 school year, rural districts accounted for 65 percent of Minnesota school districts and 25 percent of students.[1] Further, district expenditures, regional characteristics, and level of student need varied across locale types. Expenditure patterns across locales differed with the type of expenditure. Total general fund expenditures per student and instruction and instruction-related expenditures per student were highest in city districts and above the state average in suburban, rural–remote, and town–remote districts. Student support expenditure per student was highest in city districts and lowest in town–remote and town–distant districts. Administration and transportation expenditures per student were above average in rural–remote and city districts and below average in the remaining locales.

Regional characteristics and level of student need also varied across locale types. Compared with other locales, rural–remote districts had lower enrollment, lower student population density, longer drive time to the center of the nearest urban area, and higher percentages of special education students and students eligible for free or reduced-price lunch (a measure of economic disadvantage). Within rural and town districts, the percentage of special education students and economically disadvantaged students increased with remoteness. The percentage of English language learner students was highest in city and suburban districts.

Regression analysis indicated that once regional characteristics and levels of student need were taken into account, district locale was not a statistically significant predictor of expenditures per student on administration, student support services, and transportation. Differences across locales in total general fund expenditures per student and instruction and instruction-related expenditures per student remained statistically significant predictors, but their shares in the overall variation in these expenditures fell considerably (from 16 percent to 3 percent for total general fund expenditures and from 19 percent to 6 percent for instruction expenditures). For these two expenditure types, only differences between town–remote districts and rural–remote and rural–distant districts were statistically significant. On the whole, regional characteristics and level of student need accounted for much of the variation in expenditures per student between districts in different geographic locales, but unexplained differences remained for Minnesota's most remote town and most remote rural districts.

Note

1. These percentages were calculated using student enrollment data and locale codes from the 2008/09 Common Core of Data and do not include nonoperating districts, charter districts, state-operated institutions, and regional education service agencies.

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Tables

This study examines differences in spending in school districts across geographic locales in Minnesota and factors that might contribute to these differences. The study finds that district spending per student in 2008/09 varied across locale types in Minnesota. These differences are largely accounted for by differences in regional characteristics and level of student need.

WHY THIS STUDY?

State policymakers must make important decisions on how best to fund public school districts facing differential costs and student needs. To help them do so, this study examines differences in spending in districts across geographic locales in Minnesota and identifies the factors that contribute to these differences.

Fiscal challenges facing rural districts

Rural districts face challenges that may lead to higher per student costs than in nonrural districts (Sipple and Brent 2008; see appendix A for a review of studies comparing expenditures in rural and nonrural districts).[1] Many rural districts in Minnesota must contend with these challenges, which include small and declining enrollments and high transportation costs (Anton 2009; Williams et al. 2009).[2]

Minnesota legislators and other stakeholders are interested in determining how costs vary across districts in different geographic areas and whether the state's funding formula adequately accounts for these differences. The state's current funding formula takes into account the remoteness of schools and geographic dispersion through "sparsity revenue" and "transportation sparsity revenue" (Minnesota House of Representatives 2010). Sparsity revenue provides additional revenue for districts with small, isolated schools. Transportation sparsity revenue provides all school districts with additional funding based on the number of student units per square mile in the school district,[3] compensating districts for increased transportation costs arising from a low number of students per square mile.

Some critics argue that the formula allowances intended to account for differences in student demographics, facilities, operating scale, and other components of Minnesota's funding formula are arbitrary and do not reflect cost differences (Hamline 2009). Others argue that the sparsity types do not adequately account for cost differences in small rural schools. Thorson and Edmondson (2000) propose a new type of funding—small school revenue—to compensate small rural schools for the high costs associated with low enrollment.

A proposed Minnesota Senate bill (S.F. No. 2089, 1st Engrossment 2009; Minnesota Legislature. 2009) directed the state commissioner of education to seek assistance from Regional Educational Laboratory Midwest in studying the cost of operating school districts in different regions of the state, taking into account demographic, geographic, and economic differences. The proposed bill, along with additional needs assessments in the state and the region, indicates the need for research on spending patterns across geographic areas with different needs.[4]

The current study

The current study examines differences in spending across districts in different geographic areas by focusing on expenditure data from a single state, Minnesota. It addresses two primary research questions:

- How do district expenditures per student, regional characteristics, and level of student need differ across geographic locales?
- To what extent do regional characteristics and level of student need account for differences in expenditures per student across geographic locales?

These research questions are addressed using the methods of a previous Issues & Answers report (Levin et al. 2011), which examines the relationships between regional characteristics and the allocation of several types of resources in four West Region states (Arizona, California, Nevada, and Utah; box 1).

The analytic approach examines expenditures at the district level, because this is where most spending decisions are made.[5] Expenditure data are for 2008/09, the most current data available for Minnesota at the time the study began. Data for the study were retrieved from publicly accessible data websites of the Minnesota Department of Education, the U.S. Census Bureau, and the U.S. Department of Education. The analysis explores relationships between expenditures per student and regional characteristics and level of student need, to see whether expenditures per student differed across locales after accounting for cost factors. Box 2 describes the key variables used in this analysis.

BOX 1

Methodology

The study team classified each school district in Minnesota into one of seven locale types, based on the urban-centric locale codes established by the National Center for Education Statistics. The study team then identified the district expenditures, regional characteristics, and level of student need in each locale type. To explore how these characteristics relate to district expenditure, models were created to determine whether differences across locales remained after controlling for other cost factors. (See appendix C for a full description of the methodology.)

FINDINGS

This study found that average expenditures per student for prekindergarten–grade 12, regional characteristics, and level of student need varied across locale types.

- Total general fund expenditures per student and instruction and instruction-related expenditures were highest in city districts and above the state average in suburban, rural–remote, and town–remote districts.
- Student support expenditures were highest in city districts and lowest in town–remote and town–distant districts.
- Administration and transportation expenditures per student were highest in rural–remote and city districts.
- Compared with other locales, rural–remote districts had lower enrollment and student population density, longer drive times to the

BOX 2

Definition of variables

This study examined three sets of variables: expenditures (prekindergarten–grade 12), cost factors, and district locale. Appendix B provides more detailed information on these data.

Expenditure measures. Five types of expenditures per student were examined: total general fund expenditures, instruction and instruction-related expenditures, administration expenditures, student support expenditures, and transportation expenditures. Data on these expenditures were either extracted directly from Minnesota's school district expenditure files or constructed from components of the files (Minnesota Department of Education 2010b).

- *Total general fund expenditures* is a measure of the overall level of spending on educational activities for prekindergarten–grade 12 funded through the general fund (Minnesota Department of Education 2010a).
- *Instruction and instruction-related expenditures* include spending on regular instruction, career and technical instruction, special education, and instructional support services.
- *Administrative expenditures* include district-level administration expenditures (expenditures for the school board, the office of the superintendent, and other central office operations) and expenditures for the administration of school sites (the cost of one licensed principal and his or her immediate office).
- *Student support expenditures* include expenditures for noninstructional services provided to students, such as counseling, guidance, health services, psychological services, and attendance and social work services.
- *Transportation expenditures* include all expenditures associated with the transportation of students.

Cost factors. This study examines the associations between expenditures and two groups of characteristics that previous studies suggest relate to differences in district expenditures between districts in different geographic locales: regional characteristics and level of student need (for a review of this literature, see appendix A). These variables are referred to as cost factors in this study.

- *Regional characteristics* include a district's total enrollment, student population density, labor costs, and geographic remoteness. Student population density is the number of students per square mile. An index of labor costs developed by the National Center for Education Statistics (NCES)—the comparable wage index—was used to measure geographic differences in the cost of hiring and retaining staff (Taylor, Glander, and Fowler 2007; U.S. Department of Education 2007). Geographic remoteness was measured by the average drive time from schools in a district to the center of the nearest urban area (see box B1 in appendix B). The drive time metric indicates the level of accessibility to goods and services.
- *Level of student need* includes the percentages of economically disadvantaged students (students eligible for free or reduced-price lunch), of special education students, and of English language learner students.

School district locale. This study uses the urban-centric locale codes developed by the U.S. Census Bureau with support from NCES. For this study, the 12 urban-centric locale codes were collapsed into 7: city, suburb, town–not remote, town–remote, rural–fringe, rural–distant, and rural–remote. Districts in the three rural types were defined as rural districts (disaggregating rural districts into three separate types allows researchers to distinguish between rural districts in relatively remote areas from rural districts located just outside urban centers). As in the study by Levin et al. (2011), town–remote districts were treated as a separate type because they are considered similar to rural districts in the characteristics of interest.

nearest urban area, and higher shares of economically disadvantaged students and special education students. Within rural and town districts, the percentage of these students increased with remoteness.

Some of these findings differ from those of Levin et al. (2011). For example, in the West Region states studied (Arizona, California, Nevada, and Utah), rural–remote districts had the highest average per student total general expenditures as well as instruction and instruction-related, administration, student support, and transportation expenditures. Both the current study and the Levin et al. study find higher proportions of special education students in rural–remote and town–remote districts, although the difference is much more pronounced in the states examined by Levin et al.

Consistent with the Levin et al. study and the literature on cost factors reviewed in appendix A, the results of this study indicate that regional characteristics and level of student need are associated with district expenditures. For the expenditure measures examined, these cost factors accounted for most of the observed differences in expenditures per student across locales.

After cost factors are accounted for, between-locale differences in expenditures per student remained only for total general fund and instruction and instruction-related expenditures. Specifically, town–remote districts had higher per student total general fund and instruction and instruction-related expenditures than did rural–distant and rural–remote districts. Additional research is needed to identify the cost factors that account for spending patterns across remote locales.

Differences in district expenditures per student, regional characteristics, and level of student need across locales

Minnesota's school districts were classified into seven types based on locale and sublocale codes (see box 2 and table B1 in appendix B). During the 2008/09 school year, rural districts accounted for 65 percent of Minnesota school districts and 25 percent of students (table 1).

TABLE 1

Distribution of Minnesota school districts and students in those districts, by locale type, 2008/09

District locale	Districts Number	Districts Percent	Students Number	Students Percent
Nonrural				
City	10	3	154,790	19
Suburb	33	10	267,916	34
Town–not remote	38	11	101,534	13
Town–remote	34	10	70,576	9
Nonrural total	*115*	*34*	*594,816*	*75*
Rural				
Rural–fringe	28	8	79,888	10
Rural–distant	82	24	58,198	7
Rural–remote	113	33	60,984	8
Rural total	*223*	*65*	*199,070*	*25*
Total	338	100	793,886	100

Note: Results are based on the analytic sample of the study, which does not include nonoperating districts, charter school districts, state-operated institutions, and regional education services. Percentages may not sum to 100 because of rounding.

Source: Authors' analysis based on data from U.S. Department of Education (2010) and Minnesota Department of Education (2009).

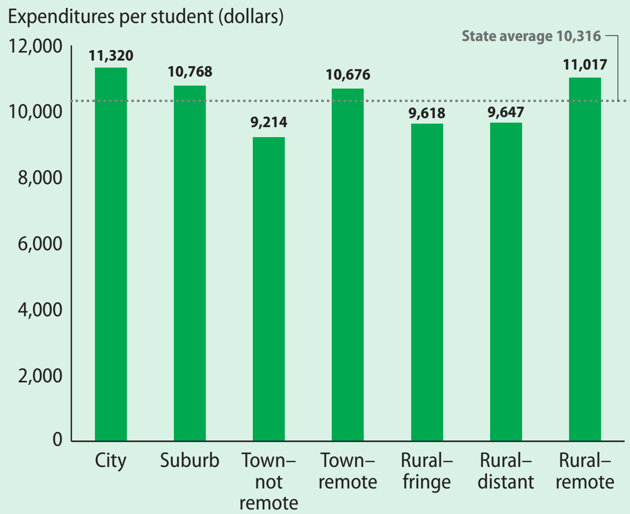
Expenditures per student by locale type. Average total general fund expenditures per student were highest for city districts ($11,320), followed closely by rural–remote districts ($11,017; figure 1; tables C1 and C2 in appendix C present the means, medians, and standard deviations for all expenditure measures and district characteristics by locale). Average expenditures in rural–distant ($9,647), rural–fringe ($9,618), and town–not remote ($9,214) locales were below the state average of $10,316.

Average instruction and instruction-related expenditures per student were highest in city ($7,979) and suburban ($7,517) districts (figure 2). Expenditures per student in rural–distant ($6,002), rural–fringe ($6,471), and town–not remote ($6,129) locales were below the state average of $6,649.

Administration expenditures per student were highest in rural–remote ($1,141) and rural–distant ($1,002) districts (figure 3). In the remaining locales, administration expenditures were below the state average of $973.

FIGURE 1

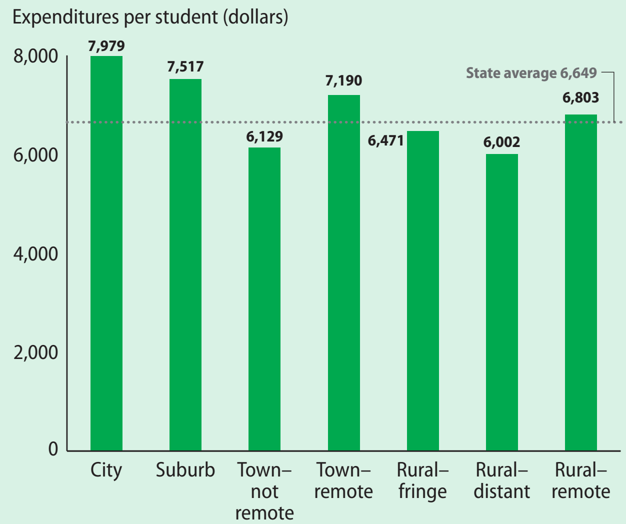
Average general fund expenditures per student by Minnesota school districts, by locale type, 2008/09



Source: Authors' analysis based on data from U.S. Department of Education (2010) and Minnesota Department of Education (2010b).

FIGURE 2

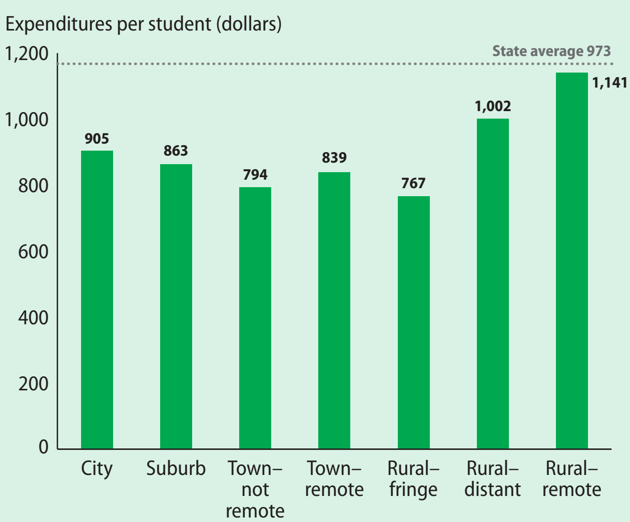
Average instruction and instruction-related expenditures per student by Minnesota school districts, by locale type, 2008/09



Source: Authors' analysis based on data from U.S. Department of Education (2010) and Minnesota Department of Education (2010b).

