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THE PARCEL TAX AS A SOURCE OF LOCAL REVENUE FOR CALIFORNIA PUBLIC SCHOOLS

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School finance is highly centralized in California, as the state determines almost all of the revenue school districts receive. The only significant source of local revenue is a tax on parcels of land. We show that the likelihood a district levies this tax is positively related to the income of district residents and negatively related to the tax-price of spending per pupil in the district. It is also negatively related to the revenue a district receives under the state's school finance system. Districts turn to the parcel tax when their residents' demand for spending is not met by the revenue provided by the state.

Key words: fiscal federalism, school finance, property tax

JEL Codes: H2, H52, H71

I. INTRODUCTION

California's school finance system is an experiment in fiscal federalism. Due to court rulings and a voter initiative, the financing of California public schools has shifted from mainly a local responsibility to almost entirely a state responsibility. The last vestige of local finance is a tax on parcels of land. By law, a parcel tax cannot be based on the value of parcels. It is typically a fixed amount per parcel, regardless of its size or use. To levy this tax, a school district must secure support from at least two-thirds of voters. About 10 percent of California districts have passed that threshold and utilize the parcel tax.

This paper explores the use of the parcel tax by California school districts. To do so, we employ a standard model of local demand for school spending to estimate the probability that a district levies a parcel tax. Three important variables have significant coefficients: tax-price, household income, and non-parcel tax revenue per pupil. The significance of these coefficients suggests that districts turn to the parcel tax when their residents' demand for school spending is not met by the revenue provided by the state.

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We also estimate the relationship between support for the parcel tax and other variables that may be related to demand. One of those variables is political ideology. In counties with a high percentage of votes for Barack Obama in the 2008 presidential election, school districts are more likely to pass a parcel tax. The probability of a tax is also higher in districts with lower fractions of vacant land, which suggests that support increases when school quality can be more fully capitalized into property value. Districts that have significant overlap with a city boundary are also more likely to pass a parcel tax, evidence that a school district's ability to coordinate resources with a city may reduce the cost of proposing and instituting a parcel tax (Fischel, 2010).

Our model allows us to infer price and income elasticities of the demand for school spending and thus to compare our results to those from other studies. Our price and income elasticity estimates are higher in absolute value than other estimates, although the confidence intervals around our estimates are large. Our higher price elasticity estimates may be due in part to the measurement of tax-price. In studies where the property tax is the source of additional revenue, tax-price depends on the assessed value of the median voter's home, a difficult concept to measure. In contrast, the tax-price under a parcel tax is students per parcel, a straightforward measure. Our higher income elasticity estimates are more difficult to explain. One possibility is that income is correlated with some unmeasured variable that increases the likelihood of passing a parcel tax. It is also possible that Tiebout bias may increase income elasticities if districts passing a parcel tax attract higher income households. We investigate the possibility of Tiebout bias for districts in the San Francisco Bay Area, using elevation as an instrument for household income. This instrument reduces our income elasticity estimate, but our point estimate is still higher than most other estimates.

II. ORIGINS OF THE PARCEL TAX

The parcel tax is a by-product of California's complex history of school finance reform. In 1970, California's school finance system was similar to the systems in most other states. Each school district levied its own property tax rate, and the property tax was the primary source of school district revenue. The state offset some differences in tax base among districts by allocating more revenue to districts with lower bases. Despite this effort, revenue per pupil varied widely across districts, leading to the landmark decision of the California Supreme Court in *Serrano v. Priest* (1972). The Court ruled that variations in revenue per pupil related to variations in tax bases violated the equal protection clauses of the state and federal constitutions.

The state legislature responded to this decision by creating revenue limits for each school district. Each district's limit capped the sum of its revenue from the property tax and state aid. Because state aid was determined by formula, the revenue limit essentially capped the property tax rate a district could levy. Limits were initially set equal to the revenue a district received in 1973–1974 and then increased over time. The increases were smaller for high revenue districts than for low revenue districts, tending to equalize revenue per pupil over time.

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The revenue limit system had a large loophole, however. By majority vote of their residents, school districts could exceed their limits. This loophole made a district's revenue limit meaningless because, before the revenue limit system was put in place, property tax rates had to be approved by a majority of voters. The loophole was closed by the passage of Proposition 13 in 1978, a statewide initiative limiting the property tax rate to 1 percent, a rate less than half of the statewide average at the time.[1] The limit applied to the sum of all rates levied by cities, counties, school districts, and special districts. The legislature was left with the task of determining how the revenue from this lower rate would be allocated among local governments.