FIGURE 3

Average administration expenditures per student by Minnesota school districts, by locale type, 2008/09



Source: Authors' analysis based on data from U.S. Department of Education (2010) and Minnesota Department of Education (2010b).

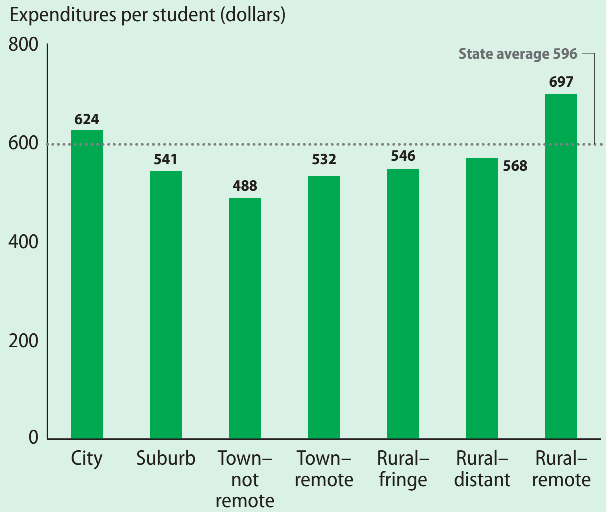
Transportation expenditures per student were highest in rural–remote ($697) and city ($624) districts (figure 4), with the remaining locales below the state average of $596.

Student support expenditures per student were below the state average of $206 in rural–remote ($171) and rural–distant ($175) districts (figure 5). The remaining locales had above-average expenditures for student support, with city districts ($343) spending the most.

Rural–remote districts had greater variation in expenditures than did other locales. The variation among rural–remote district was about twice that among city districts in general fund expenditures (standard deviation of $2,574 compared with $1,270) and about three times that in administration expenditures ($398 compared with $132; see table C1 in appendix C). The spread of instruction and instruction-related expenditure was highest in town–remote districts ($1,983), followed by rural–remote districts ($1,785). Town–remote districts also had the second-highest variation in total

FIGURE 4

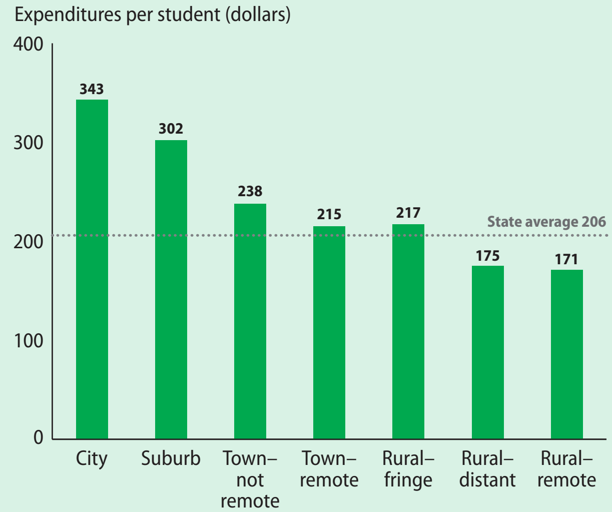
Average transportation expenditures per student by Minnesota school districts, by locale type, 2008/09



Source: Authors' analysis based on data from U.S. Department of Education (2010) and Minnesota Department of Education (2010b).

FIGURE 5

Average student support expenditures per student by Minnesota school districts, by locale type, 2008/09



Source: Authors' analysis based on data from U.S. Department of Education (2010) and Minnesota Department of Education (2010b).

general fund expenditure per student ($2,113). For administration, transportation, and student support services, rural–distant districts had the second-highest variation.

Regional characteristics by locale type. Average district enrollment was highest in city and suburban districts and lowest in rural–remote and rural–distant districts (figure 6). Enrollment and student population density were higher in rural–fringe districts than in either town type.

The average drive time to the center of the nearest urban area is a measure of the relative accessibility of districts to goods and services. A longer drive time indicates lower accessibility of these things. The drive times were longest in the two most remote types of rural districts (37 minutes in rural–remote and 21 minutes in rural–distant districts[6]). The next-longest average drive times were in suburban (18 minutes) and city (15 minutes) districts.[7]

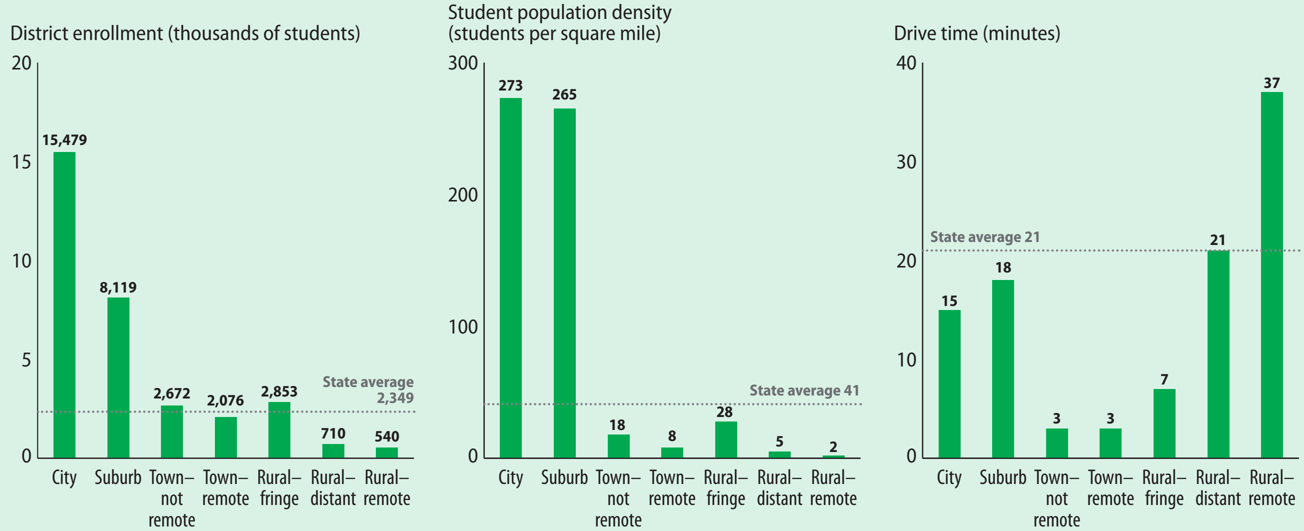
Level of student need by locale type. Level of student need (percentages of economically disadvantaged students, of special education students, and of English language learner students), which can potentially affect costs, varied by locale type.

The percentage of economically disadvantaged students (students eligible for free or reduced-price lunch) was highest in rural–remote districts (45.2 percent; figure 7), followed by town–remote (38.0 percent) and city (34.0 percent) districts. Rural–fringe districts had the lowest average percentage of economically disadvantaged students (24.8 percent). Within town and rural locales, the average percentage of economically disadvantaged students increased with geographic remoteness.

The percentage of special education students was highest in rural–remote districts (16.1 percent), followed by town–remote (15.5 percent) and rural–distant (14.9 percent) districts. Suburban and town–not remote districts had the lowest average percentages of special education students (13.4 percent for both). Within town and rural locales, the average percentage of special education students increased with geographic remoteness.[8] The variation across locales was much lower for special education students than for economically disadvantaged students.

FIGURE 6

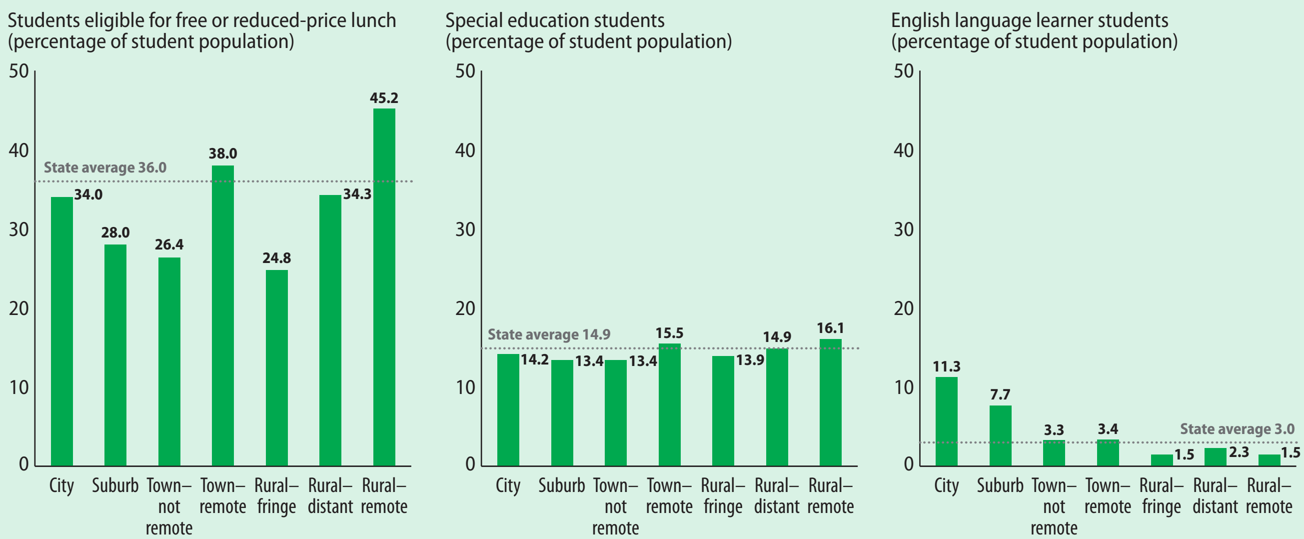
Average enrollment, student population density, and drive time to school in Minnesota school districts, by locale type, 2008/09



Source: Authors' analysis based on data from U.S. Department of Education (2010); Minnesota Department of Education (2009); U.S. Census Bureau (2008); and Environmental Systems Research Institute (2010b).

FIGURE 7

Average level of student need in Minnesota school districts, by locale type, 2008/09



Source: Authors' analysis based on data from U.S. Department of Education (2010) and Minnesota Department of Education (2009).

The percentage of English language learner students was highest in city (11.3 percent) and suburban (7.7 percent) districts. Percentages were below the state average in the three rural locales, with rural–remote and rural–fringe having the lowest shares (1.5 percent for both).

Differences in expenditures per student across locales after accounting for regional characteristics and level of student need

The descriptive analysis found that average expenditures per student in Minnesota varied across locale types. It also found that cost factors (regional characteristics and level of student need) varied across locale types. However, the descriptive analysis alone could not indicate whether the differences in cost factors accounted for the differences in expenditures across locales.

Therefore, a series of analyses were done to examine the relationship between each cost factor and each type of expenditure, controlling for the remaining cost factors. Table 2 compares the results from the initial model, which includes only the locale type to explain differences in expenditure, and the full model, which accounts for the locale of the school, student need, enrollment, density, cost of labor, and remoteness for each expenditure measure. Appendix D presents the detailed regression results.

The full model—including all cost factors—explained far more of the variation in expenditures (27.6–54.5 percent; table 2, column [2]) than the initial model, which included only locale type (15.6–23.0 percent; table 2, column [1]). This result suggests that cost factors explain a substantial portion of the differences in spending patterns across districts over and above what is explained by locale type. When cost factors are accounted for, there are no statistically significant differences in how much districts in different locales spend per student on administration, student support, and transportation (see tables D1–D5, row "*F*-value [locale]" for model 5).

TABLE 2

Proportion of variance explained in the initial and the full model for each expenditure type

Predictors in the model	Locale only	Locale and other factors
Type of expenditure	[1] Proportion of variance explained	[2] Proportion of variance explained
Total general fund	0.159*	0.545*
Instruction and instruction-related	0.191*	0.507*
Administration	0.230*	0.541*
Student support	0.163*	0.361*
Transportation	0.156*	0.276*

* The model explains a statistically significant (α=0.05) proportion of the variation in the expenditure.

Note: Columns 1 and 2 report how well the model explained the variation in district expenditure (the R^2). Values reported indicate what proportion of the variation in spending is due to the factors included in the model (values range from 0 to 1). Column 1 looks solely at the relationship between locale and expenditure, while column 2 also accounts for any differences in cost that may be due to student need (percentages of economically disadvantaged students, special education students, and English language learner students), district enrollment, population density, labor costs, and drive time.

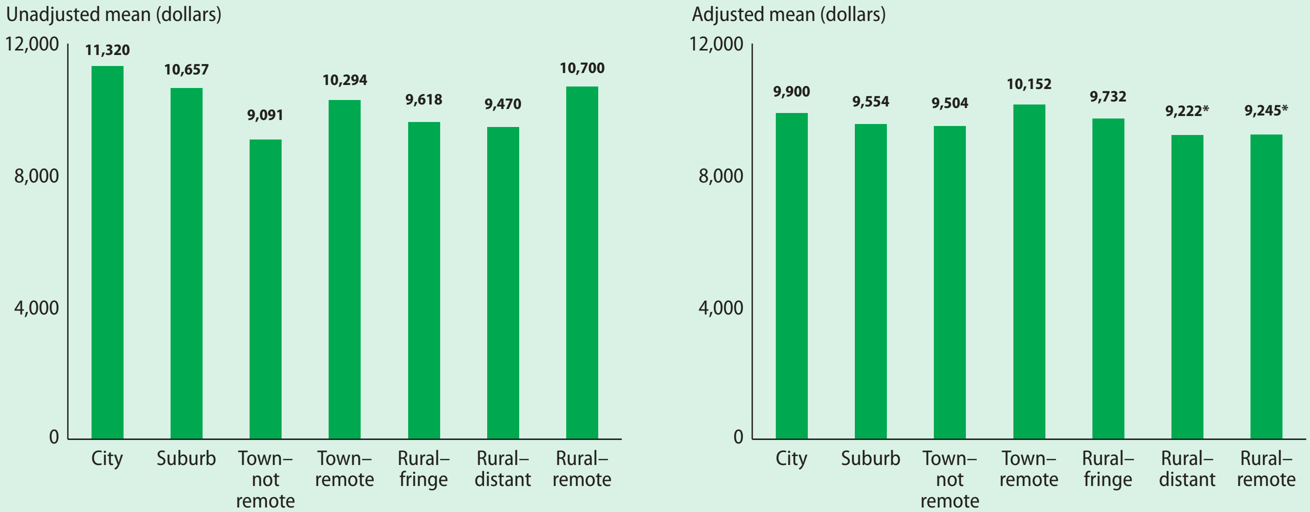
Source: Authors' analysis based on data from U.S. Department of Education (2010); Minnesota Department of Education (2009); U.S. Census Bureau (2008); and Environmental Systems Research Institute (2010b).

The differences in total general fund expenditures per student and instruction and instruction-related expenditure per student remain statistically significant across locales, but differences in locale explain far less of the variation (declining from 16 percent to 3 percent for total general fund expenditures and from 19 percent to 6 percent for instruction and instruction-related expenditures).[9] These findings indicate that the differences in spending across locales can be attributed largely to differences in cost factors across districts. However, these models do not explain all the variation in spending across districts, and additional unknown or unmeasured factors may contribute to differences in district expenditures per student.

Two measures of average expenditures per student illustrate how cost factors account for differences across locales. Figures 8–12 display average

FIGURE 8

Unadjusted and adjusted means for total general fund expenditures per student in Minnesota school districts, by locale type, 2008/09

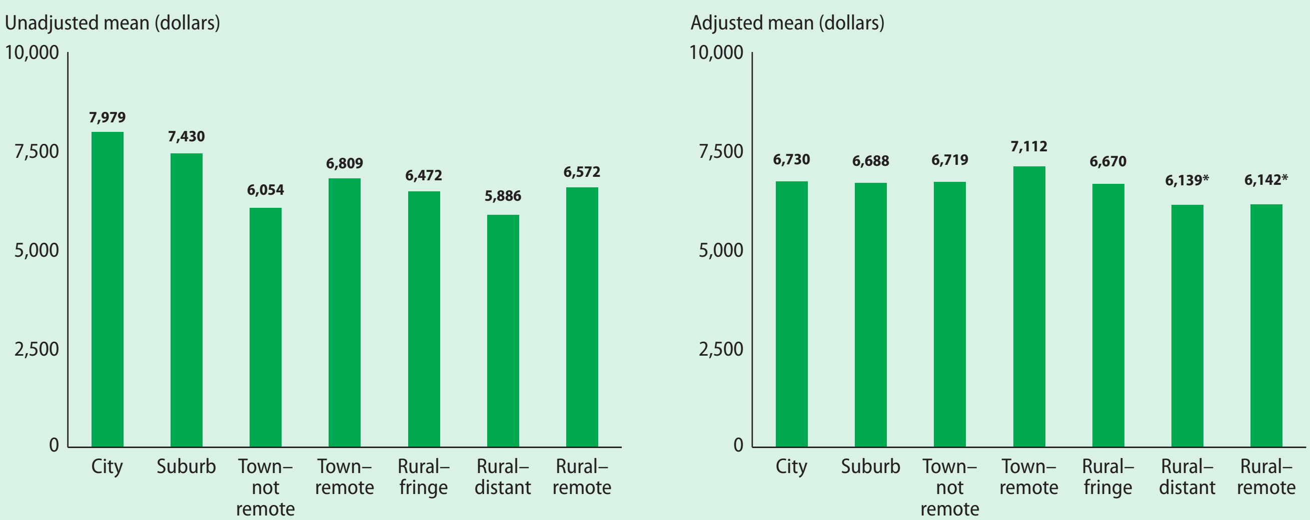


* Significantly different (at the .05 level) from the adjusted mean for town–remote.

Source: Authors' analysis based on data from U.S. Department of Education (2010); Minnesota Department of Education (2009); U.S. Census Bureau (2008); and Environmental Systems Research Institute (2010b).

FIGURE 9

Unadjusted and adjusted means for instruction and instruction-related expenditures per student in Minnesota school districts, by locale type, 2008/09

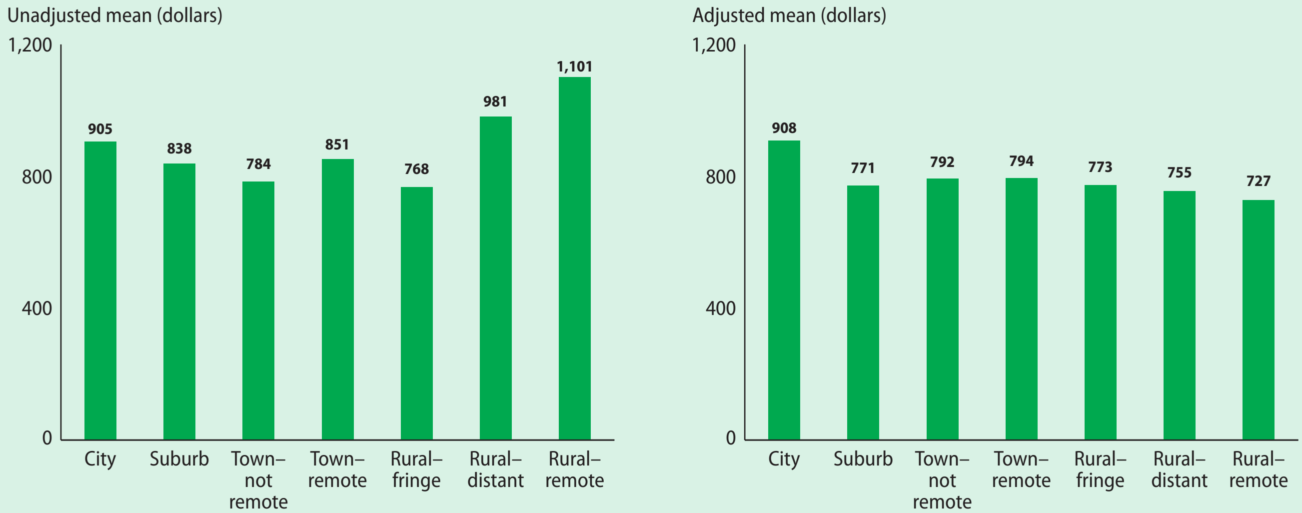


* Significantly different (at the .05 level) from the adjusted mean for town–remote.

Source: Authors' analysis based on data from U.S. Department of Education (2010); Minnesota Department of Education (2009); U.S. Census Bureau (2008); and Environmental Systems Research Institute (2010b).

FIGURE 10

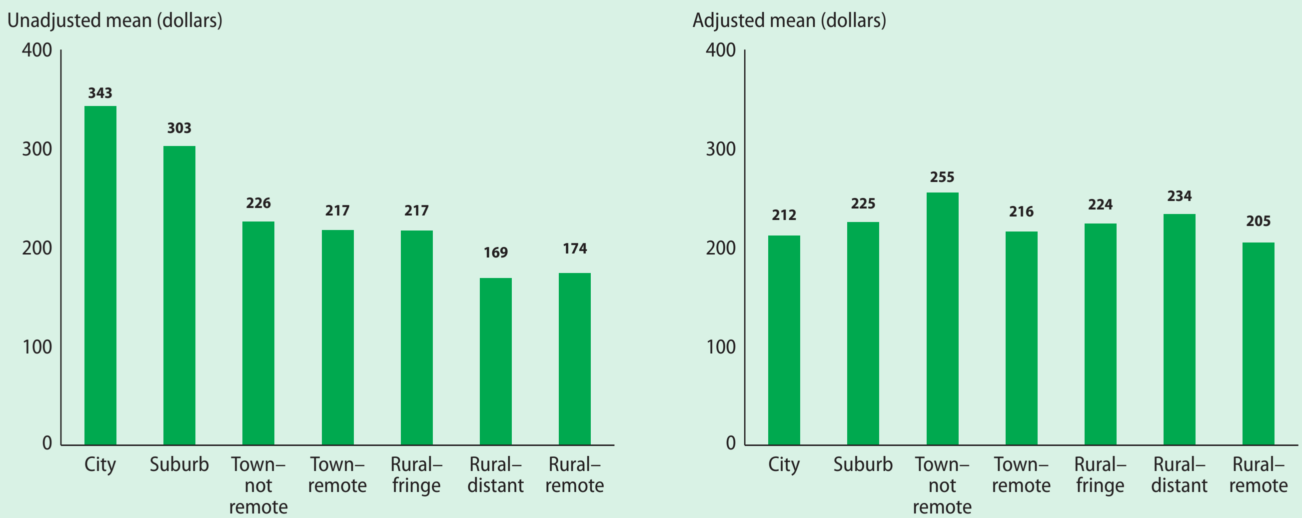
Unadjusted and adjusted means for administration expenditures per student in Minnesota school districts, by locale type, 2008/09



Source: Authors' analysis based on data from U.S. Department of Education (2010); Minnesota Department of Education (2009); U.S. Census Bureau (2008); and Environmental Systems Research Institute (2010b).

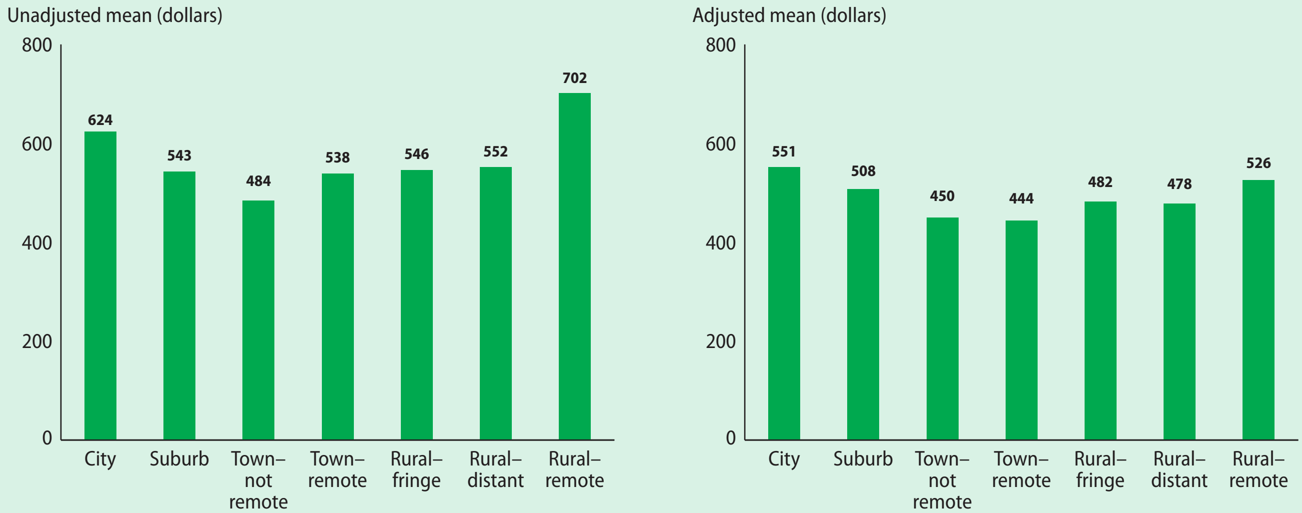
FIGURE 11

Unadjusted and adjusted means of student support expenditures per student in Minnesota school districts, by locale type, 2008/09



Source: Authors' analysis based on data U.S. Department of Education (2010); Minnesota Department of Education (2009); U.S. Census Bureau (2008); and Environmental Systems Research Institute (2010b).

FIGURE 12
Unadjusted and adjusted means for transportation expenditures per student in Minnesota school districts, by locale type, 2008/09



Source: Authors' analysis based on data from U.S. Department of Education (2010); Minnesota Department of Education (2009); U.S. Census Bureau (2008); and Environmental Systems Research Institute 2010b).

expenditures per student across locales for each expenditure measure. Unadjusted means are the observed average district expenditures in each locale (the same means presented in the descriptive analysis), excluding any districts identified as outliers and removed from the analysis (see appendix E for information on outliers). Adjusted means are the estimated mean expenditures in each locale adjusted for the cost factors. These means account for any differences in cost that may be due to student need (percentages of economically disadvantaged students, special education students, and English language learner students), district enrollment, student population density, labor costs, and drive time.[10]

Comparisons were conducted to identify which pairs of locales had statistically different adjusted means.[11] The only statistically significant differences were between town–remote districts on the one hand and rural–distant and rural–remote districts on the other (see figures 8 and 9). After adjusting for the cost factors, town–remote districts spent about 10 percent more on total general fund expenditures per student than did rural–distant districts and 9 percent more than rural–remote districts. They also spent 15 percent more per student on instruction and instruction-related activities than did both rural–distant and rural–remote districts. These findings suggest that on average, among districts with the same regional characteristics and level of student need, town–remote districts spent more on total general fund and instruction and instruction-related expenditures than did both rural–remote and rural–distant districts.

CONCLUSIONS AND STUDY LIMITATIONS

As state policymakers evaluate district funding formulas and allocate resources, the findings in this study may help them consider the full range of factors associated with variations in expenditures across types of districts. In particular, the study shows that using more finely grained (and publicly available) measures related to cost factors (namely, regional characteristics and level of student need) helps explain much of the variation. Leaders in other states may consider exploring these cost factors as they analyze district-level differences in expenditures between rural and nonrural districts, keeping in mind that the association between these cost factors and district expenditures may vary considerably across states and regions.

Several study limitations need to be considered when interpreting the findings:

- Determining which districts are rural is complex and sometimes controversial, because different definitions of *rural* can result in changes in the number of rural districts and have different implications for stakeholders. The urban-centric locale codes used in this study are an improvement over earlier locale code assignments in completeness, precision, and reliability (Arnold et al. 2007). However, many government agencies and researchers have defined rural districts in different ways. Different categorizations of rural districts are likely to yield different depictions of the spending patterns in rural and nonrural districts in Minnesota.

- This study uses the district as the unit of analysis because it is the level at which most education finance decisions are made and because district-level data are publicly available. District-level analysis is also appropriate because the proposed Minnesota Senate bill that motivated this study focused on variations in the costs of operating a school district. However, there may be important differences in spending by schools within a district, which district-level analysis masks, such as which teachers are allocated to which schools and which schools have newer facilities and books. Moreover, under the urban-centric locale system, school locales are assigned first and district locales are derived from school locales. Some students may attend rural schools that are in districts that are not designated as rural. This study does not reveal these differences. In light of the current emphasis on school accountability for student achievement, future research might usefully focus on resource allocation at the school level.

- This study is based on only the most recent year of data available (rather than several years of data) because it examines differences in district expenditures across locales and most districts' locale classifications remain stable over a short period of time. In the future, longitudinal analyses should be conducted to investigate the stability of the relationships between expenditures and other factors over time.