The legislature responded by giving each government the same share of the revenue from each property that it had received before Proposition 13. Because school districts depended heavily on the property tax, they suffered a very large reduction in revenue. The legislature made up this reduction by increasing state aid to bring each district's revenue up to its revenue limit. The revenue limit essentially became each district's revenue allocation.

The legislature has slowly equalized revenue limits over time. In about 10 percent of districts, high property values lead to property tax revenue that exceeds revenue limits. Districts are allowed to retain this excess revenue and so have much higher revenue than other districts. In addition, over the last 20 years, the state has added a large number of categorical programs to address specific needs (Sonstelie, 2008).

Because of the centralization of school finance in California, revenue is certainly higher in some districts than it would have been under the previous system of local finance. However, since Proposition 13 in 1978, current expenditures per pupil have fallen in California relative to other states (Figure 1). In 2008–2009, spending per pupil was 11 percent lower in California than in the average of all other states. Because teacher salaries in California are higher than in other states (27 percent higher in 2008–2009), lower spending per pupil translates into lower resource levels. In 2008–2009, the ratio of teachers per pupil in California was 70 percent of the ratio for all other states.[2] For the average California school district, the growth in resources per pupil since the advent of state finance has not kept pace with the growth in other states.

Districts can circumvent their revenue limits by levying a parcel tax. Ironically, the parcel tax stems from Proposition 13 itself. The Proposition limited the ad valorem tax on property to 1 percent and further required that any "special taxes" levied by local governments must be approved by two-thirds of a jurisdiction's voters. The year following the passage of Proposition 13, the state legislature authorized local jurisdictions to levy special taxes on parcels of land to support police and fire protection. This authority was soon extended to school districts.

Parcel taxes are administrated as part of the property tax system. A parcel tax is merely an additional charge on a parcel's property tax bill. It is essentially an avenue for school

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[1] Fischel (1989) argues that the *Serrano* decision caused Proposition 13.

[2] Salary data are from Rankings and Estimates: 2008–2009, National Education Association, http://www.nea.org/rankings-andestimates. Enrollments and number of teachers are from the Common Core of Data, National Center for Education Statistics, https://nces.ed.gov/ccd/.

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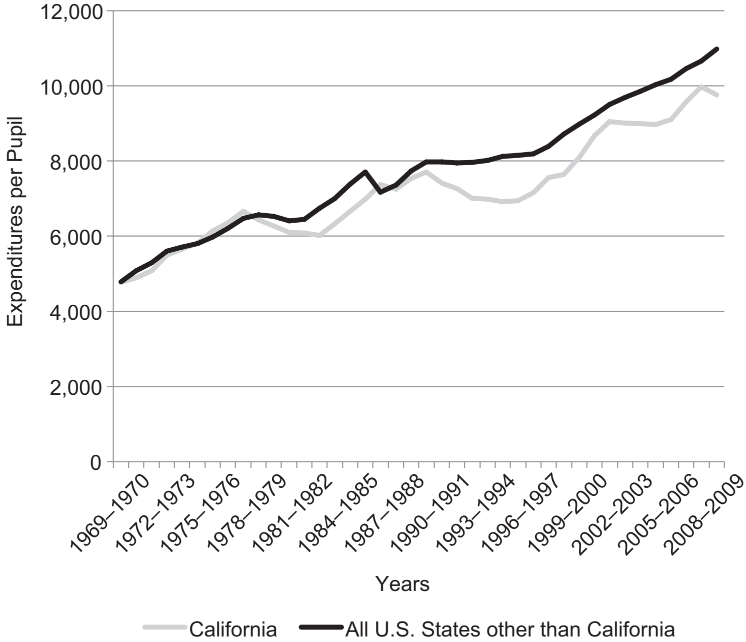
Figure 1

Current Expenditures per Pupil in California versus All Other States (Constant 2009–2010 Dollars)



districts to evade the cap on property taxes imposed by Proposition 13. Because parcel tax revenue does not count as local revenue for the state's revenue limits, it is also a way for school districts to exceed the revenue caps imposed by the state. It is truly a local revenue source.