- This study focuses on five expenditure measures. It conducted univariate regression analyses using each expenditure measure as a dependent variable and the same set of predictors as independent variables. The *p*-values of the regression estimates were not adjusted for multiple testing, however.[12]

- This study is based on regular school districts in Minnesota in 2008/09. The findings should not be generalized to charter school districts in Minnesota or to districts in other states (separate studies could be conducted on charter school districts). However, the methods used in this study are relevant to other states.

- This study focuses on expenditures. It implies nothing about the level of spending required to achieve similar outcomes in rural and nonrural districts of given demographics.

- The relationships examined in this study are correlational. No claims regarding causality can be made or should be inferred.

APPENDIX A THE LITERATURE ON FINANCING RURAL EDUCATION

The literature on financing rural education is limited: Arnold et al. (2005) reviewed the extant literature on rural education and found that only 9 of 498 articles (1.8 percent) published between 1991 and summer 2003 focused on school finance, and only 7 of those 9 articles had a rural-specific focus.[13] This appendix reviews some of this literature.

Studies comparing rural and nonrural expenditures

Descriptive studies. Most studies comparing rural and nonrural cost and expenditure patterns are descriptive. At the national level, Stern (1994) finds that expenditures per student are higher in nonmetropolitan than metropolitan areas. Provasnik et al. (2007) find that adjusted current expenditures per student are higher in rural areas than in cities, suburbs, and towns.[14]

Descriptive studies at the state level also suggest that expenditures per student in rural areas exceed those in nonrural areas. For example, Imazeki and Reschovsky (2003) find that in Texas, nonmetropolitan rural schools have higher expenditures per student than do central city and suburban schools.

Studies that include statistical controls. Parrish, Matsumoto, and Fowler (1995) examine the associations between education expenditures and individual district and community factors (including urban, suburban, or rural status) at the national level, taking into account other potential influences on expenditures and adjusting for variations in resource costs and level of student need. Their results indicate higher expenditures per student in rural districts than in urban and suburban districts.

Levin et al. (2011) conducted regression analyses to explore the relationship between expenditures and selected potential cost factors in Arizona, California, Nevada, and Utah. To explore the association between geographic locale and spending patterns, they included not only locale types but also continuous measures of regional characteristics (characteristics that distinguish rural from nonrural districts). These measures included student enrollment, student population density, and drive time to the center of the nearest urban area (a measure of remoteness). The study found that regional characteristics are more strongly related to expenditures than are measures of student need or the cost of resources. Enrollment had the most significant correlation with spending, with districts with lower enrollment having higher expenditures per student.

Studies on other cost factors that contribute to differences in expenditures across districts

School- and district-level variation in education costs derives in part from regional characteristics (enrollment, population density, and geographic remoteness), labor costs, and costs associated with serving economically disadvantaged students or other students with greater educational needs. Evidence from previous studies suggests that these variables account for part of the differential between expenditures in rural and nonrural districts.

Enrollment. Expenditures per student are above the state average in districts with small student enrollments (see, for example, Thorson and Edmonson 2000). This pattern is especially evident in districts with fewer than 1,000 students (Levin et al. 2011; Parrish, Matsumoto, and Fowler 1995; Provasnik et al. 2007). The smallest districts face diseconomies of small scale because certain administrative and facilities-related expenditures must be spread over smaller numbers of students or schools. For example, the cost to serve students —in particular students with specific needs—may be higher in districts with low enrollment because the district cannot spread the cost of instructors and specialized services over a larger number of students (Imazeki and Reschovsky 2003).

Student population density and geographic remoteness. Certain costs may be disproportionately high in districts with geographically dispersed students. Transportation costs, for example, are directly related to the length and duration of students' bus rides. A national-level analysis finds that transportation costs are nearly twice as high in rural district as in urban districts and nearly 50 percent higher than in suburban districts (Killeen and Sipple 2000).

Expenditures may also rise with increasing distance from an urban center because of differences in accessibility to goods and services. Imazeki and Reschovsky (2003) find that in Texas and Wisconsin, rural schools outside metropolitan areas have higher expenditures per student than rural schools within metropolitan areas. Using drive time from the district to the center of the nearest urban area as a measure of remoteness, Levin et al. (2011) find that districts in four western states with longer drive times have higher expenditures per student.

Teacher costs. Because teacher compensation normally constitutes more than half a district's budget (Duncombe and Yinger 2008), labor market conditions can affect spending patterns. Differences in teacher compensation between rural and nonrural districts can vary with the relative influences of competing factors. Teachers' reluctance to live in geographically and socially isolated areas (Hammer et al. 2005) may place upward pressure on salaries in rural districts (Chambers and Fowler 1995). Placing downward pressure on compensation are other factors such as favorable working conditions (for example, low student–teacher ratios), a lower cost of living (driven largely by lower housing costs), low district fiscal capacity, and reduced job market competition in districts too remote from neighboring areas (Monk 2007). National data suggest that average teacher salaries are lower in rural districts than in urban or suburban districts (National Center for Education Statistics 2009).

Level of student need. It typically costs more to provide a comparable education to students enrolled in special programs (Duncombe and Yinger 2008). Significant additional funds are also needed to educate economically disadvantaged students: Reschovsky and Imazeki (1998) estimate that in Wisconsin, achieving a given education outcome costs 2.5 times more for students from low-income households than it does for other students. Duncombe (2002) estimates that educating students from low-income households in New York State costs twice as much as educating other students. Rural districts often enroll above-average proportions of students from low-income households. On average, both nationally and in Minnesota, rural districts also enroll above-average proportions of students qualifying for special education services (Johnson and Strange 2009).

APPENDIX B
DATA AND DATA SOURCES

This appendix describes the expenditure measures, cost factors, and district locale data used in this study and identifies their sources.

Expenditure measures

Minnesota reports district-level overall expenditures per student as well as expenditures per student by functional types. For student count, it uses "average daily membership," which reflects actual student attendance over the school year. Average daily membership is the sum for all students of the number of days in the district's school year each student is enrolled, divided by the number of days schools are in session. The Minnesota district expenditure file for fiscal year 2009 reports expenditures per average daily membership by 19 functional types (or combinations of types), such as instruction, administration, support, and operations. This study uses the term *per student* to refer to what is called *per average daily membership* in Minnesota's data file.

Total general fund expenditures. Total general fund expenditures for prekindergarten–grade 12 measure the overall level of education expenditures. Minnesota's general fund is used to finance education activities, district instructional and student support programs, the superintendent and district administration, normal operations and maintenance, student transportation, capital investments, and legal school district expenditures not specifically designated to be accounted for in any other fund (expenditures on food service, debt service, community service, and building construction are funded through separate funds; Minnesota Department of Education 2010b). On average, the general fund accounts for about 85 percent of school district spending in Minnesota (authors' calculation based on data from Minnesota Department of Education 2010b).

Instruction and instruction-related expenditures. Instruction and instruction-related expenditures include spending on regular instruction, career and technical instruction, special education, and instructional support services (Minnesota Department of Education 2010a).

Administration expenditures. Administrative expenditures are the sum of district-level and school-level administration expenditures. District-level administration expenditures include expenditures for the school board, the office of the superintendent, and other central office operations such as business and legal services, personnel, and printing; school-level administration expenditures include the cost of one licensed principal (or a prorated amount if the principal is shared between sites) and his or her immediate office (Minnesota Department of Education 2010a).

Student support expenditures. Student support expenditures include expenditures for noninstructional services provided to students, such as counseling, guidance, health services, psychological services, and attendance and social work services (Minnesota Department of Education 2010a).

Transportation expenditures. Transportation expenditures includes all expenditures associated with the transportation of students, including salaries of bus drivers and mechanics and program supervisors, contracted services, fuel for buses, transportation safety activities, and other expenditures associated with the transportation of students to and from school or for school-related trips and activities (Minnesota Department of Education 2010a).

Cost factors

The following cost factors were selected for investigation, based on evidence from previous studies that they are associated with rural/nonrural variations in district-level expenditures.[15]

Enrollment. The total enrollment count of a district in 2008/09 was drawn from publicly available sources on the Minnesota Department of Education website (Minnesota Department of Education 2009).

Student population density. The number of students per square mile was calculated by dividing a district's total enrollment by its area. The area of each district was calculated using geographic information system software (ArcGIS) based on the district boundary files provided by the U.S. Census Bureau (2008).

Drive time. The average drive time from district schools to the center of the nearest urban area was included to capture the relative accessibility of each district to goods and services (box B1). It was used in the regression analyses as a proxy for some of the variation in non–teacher input prices. Lack of access to services or suppliers or increased shipping costs may raise costs in remote districts. The drive time metric used is the drive time from schools within a district to the center of the nearest urbanized area or urban cluster aggregated at the district level, weighted by school enrollment.

Labor costs: comparable wage index. The comparable wage index for 2005 (the most recent year

BOX B1

Creation of the drive time metric

The U.S. Census Bureau's definition of *rural*—and hence the four major National Center for Education Statistics (NCES) locale categories —is based primarily on population density; distance from an urban area distinguishes the type of rural area. One could argue that drive time is not necessary for the analysis in this study, because rural districts are already categorized as fringe, distant, or remote. In fact, the drive time measure is useful, for three main reasons.

First, as Levin et al. (2011) note, drive time provides a continuous measure that compares the level of accessibility of each district and allows for the estimation of a continuous relationship between geographic isolation and expenditures. Second, drive time may capture dimensions of a rural location and remoteness that are not captured by the NCES typology. Third, the Census Bureau classification uses straight-line distance; the drive time metric, which is based on actual road distance and travel time, may better reflect the accessibility of some education services and the costs of providing them.

ArcGIS desktop software was used to compute drive times. The most recent latitude and longitude coordinates for every regular public school in Minnesota were downloaded from the Common Core of Data (U.S. Department of Education 2010). Geographic information on urban areas and clusters from the 2000 census (Environmental Systems Research Institute 2010b) was also incorporated. Street data from the 2003 TeleAtlas for Minnesota and neighboring states were then incorporated with urban area boundaries (Environmental Systems Research Institute 2010a). The exact centroid was found for each urban area in Minnesota and neighboring states, and X and Y coordinates were generated for the centroids. In some circumstances, the exact centroid of an urban area was not located directly on the street network. In these instances, a radius of one mile was used when placing urban area/cluster centroids onto the street network. Each school's coordinates served as the starting point ("origin") for the drive time calculation, with centroids for urban areas serving as the end points ("destinations").

Next, the length of each street segment within the 2003 TeleAtlas street data was calculated based on a Minnesota-specific map projection (UTM Zone 15N). TeleAtlas street data contain a field for each street segment that indicates the speed limit. This field was used in conjunction with the length field to determine how long it takes to travel the entire length of each street segment in the streets network.

The Network Analyst extension for ArcGIS desktop mapping software was used to compute an origin-destination cost matrix using all school locations as origins and urban area centroids as destinations to determine the closest urban areas to each school. The cost matrix automatically takes each origin point and calculates how long it takes to travel to each destination point, using the streets network and associated fields (length, miles per hour) and then ranks each destination based on its proximity to the origin. The drive time from each school to the closest destination was used as the drive time estimate for the school. The school-level drive time was then aggregated at the district level to yield an estimate of drive time for each district by calculating the average drive time of schools within a district weighted by school enrollment.

for which data were available) was used to control for geographic variations in the cost of hiring and retaining staff. The index also reflects regional variations in the salaries of college graduates who are not educators; it can thus be viewed as the opportunity cost educators face. The measure can serve as an index of the differential cost of hiring and retaining education staff in various locations.

Indicators of student need. Three district-level measures of the level of students with greater education needs were used: percentages of economically disadvantaged students (students eligible for free or reduced-price lunch), of special education students (students with an individualized education program), and of English language learner students. These data were downloaded from the Minnesota Department of Education website (Minnesota Department of Education 2009).

District locale

This study uses the urban-centric locale codes developed by the National Center for Education Statistics. Data on the district locale codes were drawn from the 2008/09 Common Core of Data (U.S. Department of Education 2010). The NCES system of locale codes builds on the U.S. Census Bureau's definitions of urban and rural territories. Urban territories consist of core census block groups or blocks with population density of at least 1,000 people per square mile whose surrounding census

TABLE B1

National Center for Education Statistics locale codes and locale types used in this study

Locale code	Description	Locale type used in this study
11: City–large	Territory inside an urbanized area and inside a principal city with a population of 250,000 or more	1: City
12: City–midsize	Territory inside an urbanized area and inside a principal city with a population of less than 250,000 but greater than or equal to 100,000	
13: City–small	Territory inside an urbanized area and inside a principal city with a population of less than 100,000	
21: Suburb–large	Territory outside a principal city and inside an urbanized area with a population of 250,000 or more	2: Suburb
22: Suburb–midsize	Territory outside a principal city and inside an urbanized area with a population of less than 250,000 but greater than or equal to 100,000	
23: Suburb–small	Territory outside a principal city and inside an urbanized area with a population of less than 100,000	
31: Town–fringe	Territory inside an urban cluster that is less than or equal to 10 miles from an urbanized area	3: Town–not remote
32: Town–distant	Territory inside an urban cluster that is more than 10 miles and less than or equal to 35 miles from an urbanized area	
33: Town–remote	Territory inside an urban cluster that is more than 35 miles from an urbanized area	4: Town–remote
41: Rural–fringe	Census-defined rural territory that is less than or equal to 5 miles from an urbanized area or a rural territory that is less than or equal to 2.5 miles from an urban cluster	5: Rural–fringe
42: Rural–distant	Census-defined rural territory that is more than 5 miles but less than or equal to 25 miles from an urbanized area or a rural territory that is more than 2.5 miles but less than or equal to 10 miles from an urban cluster	6: Rural–distant
43: Rural–remote	Census-defined rural territory that is more than 25 miles from an urbanized area and more than 10 miles from an urban cluster	7: Rural–remote

Source: U.S. Department of Education 2011; U.S. Census Bureau 2009.

blocks have an overall density of at least 500 people per square mile. A core with at least 50,000 people is designated as an urbanized area. Core areas with populations of 25,000–50,000 are classified as urban clusters. All territories outside urbanized areas and urban clusters are classified as rural.

The urban-centric locale system classifies schools into four major locale types—city, suburb, town, and rural—based on their location in relation to the nearest urbanized area or urban cluster. City and suburban schools are then classified into sublocales by size (large, midsize, and small), and town and rural schools are classified into sublocales by distance from an urbanized area or urban cluster (fringe, distant, and remote).

The locale codes for districts are then derived from the locale codes of schools in the district and the percentage of students attending those schools. A district is assigned the major locale type associated with the largest percentage of students in the district. If this percentage is less than 50, the district is assigned the smallest or most remote sublocale code for that type.

The full set of 12 urban-centric locale codes (table B1) is often consolidated into the four primary types (city, suburb, town, rural) in National Center for Education Statistics data products and publications as well as in other research reports (see, for example, Provasnik et al. 2007; Aud et al. 2011).

This study defined rural districts as those located in the urban-centric codes 41 (rural–fringe), 42 (rural–distant), and 43 (rural–remote). Because the primary focus is on variations in expenditures across geographic areas and variations in costs and because expenditures within rural districts are large, the three rural locale types were retained as separate types. In contrast, the three city sublocales were collapsed into a single city type, and the three suburban sublocales were collapsed into a single suburb type. Town–remote districts were treated as a separate type, because they are similar to rural districts in the characteristics of interest (Levin et al. 2011). The other two town types (town–fringe and town–distant) were collapsed into one type (town–not remote). Separating districts into seven categories also made the locale groups more similar in size, which makes the analysis more robust to violations of the homogeneity of variance assumption in multiple regression.

APPENDIX C
SAMPLE STATISTICS AND METHODOLOGY

This appendix provides the sample statistics and describes the methodologies used to answer each of the research questions.

Unit of analysis and analytical sample

Analysis was restricted to regular school districts, as defined in the Common Core of Data (U.S. Department of Education 2010).[16] Minnesota had 340 regular school districts in 2008/09, including two nonoperating districts, which were excluded from the study.

Minnesota also had 158 charter school districts in 2008/09. Finance data were not available for six of these districts, because they did not meet eligibility for measurement or were not active in 2008/09. The 152 charter school districts for which data were available served about 4 percent of public school students in prekindergarten–grade 12 and about 80 percent of all charter school students. About 70 percent of these schools were in cities or suburbs. Charter school districts were excluded from the study because the substantial differences between their revenues and expenditures and those of regular public school districts would have confused the analysis.[17] Moreover, because charter school districts have no clearly defined geographic boundaries, student population density values cannot be calculated for them.

Also excluded were all state-operated institutions and regional education services agencies. The final analytic sample thus included 338 regular school districts, which served 95.7 percent of all public school students in prekindergarten–grade 12 in Minnesota in 2008/09.

Methodology used to answer the question on how expenditures per student, regional characteristics, and level of student need differ across geographic locales

A comparative descriptive analysis of expenditures per student, regional characteristics, and level of student need was conducted to answer the first research question. District-level means and standard deviations were calculated for each locale type. Because the data did not always have a symmetric distribution, medians are also reported as a measure of central tendency, because they are robust to skewness (tables C1 and C2).

Methodology used to answer the question on the extent to which regional characteristics and level of student need account for differences in expenditures per student across geographic locales

For each expenditure measure, five regression models were built to explore the possible relationships between expenditures per student, regional characteristics, and level of student need.[18] Researchers then examined whether expenditures per student differed across locales after accounting for district characteristics. Mean expenditures per student were calculated for each locale type after adjusting for cost factors.

Researchers investigated different model specifications (for example, log-linear models) and transformations (for example, log transformations) of certain variables. In searching for the best model, they were guided by theory and previous research on similar topics; visual examination of the original data; and tests of significance, goodness-of-fit criteria (for example, R^2), and the usual regression diagnostics (for example, residual analysis and multicollinearity statistics). The models adopted use the natural logarithm of expenditure measures as the dependent variable.[19] Both student population density and enrollment were transformed into logarithmic forms, because they had very skewed distributions (figures C1 and C2).[20] Visual examinations of the scatter plots suggested the possibility of bivariate curvilinear relationships (figures C3 and C4). Polynomial (quadratic) terms were therefore included for both variables to assess whether a model incorporating these nonlinear terms would better approximate the effects of these variables.[21] Logarithmic transformations were also performed on the comparable wage index to reduce multicollinearity in the data. The

TABLE C1

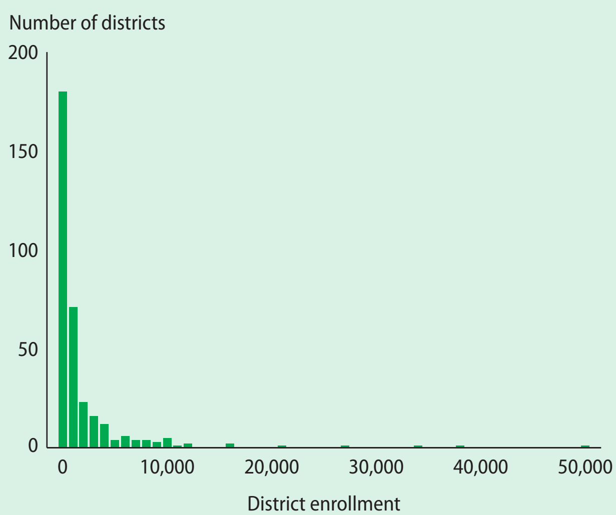
Measures of central tendency for Minnesota school district expenditures, by locale type, 2008/09

Type of expenditure	City	Suburb	Town–not remote	Town–remote	Rural–fringe	Rural–distant	Rural–remote	Overall
Total general fund								
Mean	11,320	10,768	9,214	10,676	9,618	9,647	11,017	10,316
Median	11,443	11,045	9,050	9,946	9,564	9,219	10,158	9,884
Standard deviation	1,270	1,772	1,319	2,113	1,544	1,657	2,574	2,130
Instruction and instruction-related								
Mean	7,979	7,517	6,129	7,190	6,471	6,002	6,803	6,649
Median	7,992	7,507	5,986	6,609	6,224	5,744	6,305	6,236
Standard deviation	1,020	1,327	988	1,983	1,250	1,100	1,785	1,569
Administration								
Mean	905	863	794	839	767	1,002	1,141	973
Median	902	799	741	822	747	942	1,030	901
Standard deviation	132	255	173	213	167	273	398	327
Student support								
Mean	343	302	238	215	217	175	171	206
Median	323	281	220	199	216	165	155	195
Standard deviation	108	96	99	81	70	125	134	123
Transportation								
Mean	624	541	488	532	546	568	697	596
Median	581	554	471	540	516	553	665	575
Standard deviation	126	118	123	129	143	205	231	201

Source: Authors' analysis based on data from Minnesota Department of Education (2010b).

FIGURE C1

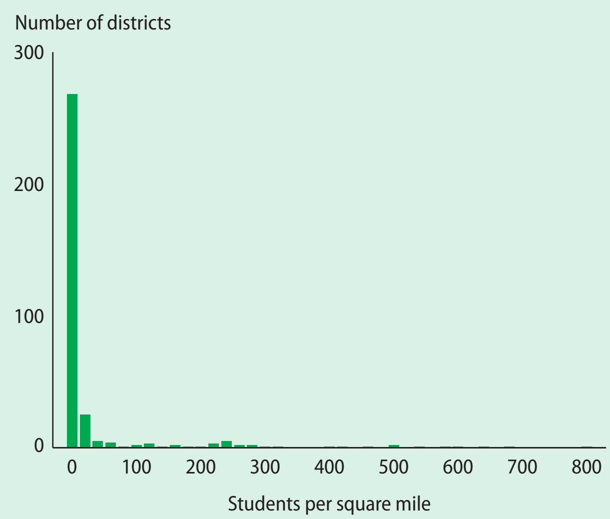
Distribution of enrollment in Minnesota school districts, 2008/09



Source: Authors' analysis based on data from U.S. Department of Education (2010) and Minnesota Department of Education (2009).

FIGURE C2

Distribution of student population density in Minnesota school districts, 2008/09



Source: Authors' analysis based on data from U.S. Department of Education (2010); U.S. Census Bureau (2008); and Environmental Systems Research Institute (2010b).

TABLE C2

Measures of central tendency for characteristics of Minnesota school districts, by locale type, 2008/09

District characteristic	City	Suburb	Town–not remote	Town–remote	Rural–fringe	Rural–distant	Rural–remote	Overall
District enrollment								
Mean	15,479	8,119	2,672	2,076	2,853	710	540	2,349
Median	10,025	6,350	1,764	1,577	2,542	628	473	911
Standard deviation	11,423	8,174	2,303	1,584	1,687	462	345	4,598
Student population density (enrollment per square mile)								
Mean	272.7	264.8	18.2	8.4	28.4	5.1	2.1	41.1
Median	254.4	236.2	14.6	6.7	21.4	4.1	1.9	4.3
Standard deviation	219.0	200.5	15.4	9.0	31.2	3.9	1.8	112.8
Drive time to the nearest urban area (minutes)								
Mean	15.3	18.0	3.4	3.0	7.1	21.3	36.8	21.0
Median	16.6	19.5	2.4	2.3	5.3	18.4	33.3	18.7
Standard deviation	7.3	5.6	3.0	2.4	5.7	10.2	16.4	17.1
Comparable wage index								
Mean	1.271	1.268	1.173	1.042	1.183	1.090	1.031	1.110
Median	1.305	1.305	1.120	1.025	1.233	1.074	1.013	1.070
Standard deviation	0.070	0.084	0.110	0.049	0.132	0.097	0.049	0.120
Percentage of economically disadvantaged students[a]								
Mean	34.0	28.0	26.4	38.0	24.8	34.3	45.2	36.0
Median	31.0	26.1	25.0	37.4	23.5	33.2	43.2	35.0
Standard deviation	21.2	14.9	9.6	8.9	12.8	11.8	13.3	14.6
Percentage of special education students								
Mean	14.2	13.4	13.4	15.5	13.9	14.9	16.1	14.9
Median	13.7	13.4	13.4	14.8	13.6	14.4	15.7	14.4
Standard deviation	3.3	1.8	2.7	3.2	3.5	4.7	4.1	3.9
Percentage of students identified as English language learner students								
Mean	11.3	7.7	3.3	3.4	1.5	2.3	1.5	3.0
Median	8.5	6.0	2.1	0.4	1.1	0.2	0.0	0.5
Standard deviation	12.3	7.1	3.6	5.3	1.4	5.4	3.9	5.5

a. Students eligible for free or reduced-price lunch.

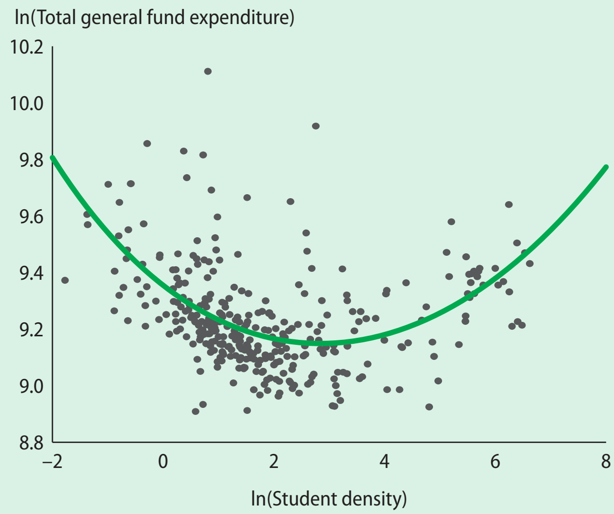
Source: Authors' analysis based on data from U.S. Department of Education (2010); Minnesota Department of Education (2009); U.S. Census Bureau (2008); and Environmental Systems Research Institute (2010b).

three levels of student need (the percentages of economically disadvantaged students, of special education students, and of English language learner students) and the drive time were included in the original scales.

For each expenditure measure, the initial model (model 1) includes only the locale type.[22] This model estimates the variations in expenditures across districts across locale types when no cost factors are taken into account. Model 2 regresses each expenditure measure on the four regional characteristic cost factors: total student enrollment, student population density, drive time to an urban area, and cost of wage adjustment. Model 3 regresses each expenditure measure on the three student need measures: proportion of students eligible for free or reduced price lunch, proportion

FIGURE C3

Correlation between total general fund expenditure per student and student population density in Minnesota school districts, 2008/09



Source: Authors' analysis based on data from U.S. Department of Education (2010); Minnesota Department of Education (2009); U.S. Census Bureau (2008); and Environmental Systems Research Institute (2010b).

FIGURE C4

Correlation between administration expenditure per student and enrollment in Minnesota school districts, 2008/09

Source: Authors' analysis based on data from U.S. Department of Education (2010); Minnesota Department of Education (2009); U.S. Census Bureau (2008); and Environmental Systems Research Institute (2010b).

of students in special education, and proportion of students who are classified as English language learner students. The two models estimate the relationship between expenditure measures and each group of cost factors, independent of the other group. Model 4 adds the regional characteristics factors to the student need factors, in order to reexamine the relationship between expenditures and each cost factor with all other cost factors, controlling for all other variables. The full model (model 5) includes all the cost factors and the locale type, in order to estimate how much variation remains across locales after accounting for all cost factors.

Model 5 produces estimates quantifying the relationships between each expenditure measure and each cost factor, controlling for all other cost factors. The estimated regression equations from this model were used to calculate the mean expenditures per student of districts within each locale type, holding all cost factors at their sample means. In models in which overall differences across locales in adjusted expenditures were significant, researchers conducted post hoc pairwise comparisons to identify which pair of locales had statistically different adjusted means. They used a Bonferroni correction to adjust for multiple pairwise comparisons. Figures 8–12 in the main report show the adjusted means and the unadjusted means (that is, means that did not take cost factors into account) for each expenditure measure. They reveal the degree to which cost factors account for expenditure differences across geographic locales.

Model specification. The final regression models used in the analysis take the following general form:

$$Y_i = \beta_0 + \Sigma_{j=1}^{6}\beta_j L_{j,i} + \Sigma_{k=1}^{4}\varpi_k X_{k,i} + \Sigma_{m=1}^{3}\pi_m Z_{m,i} + \varepsilon_i \quad \text{(C1)}$$

where Y_i is an expenditure measure for school district i; $L_{j,i}$ is a vector of dummy indicators denoting district locale (the rural–remote locale serves as the reference type); X_k is a vector of four regional characteristics; Z_m is a vector of three variables indicating level of student need; and ε_i is a Gaussian random error that includes all unobserved factors that affect the outcome. β_0 is the mean outcome for rural–remote districts adjusted for regional characteristics and level of student need; and the β_js are the adjusted mean differences between rural–remote districts and districts of other locale types. Each slope in ϖ_k and π_m represents the association between a district characteristic and an expenditure level, adjusted for the other factors in the model. The model was fitted to each expenditure measure.