School districts can levy parcel taxes to support capital investments or to finance current operating expenditures. We focus on parcel taxes for current operating expenditures, the first of which was levied in 1983. Five school districts proposed a tax in that year, and one was successful in securing the necessary support from voters. Despite this lackluster start, several more school districts proposed taxes over the next few years. Between 1983 and 1988, 69 parcel taxes were proposed, and 22 were approved. Districts in the six county San Francisco Bay Area[3] were the most active in proposing taxes and the most successful in securing approval. Though only 11 percent of California school districts are located in the Bay Area, those districts held 40 percent of the parcel tax

[3] The counties are Alameda, Contra Costa, Marin, San Francisco, San Mateo, and Santa Clara.

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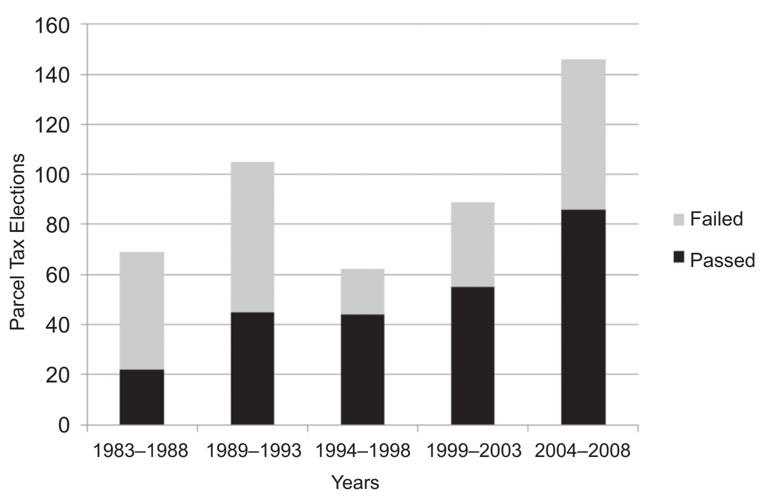
elections from 1983 through 1988. Half of these elections were successful as opposed to only 20 percent in the rest of the state.

The success rate of districts has increased substantially since then (Figure 2). Between 2004 and 2008, California school districts held 146 parcel tax elections. In 86 of those elections, at least two-thirds of voter supported the proposed tax.[4] Almost all proposals specify a time period for the tax, usually between 4 and 10 years. In 2009–2010, the year we focus on in our analysis, 90 of California's 963 school districts received parcel tax revenue.[5] For these districts, revenue averaged $799 per pupil. Twenty districts raised more than $1,000 per pupil. Districts in the Bay Area continue to be the most successful in parcel tax elections, and 68 of the 90 districts with parcel tax revenue are located in that area.

Parcel tax proposals are usually quite simple. Most propose the same rate for every parcel. Of the 146 elections in 2004–2008, 128 proposed a flat rate, and the average rate was $127 per parcel. The remaining 18 proposals involved either a different flat

Figure 2

Parcel Tax Elections by California School Districts



[4] The majority of elections are held in presidential election years. There were 43 elections held in 2004, with a passing rate of 53 percent, and 73 percent of 41 elections passed in 2008. The increased passing rate may suggest that voters were using the parcel tax to supplement school spending during the recession that began in late 2007.

[5] Three more districts reported some parcel tax revenue, but had no record of a successful parcel tax election in the Ed-Data website maintained by the California Department of Education.

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rate for different classes of property or a tax based on square footage. Property owners in one of these districts have challenged the legality of these more complicated rate structures, arguing that structures of this type violate legislation requiring parcel taxes to be levied uniformly on all parcels.[6] A Superior Court ruling in favor of the district was overturned by the California Court of Appeals in December of 2012, and the California Supreme Court has declined to review that appeal.

In addition to its simplicity, the parcel tax exhibits other features that differentiate it from the property tax. Under the property tax, a homeowner's tax-price of school spending depends on the value of her property. Homeowners with higher relative home values bear higher tax-prices. Under a parcel tax, every homeowner faces the same tax-price of school spending, equal to the ratio of students to parcels in the district. Brunner (2001) compared the tax-price of school spending when the parcel tax is the source of discretionary revenue with the tax-price when the property tax is the source. He estimates that the parcel tax increases the tax-price of school spending for the average homeowner in Los Angeles County by as much as 47 percent.