Model 5 identified outliers based on a common set of criteria (see appendix E for a discussion of outliers). Models 1–5 were then rerun without the outliers. The models excluding the outliers fit the data better based on goodness-of-fit criteria, and they met the assumptions of regression better using the usual regression diagnostics (for example, residuals are normally distributed and have constant variance).[23] The findings reported in the main text are based on regression results presented in tables D1–D5, after outliers were excluded from each model. For comparison, the regression results from model 5, which included all the valid observations (that is, no outliers were excluded), are presented in table D6.

Model 5 takes the following form:

$$\ln(Y)_i = \beta_0 + \Sigma_{j=1}^{6}\beta_j(\text{locale})_i + \beta_7(\text{drive time}) + \beta_8\ln(\text{enrollment})_i + \beta_9(\ln(\text{enrollment})_i)^2 + \beta_{10}\ln(\text{student density}) + \beta_{11}(\ln(\text{student density})_i)^2 + \beta_{12}(\text{free or reduced-price lunch percentage})_i + \beta_{13}(\text{special education percentage})_i + \beta_{14}(\text{ELL percentage})_i + \beta_{15}\ln(\text{CWI})_i + \varepsilon_i \qquad \text{(C2)}$$

where i denotes district-specific observations.

The models were fitted using both regression and the general linear model (GLM) procedure in SPSS.[24] GLM fitted the same regression models as the regression procedures, but in GLM, locale was entered as one fixed factor and the procedure performed the dummy coding automatically. GLM also provides an overall F-test value for the locale factor, which indicates whether significant variations were left across locale types after controlling for all cost factors.

The GLM procedure also provides estimated marginal (adjusted) means, the estimated means of expenditures for each level of the factor (locale) at the mean of the covariates in the model.[25] In cases where GLM yielded a significant main effect in data for the locale indicator, pairwise comparisons in post hoc tests were conducted with Bonferroni correction to adjust for multiple comparisons. The adjusted means were then compared with the corresponding unadjusted means (see figures 8–12).

Example of calculating adjusted mean expenditures. This study sought to determine how districts across locale types differ in expenditures after taking account of selected cost factors. It uses estimated regression models (see equation C2) to calculate the adjusted (predicted) mean expenditures for districts in each locale type. In each locale type, the expected expenditure for an "average" district (meaning that all other cost factors were set at their average across all districts in the sample) was calculated, holding all other cost factors at their sample means.

The βs in equation C2 were populated with corresponding regression coefficients from the final model (model 5), all the covariates were set at their sample means, and the error term was set at 0. When all six locale indicators are set at 0, the predicted outcome ($\ln(Y)$) is the predicted expenditure value for an average rural–remote district (the reference type); the predicted outcome when each locale indicator is set at 1 and other locale indicators are set at 0 is the estimated mean expenditure for an average district in that locale type.

Table C3 illustrates how the adjusted mean total general fund expenditures per student were calculated for each locale type using the regression coefficients from the full regression model (model 5 in table D1). The model used the natural logarithm of total general fund expenditures per student as the dependent variable. The antilogs of the predicted values (column 6) were used to obtain the dollar values of the total general fund expenditures per student (column 7). The adjusted means for other expenditure measures were calculated in a similar manner.

TABLE C3

Sample calculation of adjusted mean total general fund expenditures per student in Minnesota school districts, 2008/09

Variable	Model coefficient	Sample mean	Transformations performed on cost factors in regression model	Transformed cost factor values	Coefficients × transformed values	Predicted expenditure values[a]	Predicted expenditures (dollars)
Constant: rural–remote as reference type	8.963	1	None	1.000	8.963	9.132	9,245
Comparable wage index (CWI)	1.105	0.100	ln(CWI)	0.100	0.013		
Drive time	0.001	20.955	None	20.955	0.018		
Enrollment	–0.002	2,348.780	ln(enrollment)	7.762	–0.016		
	0.001		$(\ln(\text{enrollment}))^2$	60.243	0.053		
Student density	–0.113	41.105	ln(student density)	3.716	–0.420		
	0.019		$(\ln(\text{student density}))^2$	13.810	0.267		
Economically disadvantaged[b]	0.003	35.997	None	35.997	0.094		
Eligible for special education	0.011	14.946	None	14.946	0.161		
English language learner student	0.000	2.973	None	2.973	–0.001		
City	0.068	(0, 1)	None	(0, 1)	(0, 0.068)	9.200	9,900
Suburb	0.033	(0, 1)	None	(0, 1)	(0, 0.033)		9,553
Town–not remote	0.028	(0, 1)	None	(0, 1)	(0, 0.028)	9.160	9,504
Town–remote	0.094	(0, 1)	None	(0, 1)	(0, 0.094)	9.226	10,152
Rural–fringe	0.051	(0, 1)	None	(0, 1)	(0, 0.051)	9.183	9,732
Rural–distant	–0.003	(0, 1)	None	(0, 1)	(0, –0.003)	9.129	9,222

Note: The dependent variable is the ln(total general fund expenditures per student).

a. Log-transformed value of the raw expenditure (dollars).

b. Students eligible for free or reduced-price lunch.

Source: Authors' analysis based on data from U.S. Department of Education (2010); Minnesota Department of Education (2009); U.S. Census Bureau (2008); and Environmental Systems Research Institute (2010b).

APPENDIX D
REGRESSION MODEL RESULTS

Tables D1–D5 present the regression results from the models, excluding all outliers (see appendix E). Table D6 presents the results from the full model including all outliers.

The coefficient for each predictor in the regression models yields an estimate of how expenditures vary with respect to the predictor (cost factor) while holding all other predictors in the model constant. Because the models use the natural logarithm of the expenditure measures and some of the cost factors were log-transformed, the

TABLE D1

Regression results for variation in total general fund expenditures per student across Minnesota school districts, 2008/09

	Model 1		Model 2		Model 3		Model 4		Model 5 (full model)	
Variable	Coefficient	*p*-value	Coefficient	*p*-value	Coefficient	*p*-value	Coefficient	*p*-value	Coefficient	*p*-value
Constant: rural–remote as reference type	9.266	0.000*	9.253	0.000*	8.879	0.000*	8.887	0.000*	8.963	0.000*
Log of comparable wage index			–0.227	0.026*			0.058	0.548	0.127	0.216
Drive time			0.000	0.770			0.000	0.807	0.001	0.163
ln(enrollment)			–0.001	0.984			0.019	0.699	–0.002	0.966
$(\ln(\text{enrollment}))^2$			0.002	0.546			0.001	0.878	0.001	0.801
ln(student density)			–0.157	0.000*			–0.123	0.000*	–0.113	0.000*
$(\ln(\text{student density}))^2$			0.026	0.000*			0.021	0.000*	0.019	0.000*
Economically disadvantaged[a]					0.004	0.000*	0.003	0.000*	0.003	0.000*
Eligible for special education					0.013	0.000*	0.011	0.000*	0.011	0.000*
English language learner student					0.002	0.070	0.000	0.736	0.000	0.848
City[b]	0.063	0.178							0.068	0.208
Suburb[b]	–0.004	0.892							0.033	0.435
Town–not remote[b]	–0.158	0.000*							0.028	0.373
Town–remote[b]	–0.035	0.221							0.094	0.002*
Rural–fringe[b]	–0.105	0.000*							0.051	0.112
Rural–distant[b]	–0.118	0.000*							–0.003	0.894
F-value (corrected model)	10.944	0.000*	39.226	0.000*	53.161	0.000*	46.043	0.000*	26.957	0.000*
F-value (locale)[c]	10.944	0.000*							2.359	0.030*
Adjusted R^2	0.159		0.414		0.326		0.533		0.545	
Number of observations	325		325		325		325		325	

* Significant at $p = .05$.

Note: Dependent variable is ln(total general fund expenditures).

a. Students eligible for free or reduced-price lunch.

b. Coefficients for the locale dummy variables (city, suburb, town-not remote, town–remote, rural–fringe, and rural–distant) indicate the differences in mean outcome between each locale type and the reference type (rural–remote), given the other variables included in the model. Their corresponding p- value indicates whether the difference is statistically significant. A similar interpretation applies to tables D2–D6.

c. F-value and p-value for the locale factor test the null hypothesis that the locale factor is not statistically significantly associated with the outcome variable, after controlling for the other predictor variables included in the model. A similar interpretation applies to tables D2–D6.

Source: Authors' analysis based on data from U.S. Department of Education (2010); Minnesota Department of Education (2009); U.S. Census Bureau (2008); and Environmental Systems Research Institute (2010b).

TABLE D2

Regression results for variation in instruction and instruction-related expenditures across Minnesota school districts, 2008/09

	Model 1		Model 2		Model 3		Model 4		Model 5 (full model)	
Variable	Coefficient	*p*-value	Coefficient	*p*-value	Coefficient	*p*-value	Coefficient	*p*-value	Coefficient	*p*-value
Constant: rural–remote as reference type	8.779	0.000*	8.854	0.000*	8.464	0.000*	8.370	0.000*	8.488	0.000*
Log of comparable wage index			–0.184	0.138			0.140	0.226	0.201	0.094
Drive time			0.001	0.417			0.000	0.498	0.002	0.003*
ln(enrollment)			–0.057	0.383			–0.025	0.659	–0.060	0.302
$(\ln(\text{enrollment}))^2$			0.008	0.076			0.005	0.184	0.006	0.132
ln(student density)			–0.122	0.000*			–0.078	0.000*	–0.065	0.000*
$(\ln(\text{student density}))^2$			0.022	0.000*			0.016	0.000*	0.014	0.000*
Economically disadvantaged[a]					0.002	0.000*	0.003	0.000*	0.003	0.000*
Eligible for special education					0.015	0.003*	0.014	0.000*	0.014	0.000*
English language learner student					0.006	0.002	–0.002	0.183	–0.002	0.232
City	0.197	0.000*							0.091	0.152
Suburb	0.130	0.000*							0.085	0.084
Town–not remote	–0.063	0.034*							0.090	0.012*
Town–remote	0.033	0.289							0.147	0.000*
Rural–fringe	–0.041	0.227							0.082	0.030*
Rural–distant	–0.108	0.000*							0.000	0.982
F-value (corrected model)	13.882	0.000*	27.283	0.000*	27.958	0.000*	34.306	0.000*	23.391	0.000*
F-value (locale)	13.882	0.000*							4.054	0.001*
Adjusted R^2	0.191		0.325		0.198		0.478		0.507	
Number of observations	328		328		328		328		328	

* Significant at $p = 0.05$.

Note: Dependent variable is ln(instruction and instruction-related expenditures).

a. Students eligible for free or reduced-price lunch.

Source: Authors' analysis based on data from U.S. Department of Education (2010); Minnesota Department of Education (2009); U.S. Census Bureau (2008); and Environmental Systems Research Institute (2010b).

interpretation of the coefficients in the original scale of the predictors is less straightforward than that of coefficients obtained through a regression model that includes no transformed variable.

When the *Y* variable (expenditure) is log-transformed but the *X* variable (predictor) is not transformed, the coefficient for *X* (*b*) can be interpreted as follows: for every one-unit change in *X*, *Y* will increase or decrease by $100 \times (e^b - 1)$ percent. In tables D1–D5, the coefficients for the locale types; the drive time; and the percentage of economically disadvantaged students, of special education students, and of English language learner students could be interpreted this way. When $|b| < 0.1$, an approximate interpretation could be that a one-unit increase in *X* is associated with an average of 100*b* percent increase in *Y*. In

TABLE D3

Regression results for variation in administration expenditures across Minnesota school districts, 2008/09

	Model 1		Model 2		Model 3		Model 4		Model 5 (full model)	
Variable	Coefficient	*p*-value	Coefficient	*p*-value	Coefficient	*p*-value	Coefficient	*p*-value	Coefficient	*p*-value
Constant: rural–remote as reference type	6.973	0.000*	8.818	0.000*	6.454	0.000*	8.585	0.000*	8.458	0.000*
Log of comparable wage index			0.102	0.519			0.273	0.104	0.259	0.148
Drive time			0.001	0.235			0.001	0.205	0.002	0.042*
ln(enrollment)			–0.442	0.000*			–0.415	0.000*	–0.379	0.000*
$(\ln(\text{enrollment}))^2$			0.023	0.000*			0.021	0.000*	0.017	0.005*
ln(student density)			–0.121	0.000*			–0.106	0.000*	–0.104	0.000*
$(\ln(\text{student density}))^2$			0.020	0.000*			0.017	0.000*	0.017	0.000*
Economically disadvantaged[a]					0.008	0.000*	0.002	0.053	0.002	0.047*
Eligible for special education					0.006	0.156	0.002	0.546	0.001	0.653
English language learner student					–0.006	0.018	0.002	0.398	0.001	0.556
City	–0.175	0.025*							0.222	0.020*
Suburb	–0.291	0.000*							0.058	0.428
Town–not remote	–0.316	0.000*							0.086	0.107
Town–remote	–0.274	0.000*							0.089	0.088
Rural–fringe	–0.333	0.000*							0.062	0.266
Rural–distant	–0.100	0.004*							0.038	0.245
F-value (corrected model)	17.025	0.000*	61.238	0.000*	30.714	0.000*	42.563	0.000*	26.292	0.000*
F-value (locale)	17.025	0.000*							1.397	0.215
Adjusted R^2	0.230		0.529		0.217		0.537		0.541	
Number of observations	323		323		323		323		323	

* Significant at $p = 0.05$.

Note: Dependent variable is ln(administration expenditures).

a. Students eligible for free or reduced-price lunch.

Source: Authors' analysis based on data from U.S. Department of Education (2010); Minnesota Department of Education (2009); U.S. Census Bureau (2008); and Environmental Systems Research Institute (2010b).

table D1, for example, the coefficient for the economically disadvantaged percentage in model 5 is 0.003, which means that a 1 percent increase in the percentage of economically disadvantaged students is associated with a 0.3 percent increase in total general fund expenditures per student. The coefficient for the dummy-coded locale variables can be interpreted as follows: the average expenditures per student for the comparison type are $100 \times (e^b - 1)$ percent higher or lower than the reference type. In model 5 in table D1, the coefficient for the town–remote type is 0.094, which means that on average, town–remote districts spend about 9 percent more per student than rural–remote districts.

When both *Y* and *X* are transformed, the coefficient for *X* (*b*) can be interpreted as follows: a 1 percent increase in *X* is associated with an average $100 \times ((1.01)^b - 1)$ percent increase in *Y*. In table D1, for example, the coefficient for the linear

TABLE D4

Regression results for variation in student support expenditures across Minnesota school districts, 2008/09

	Model 1		Model 2		Model 3		Model 4		Model 5 (full model)	
Variable	Coefficient	*p*-value	Coefficient	*p*-value	Coefficient	*p*-value	Coefficient	*p*-value	Coefficient	*p*-value
Constant: rural–remote as reference type	4.959	0.000*	–1.162	0.231	5.388	0.000*	–1.335	0.194	–1.375	0.199
Log of comparable wage index			–0.460	0.285			–0.080	0.861	–0.314	0.517
Drive time			0.002	0.338			0.003	0.270	0.004	0.166
ln(enrollment)			1.455	0.000*			1.468	0.000*	1.441	0.000*
$(\ln(\text{enrollment}))^2$			–0.073	0.000*			–0.074	0.000*	–0.071	0.000*
ln(student density)			–0.199	0.004*			–0.172	0.013*	–0.189	0.008*
$(\ln(\text{student density}))^2$			0.031	0.002*			0.022	0.042*	0.025	0.039*
Economically disadvantaged[a]					–0.006	0.028*	0.004	0.200	0.005	0.113
Eligible for special education					–0.007	0.549	–0.005	0.624	–0.005	0.574
English language learner student					0.041	0.000*	0.014	0.039*	0.013	0.068
City	0.839	0.000*							0.033	0.899
Suburb	0.701	0.000*							0.094	0.638
Town–not remote	0.441	0.000*							0.219	0.148
Town–remote	0.332	0.003*							0.052	0.724
Rural–fringe	0.363	0.003*							0.090	0.569
Rural–distant	0.054	0.527							0.131	0.159
F-value (corrected model)	11.283	0.000*	29.659	0.000*	16.355	0.000*	21.275	0.000*	12.935	0.000*
F-value (locale)	11.283	0.000*			5.388	0.000*			0.646	0.693
Adjusted R^2	0.163		0.352		0.127		0.365		0.361	
Number of observations	318		318		318		318		318	

* Significant at $p = .05$.

Note: Dependent variable is ln(student support expenditures). In addition to outliers, four other districts were excluded: two districts had no student support expenditure, two had negative values. These four districts were excluded from all analyses of student support expenditure.

a. Students eligible for free or reduced-price lunch.

Source: Authors' analysis based on data from U.S. Department of Education (2010); Minnesota Department of Education (2009); U.S. Census Bureau (2008); and Environmental Systems Research Institute (2010b).

term of log-transformed student population density is –0.113, and $100 \times (1.01^{-0.113} - 1) = -0.112$. This means that on average, a 1 percent increase in student population density is associated with a 0.1 percent decrease in total general fund expenditures per student. However, because the model also includes a quadratic term for student population density and the coefficient for the quadratic term (a) is positive, the size of the negative relationship is different at every value of X, and the relationship levels off and turns positive at the point at which $\ln(X)$ equals $-b/2a$. In this example, the natural logarithm of student population density at the threshold point is $0.113/2 \times 0.019 = 2.97$, which corresponds to a student population density value of about 20 students per square mile. The coefficients for enrollment can be interpreted in a similar way.

TABLE D5

Regression results for variation in transportation expenditures across Minnesota school districts, 2008/09

	Model 1		Model 2		Model 3		Model 4		Model 5 (full model)	
Variable	Coefficient	*p*-value	Coefficient	*p*-value	Coefficient	*p*-value	Coefficient	*p*-value	Coefficient	*p*-value
Constant: rural–remote as reference type	6.519	0.000*	6.608	0.000*	5.976	0.000*	5.975	0.000*	5.829	0.000*
Log of comparable wage index			–0.074	0.749			0.147	0.541	0.226	0.376
Drive time			0.001	0.293			0.001	0.350	–0.001	0.482
ln(enrollment)			–0.060	0.634			0.041	0.748	0.110	0.403
$(\ln(\text{enrollment}))^2$			0.008	0.384			0.001	0.917	–0.004	0.685
ln(student density)			–0.222	0.000*			–0.204	0.000*	–0.197	0.000*
$(\ln(\text{student density}))^2$			0.027	0.000*			0.025	0.000*	0.022	0.001*
Economically disadvantaged[a]					0.006	0.000*	0.002	0.119	0.002	0.226
Eligible for special education					0.012	0.013*	0.010	0.023*	0.012	0.010*
English language learner student					–0.006	0.060	–0.002	0.521	–0.001	0.659
City	–0.100	0.281							0.048	0.729
Suburb	–0.229	0.000*							–0.035	0.747
Town–not remote	–0.349	0.000*							–0.156	0.044*
Town–remote	–0.272	0.000*							–0.170	0.021*
Rural–fringe	–0.249	0.000*							–0.086	0.282
Rural–distant	–0.226	0.000*							–0.095	0.043*
F-value (corrected model)	11.158	0.000*	18.891	0.000*	19.297	0.000*	14.309	0.000*	9.344	0.000*
F-value (locale)	11.158	0.000*							1.639	0.136
Adjusted R^2	0.156		0.246		0.143		0.267		0.276	
Number of observations	329		329		329		329		329	

* Significant at $p = 0.05$.

Note: Dependent variable is ln(transportation expenditures).

a. Students eligible for free or reduced-price lunch.

Source: Authors' analysis based on data from U.S. Department of Education (2010); Minnesota Department of Education (2009); U.S. Census Bureau (2008); and Environmental Systems Research Institute (2010b).

TABLE D6

Regression results for models of differences in expenditures across Minnesota school districts that include outliers, 2008/09

	ln(total general fund expenditures)		ln(instruction and instruction-related expenditures)		ln(administration expenditures)		ln(student support expenditures)[a]		ln(transportation expenditures)	
Variable	Coefficient	*p*-value	Coefficient	*p*-value	Coefficient	*p*-value	Coefficient	*p*-value	Coefficient	*p*-value
Constant: rural–remote as reference type	8.951	0.000*	8.333	0.000*	7.922	0.000*	–1.738	0.146	5.531	0.000
Log of comparable wage index	0.243	0.065	0.288	0.059	0.412	0.056	–0.636	0.341	0.386	0.171
Drive time	0.002	0.026*	0.002	0.028*	0.001	0.238	0.001	0.804	–0.002	0.177
ln(enrollment)	–0.024	0.692	–0.023	0.746	–0.273	0.007*	1.543	0.000*	0.180	0.172
$(\ln(\text{enrollment}))^2$	0.003	0.507	0.004	0.376	0.011	0.115	–0.074	0.002*	–0.007	0.429
ln(student density)	–0.100	0.000*	–0.081	0.000*	–0.102	0.001*	–0.209	0.024*	–0.231	0.000*
$(\ln(\text{student density}))^2$	0.016	0.000*	0.014	0.000*	0.016	0.002*	0.034	0.032*	0.028	0.000*
Economically disadvantaged[a]	0.004	0.000*	0.005	0.000*	0.003	0.007*	0.008	0.054	0.003	0.106
Eligible for special education	0.010	0.000*	0.012	0.000*	0.007	0.049*	–0.022	0.087	0.012	0.014*
English language learner student	–0.002	0.323	–0.003	0.107	0.000	0.891	–0.011	0.198	–0.004	0.223
City	0.064	0.361	0.095	0.241	0.187	0.104	–0.005	0.989	–0.013	0.932
Suburb	0.050	0.350	0.095	0.127	0.075	0.393	0.041	0.882	–0.115	0.318
Town–not remote	0.044	0.254	0.077	0.088	0.047	0.465	0.198	0.324	–0.186	0.027*
Town–remote	0.130	0.001*	0.174	0.000*	0.041	0.505	0.028	0.885	–0.176	0.029*
Rural–fringe	0.057	0.164	0.093	0.050*	0.003	0.964	0.030	0.887	–0.111	0.207
Rural–distant	0.005	0.842	0.006	0.818	0.036	0.363	0.165	0.175	–0.091	0.077
F-value (corrected model)	19.251	0.000*	16.364	0.000*	18.970	0.000*	10.417	0.000*	8.171	0.000*
F-value (locale)	2.504	0.022*	3.338	0.003*	0.717	0.636	0.527	0.788	1.364	0.229
Adjusted R^2	0.448		0.406		0.444		0.298		0.242	
Number of observations	338		338		338		334*		338	

* Significant at $p = .05$.

a. Four districts were always excluded from any analysis on student support expenditures: two districts had 0 student support expenditures and the other two had negative values.

b. Students eligible for free or reduced-price lunch.

Source: Authors' analysis based on data from U.S. Department of Education (2010); Minnesota Department of Education (2009); U.S. Census Bureau (2008); and Environmental Systems Research Institute (2010b).

APPENDIX E
OUTLIERS DROPPED FROM THE REGRESSION ANALYSIS

For this study, a case was considered an outlier if it met all of the following criteria:

1. The absolute value of the studentized deleted residual was greater than 2. The studentized deleted residual is the residual that would be obtained if the regression were rerun omitting that observation from the analysis.

2. The Cook's D-value was greater than $4/n$ (sample size). This value is a general measure of the influence a point has on the whole model: the higher the Cook's D, the more influential the point is; $4/n$ is a conventional cutoff point (Bollen and Jackman 1990).

3. The absolute value of the DFBETA for any coefficient was greater than $2/\sqrt{n}$ (the difference between a parameter estimated using all cases and a parameter estimated when one case is excluded is known as DFBETA). It is a more specific measure of influence that assesses how each coefficient is changed by including a particular case. A DFBETA value can be computed for each observation for each predictor; $2/\sqrt{n}$ is a conventional cutoff value (Belsley, Kuh, and Welsch 1980).

Table E1 lists the number and percentage of outliers excluded from the regression analysis for each expenditure measure, as well as the number and percentage of students served by those districts, by locale type. More rural–remote and rural–distant districts were identified as outliers than districts in other locale types.[26]

TABLE E1

Outliers in regression analysis of differences in expenditure across Minnesota school districts, by type of expenditure and locale, 2008/09

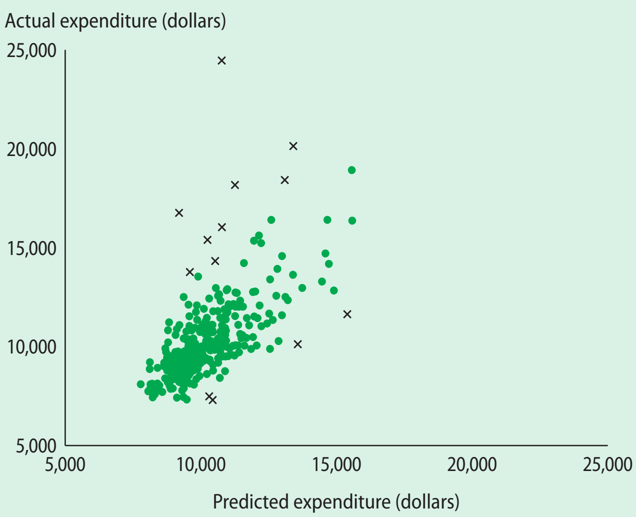
Locale type	Total general fund expenditure				Instruction and instruction-related expenditure				Administration expenditure				Student support expenditure				Transportation expenditure			
	District		Student		District		Student		District		Student		District		Student		District		Student	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Nonrural																				
City																				
Suburb	1	3	8,371	3					2	6	14,917	6					1	3	1,747	1
Town–not remote	1	3	3,486	3	1	3	5,140	5									1	3	1,319	1
Town–remote	2	6	5,424	8	2	6	5,424	8	2	6	2,142	3								
Rural																				
Rural–fringe					1	4	1,435	2	1	4	4,873	6								
Rural–distant	4	5	1,099	2	3	4	946	2	1	1	1,482	3	5	6	808	1	3	4	1,638	3
Rural–remote	5	4	3,097	5	3	3	2,361	4	9	8	5,071	8	11	10	3,018	5	3	3	736	1
Total	13	4	21,477	3	10	3	15,306	2	15	4	28,485	4	16	5	3,826	0	8	2	5,440	1

Source: Authors' analysis based on data from U.S. Department of Education (2010); Minnesota Department of Education (2009); U.S. Census Bureau (2008); and Environmental Systems Research Institute (2010b).

Figures E1–E5 display the actual versus predicted expenditures when all outliers are included in the analysis. The predicted expenditures are what would be expected (based on regression models) from the district given its regional characteristics and level of student need. Most outlier districts in total general fund, instruction and instruction-related, and administration expenditures spend more than districts in the same locale types with similar regional characteristics and level of student need. Most also spend more on these expenditures than districts that are not outliers. In contrast, most outlier districts in transportation and student support expenditures spend less than districts in the same locale type with similar regional characteristics and level of student need. Outlier districts also tend to spend less on these two expenditure types than districts that are not outliers.

FIGURE E1

Outliers in regression analysis of differences in total general fund expenditures across school districts in Minnesota, 2008/09

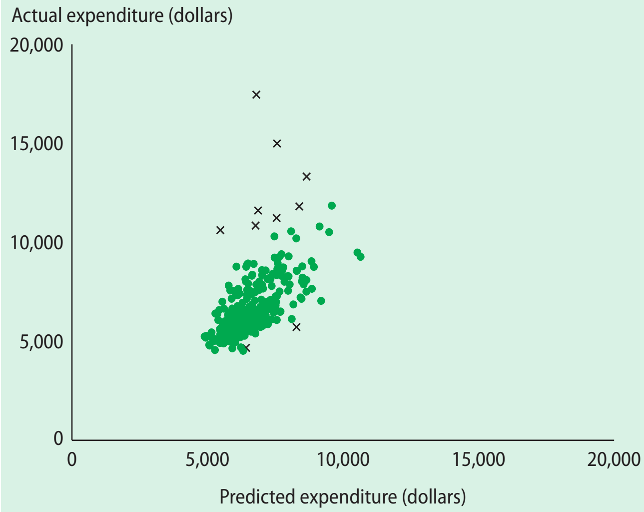


Note: Outliers are marked by the × sign.

Source: Authors' analysis based on data from U.S. Department of Education (2010); Minnesota Department of Education (2009); U.S. Census Bureau (2008); and Environmental Systems Research Institute (2010b).

FIGURE E2

Outliers in regression analysis of differences in instruction and instruction-related expenditures across school districts in Minnesota, 2008/09

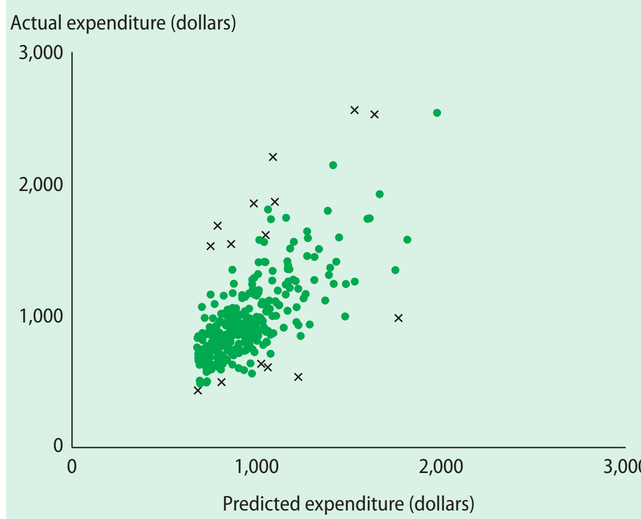


Note: Outliers are marked by the × sign.

Source: Authors' analysis based on data from U.S. Department of Education (2010); Minnesota Department of Education (2009); U.S. Census Bureau (2008); and Environmental Systems Research Institute (2010b).

FIGURE E3

Outliers in regression analysis of differences in administration expenditures across school districts in Minnesota, 2008/09



Note: Outliers are marked by the × sign.

Source: Authors' analysis based on data from U.S. Department of Education (2010); Minnesota Department of Education (2009); U.S. Census Bureau (2008); and Environmental Systems Research Institute (2010b).

FIGURE E4

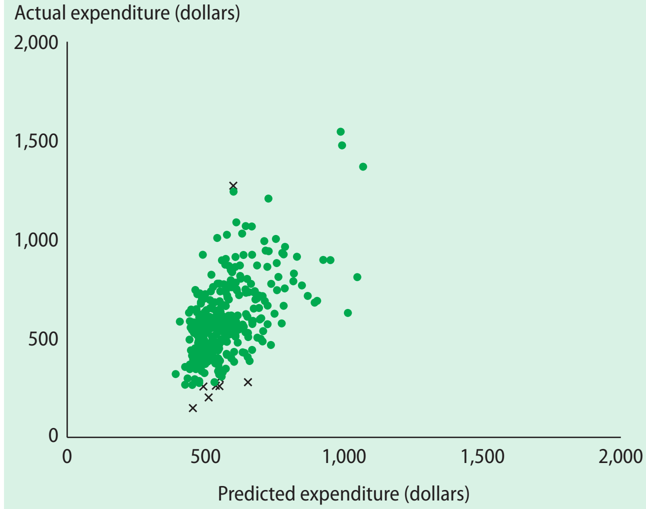
Outliers in regression analysis of differences in student support expenditures across school districts in Minnesota, 2008/09

Note: Outliers are marked by the × sign.

Source: Authors' analysis based on data from U.S. Department of Education (2010); Minnesota Department of Education (2009); U.S. Census Bureau (2008); and Environmental Systems Research Institute (2010b).

FIGURE E5

Outliers in regression analysis of differences in transportation expenditures across school districts in Minnesota, 2008/09



Note: Outliers are marked by the × sign.

Source: Authors' analysis based on data from U.S. Department of Education (2010); Minnesota Department of Education (2009); U.S. Census Bureau (2008); and Environmental Systems Research Institute (2010b).

NOTES

1. This study defines rural districts as those identified as rural–distant, rural–remote, or rural–fringe in the urban-centric classification system developed by the U.S. Census Bureau and the National Center for Education Statistics (NCES; U.S. Department of Education 2010). The urban-centric codes were adopted here because they provide a useful framework for analyzing spending differences across districts in different geographic areas. They have been widely used in federal and state reporting (for example, in Aud et al. 2011) and in education research. NCES's classification of rural schools and districts is also important to states because the federal government tends to rely on NCES classifications as policy tools (for example, in the Rural Education Achievement Program, or REAP). The urban-centric locale codes are expected to be gradually phased in as federal programs such as REAP are reauthorized. Table B1 in appendix B defines the locale codes and shows how they are used in this study.

2. In 2008/09 NCES classified 52 percent of Minnesota school districts as rural. These districts enrolled 25 percent of Minnesota's public school students.

3. In Minnesota, most funding programs use the pupil count, known as adjusted marginal cost pupil units to determine school and district revenue amount. Minnesota House of Representatives (2010) details how pupil units are calculated.

4. This study does not examine the costs of achieving a set of state education outcomes, because it does not relate district spending to student performance. Examining differences in spending nevertheless provides insight into the extent to which factors outside a district's control affect district spending. This study is therefore a good first step toward better understanding the cost of education across regions in Minnesota. Future studies linking spending to education outcomes are needed to obtain a more comprehensive understanding of the cost of operating a school district in different areas of Minnesota.

5. In Minnesota, the state determines how much money a school district will receive, but the school district makes its own choices about how to spend the funds it receives within specific parameters. The school district board of education reviews and approves the district budget and the expenditure decisions made by district staff, such as selecting and employing teachers and administrators, employee salaries and benefits, changes in curriculum and textbooks, investments in the construction, maintenance, and upgrading of their facilities.

6. One could argue that drive time is not necessary for the analysis in this study, because rural districts are already categorized as fringe, distant, or remote. In fact, the drive time measure is useful, for three main reasons. First, as Levin et al. (2011) note, it provides a continuous measure that compares the level of accessibility of each district and allows for the estimation of a continuous relationship between geographic isolation and expenditures. Second, drive time may capture dimensions of a rural location and remoteness that are not captured by the NCES typology. Third, the Census Bureau classification uses straight-line distance; the drive time metric, which is based on actual road distance and travel time, may better reflect the accessibility of some education services and the costs of providing them.

7. Levin et al. (2011) obtain the same result. An explanation similar to the one they provide is applicable here. According to NCES definitions, town schools are inside "urban clusters," whereas city and suburban schools are inside "urbanized areas," which are geographically larger than urban clusters. Therefore, the distance from a town school to the center

of an urban cluster is likely to be shorter than the distance from a city or suburban school to the center of an urbanized area. As Levin et al. note, this finding underscores the value of using drive time as a measure of remoteness in the regression analysis, because it provides information lacking in the NCES locale typology.

8. This analysis does not explain why the percentage of special education students is higher in more remote districts. The process of referring and placing a student in a special education program likely involves a variety of policies and practices at the school and district levels (see, for example, Skiba et al. 2006). The percentage of special education students is highest in the locales that have the highest percentages of economically disadvantaged students (students eligible for free or reduced-price lunch). Prior studies (focusing primarily on racial/ethnic minority students in urban areas) note that poverty may factor into the referral and placement of students into special education programs in several ways. First, poverty is associated with a variety of risk factors that inhibit academic readiness (National Research Council 2002). Second, teachers may refer economically disadvantaged students to special programs if they themselves lack the resources to address these students' needs (Skiba et al. 2006). Rural-focused research is needed to understand how student poverty and other factors relate to referring and placing students in special education classes in rural settings.

9. After accounting for the cost factors, the proportion of the total variance explained by the locale factor reduces to about 3 percent ($\eta^2 = 0.029$) for total general fund expenditures and to 6 percent ($\eta^2 = 0.055$) for instruction and instruction-related expenditures. η^2 for a predictor reflects the proportion of variance in the dependent variable that can be explained by the predictor while controlling for other predictors in the sample data.

10. Adjusted mean expenditures were calculated using the final regression model. Appendix C provides details about this procedure; table C3 shows how the adjusted means were calculated.

11. Authors used a Bonferroni correction to adjust for multiple pairwise comparisons.

12. Most of the significant associations (tables D1–D5) would have remained significant had they been adjusted for multiple comparisons using the Bonferroni adjustment procedure. The Bonferroni correction would test each of the individual tests at a significance level of .05/5 = .01. Estimates with p–values lower than .01 would be considered statistically significant.

13. The other two studies were rural-context only, occurring only incidentally in rural contexts but with no apparent intent to investigate a rural education issue or explain how a rural location influences some aspect of schooling.

14. The study by Provasnik et al. (2007) uses the comparable wage index (CWI) to adjust for geographic cost differences. It is considered a descriptive study because although it was arithmetically adjusted using the CWI, it did not include other statistical controls. For more information on the CWI, see Taylor and Fowler (2006).

15. Two other community characteristics that may be related to variations in expenditures—median household income and mothers' education level—were also considered. However, the two variables were highly correlated with each other ($r = .714$) and with some of the cost factors considered (for example, $r = .712$ between the comparable wage index and median household income and $r = .670$ between median household income and student population density). Analyses of models that include these two variables indicated that they did not contribute uniquely to explaining

variations in the dependent variables. Moreover, collinearity diagnostics suggested almost perfect collinearity between these two variables and the rest of the predictors in the models, resulting in unstable coefficient estimates. The two variables were therefore dropped from the study to obtain more stable coefficient estimates for the cost factors, which are the focus of this study. Another set of variables originally considered for inclusion in the regression models as statistical controls are the percentages of revenues from local and state sources. However, in econometric terms, including them in the model mixes properties of demand (cost factors) and properties of supply (revenue sources) in the same equation. Regressing in this way would yield a measurement of a mixture (that is, a linear combination) of the supply and demand equations, making it difficult to distinguish between the underlying structures of supply and demand (Fennel 2006). From a statistics point of view, including supply and demand factors in the same equation raises concerns, because what a district spends is made possible by the revenue it has, causing endogeneity problems that cannot easily be resolved. In view of these problems, revenue sources were not included in the model. The regression equation is thus essentially a spending equation that captures the underlying demand effects.

16. The Common Core of Data defines regular school districts as local governmental entities responsible for providing free public elementary or secondary education, including independent school districts and those that are a dependent segment of a local government, such as a city or county.

17. Charter school districts in Minnesota differ from regular local public school districts in three ways that can have implications for revenues and expenditure. Local school districts in Minnesota receive excess levy referendum revenues for operations from local property taxes, whereas charter schools do not have access to local revenue from property taxes or bond measures.

18. Some charter schools do not have a legal obligation to provide some services, such as lunch and transportation. For example, 27 of the 152 charter districts in the data reported no transportation expenditures, and 21 of them had no student support expenditures. Several charter schools in Minnesota focus exclusively on special learning programs, such as online learning programs, alternative learning programs, or programs for special education students. The Minnesota Office of the Legislative Auditor (2008) identified nine such districts in 2008.

19. Although the study data include the full population of regular local school districts in Minnesota in 2008/09 (with the exception of the two nonoperating districts), analytic methods that involve significance tests on these data are appropriate for this study (Rubin 1985). The finite population of regular school districts included in this study represents only a single snapshot (purposive sample) of that population (an infinite "superpopulation") at a given point in time. Methods that take into account sampling errors are therefore appropriate so that classical sampling inferences can be applied to that superpopulation. The regression results from this study can therefore be used to make inferences about the population of regular school districts in Minnesota but should not be generalized beyond that population (for example, to charter school districts or regular school districts in other states). The use of significance tests with population data has been debated in the social science literature (see Cowger 1984; Glisson 1985).

20. Applied economists often use log transformation to deal with a dependent variable that is highly skewed to the right and to compute elasticities (the percentage change in y for a given percentage change in x; Manning and

Mullahy 2001). Education researchers adopt this approach in dealing with expenditure data (see, for example, Hussar and Bailey 2011). In this study, following the approach used by Levin et al. (2011), researchers applied log transformation to the expenditure measures in order to estimate the proportional relationships between cost factors and expenditures. In addition, as the distribution of all five types of expenditures is heavily skewed to the right, log transformation was applied to improve model fit. The use of log-transformed expenditures improved the model fit for four of the five outcome variables. The improvement in the overall variances explained for the models with transformed expenditure measures is .14 for total general fund expenditures, .15 for instruction and instruction-related expenditures, .17 for administration expenditures, and .09 for student support expenditures. Using log-transformed transportation expenditures did not increase R^2. For all five expenditure measures, analysis of the residuals suggests that the use of log-transformed expenditures improves the validity of the linear regression assumptions of normality and constant variance.

21. The distributions for both variables are skewed heavily to the right. Taking the logarithm removed much of the skewness (reducing the skewness value from 5.257 to 0.348 for total enrollment and from 3.929 to 0.922 for student population density).

22. Using a quadratic function (the natural log of enrollment and its square) to model the possible nonlinear relationship between enrollment and per student expenditures is a common approach for measuring the economies of scale in education finance studies (Duncombe and Yinger 2008). The Levin et al. (2011) study, for example, finds a significant effect of the quadratic term of enrollment on per student expenditures. A quadratic of population density is often included in model specifications in studies of public finance (see, for example, Ladd 1994; Leigh 2008).

23. Locale was entered as one fixed factor in SPSS general linear modeling. SPSS automatically dummy coded it (rural–remote as the reference type).

24. Removing outliers from the data increased the R^2 by .04–.10 and the *F*-value for the overall model by 1–8. When the outliers are excluded, the coefficient of the drive time for total general fund expenditures per student falls from 0.002 to 0.001 and is no longer significant at the .05 level. In contrast, the relationship between drive time and administration expenditures becomes significant at the .05 level (the value of the coefficient increases from 0.001 to 0.002). Changes in other regression coefficients are also observed, but the changes in their corresponding *p*-values did not cross the .05 threshold line (that is, none of the changes resulted in the coefficient changing from being significant to not significant or vice versa).

25. As regression is an application of GLM, GLMs can be used to analyze regressions. For this study, GLM presents an advantage in automatically dummy coding the categorical variable (locale), which has seven levels, and for obtaining an overall *p*-value for the locale factor as a whole. GLM also computes the estimated marginal means of the dependent variables, with covariates held at their mean value, for specified between- or within-subject factors in the model. GLM can also perform pairwise comparisons of the estimated marginal means of the dependent variables. However, some of the options available from the regression procedure are not available in GLM. For instance, the diagnostic tests of residuals are much more comprehensive in the regression procedure. Regression also provides multicollinearity diagnostics, which are not available in the regression procedure. For these reasons, both procedures were used

in developing the final models. The approach was to generally use GLM for analysis and then rerun the model in regression if there was reason to be concerned about multicollinearity or additional diagnostic tests of residuals were needed.

26. When SPSS GLM calculates adjusted means, by default it sets the covariates at the mean of the log-transformed variable ($(\sum_1^n \ln X)/n$). This syntax was changed so that the covariates were set at the log of their real sample mean ($\ln(X)$).

27. The expenditure data used for the analysis were compared with data from previous years that are available on the Minnesota Department of Education website. Those data indicate greater instability (sudden increases and decrease) in expenditures in rural–remote and rural–distant districts than in districts in other locale types. This result may reflect changes in district organization or some other special conditions that may be more likely in remote areas. Of the two most extreme outliers (both rural–remote) in total general fund expenditures, one was closed after the 2008/09 school year, which resulted in higher than usual expenditures; the other almost doubled its expenditures over previous years. Keeping cases like these in the analysis would have seriously biased the analysis (for example, the highest DFBETA value was 0.3172 when the district that was closed was included and 0.5682 when the district that doubled its expenditure was included in the analysis on total general fund expenditure). However, it was not always possible to identify the special circumstances that might have accounted for a district being an outlier.

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