While other research on the parcel tax has been limited, Hill and Kiewiet (2015) find that parcel taxes are most often proposed and passed in high-income districts with larger proportions of voters favoring candidates of the Democratic Party. They also find that the size of a parcel tax tends to increase in a district over time, which may be evidence of households with high demand sorting into neighborhoods that value education. Other research provides evidence that districts that pass parcel taxes are more likely to collect voluntary contributions through local education foundations (Hill, Kiewiet, and Arsneault, 2014), suggesting that these two methods of fundraising are complementary. Finally, the tax-price of school spending under the parcel tax plays a prominent role in Duncombe and Yinger (2011). They estimate the demand for school quality, as measured by standardized test scores, as a function of demand variables including students per parcel. However, Duncombe and Yinger do not estimate how this tax-price affects the parcel tax revenue districts raise or the probability that a district levies a parcel tax.

III. A MODEL OF LOCAL DEMAND FOR PUBLIC SCHOOL SPENDING

Is the parcel tax the resurrection of local finance in California's centralized system? To address this question, we use a standard public choice model to analyze the decision of school districts to levy a parcel tax. If that analysis shows that demand variables such as price and income are significantly related to the likelihood a district levies a parcel tax, the parcel tax can be viewed as a natural response to a mismatch between local demand and state revenue.

The model we employ dates back to the median voter model first implemented by Borcherding and Deacon (1972) and Bergstrom and Goodman (1973). In those models, voters have demand functions for public goods, much like private good demand functions. In this particular case, the public good is the resources for local public schools.

[6] *Borikas v. Alameda Unified School Districts*, 2012

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These resources include personnel of various types, materials, extra-curricular activities, and so on. The abundance of any school's resources also depends on the number of students it serves. For the baseline model, we assume constant returns to district size. To maintain educational quality as the number of students increase, resources must increase proportionally. Quality is measured by resources per pupil.

To capture these ideas, we assume that there is an index of resources per pupil, which we denote by q. The cost per pupil of one unit of that measure is denoted by c, a parameter that may vary from district to district. Spending per pupil is cq.

Like many previous papers in this literature, we develop the model under the assumption that all residents are homeowners and thus pay property taxes to support local schools. Each homeowner would also pay a parcel tax if the district levied one. We also assume that all homeowners benefit from their local public schools and have the same demand function for school quality. We then amend the model to include renters who do not pay either property taxes or parcel taxes directly and older residents who do not have children in local public schools and thus do not benefit directly from those schools.[7]

Local property taxes and state and federal funds finance a level of school resources denoted by q^0. The school district can provide a higher level of resources, q, by levying a parcel tax. The revenue per pupil necessary for that increase is $c(q - q^0)$. This requires a parcel tax rate of $pc(q - q^0)$, where p is students per parcel in the school district.

The voter has income of w and pays a tax of t^0 for the resources the school district currently employs. Letting x denote all other expenditures, the voter's budget constraint is

$$(1) \quad x + pc(q - q^0) = w - t^0.$$

In standard form, this constraint is

$$(2) \quad x + pcq = w + (pcq^0 - t^0).$$

A voter's demand is the value of q that maximizes his or her utility. The voter's tax-price for resources per pupil is pc, the tax-price for spending per pupil is p, and full fiscal income is $y = w + (pcq^0 - t^0)$.

The terms in parentheses in the expression for full fiscal income arise because the parcel tax is only used for increments in school funding. The base level of funding for each district comes from local property taxes, state taxes, and federal taxes. The difference between the two terms in parentheses result from the difference between the share of parcel taxes a voter would pay relative to the share of local, state, and federal taxes he pays.

[7] Households with children in private school also do not directly benefit from public schools and may have similar preferences as older residents. In robustness checks, we include the fraction of students within a district that are enrolled in private schools.

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As in most previous studies, we assume that the demand for school resources is log-linear in tax-price and income, or

$$(3)\qquad \ln(q) = \alpha + \varepsilon \ln(pc) + \eta \ln(y),$$

where α, ε, and η are parameters to be estimated. The parameter ε is the price elasticity of demand, and the parameter η is the income elasticity. We do not observe the level of resources directly so we focus on spending per pupil, which is $e = cq$. Rewriting the demand for resources in terms of the demand for spending per pupil yields

$$(4)\qquad \ln(e) = \alpha + \varepsilon \ln(p) + \eta \ln(y) + (\varepsilon + 1)\ln(c).$$

School districts in California fall into three main types: elementary districts, high school districts, and unified districts that serve all grades. Seventy percent of California students attend unified districts, 20 percent attend elementary districts, and 10 percent attend high school districts. Most elementary districts cover kindergarten through grade 8, and most high school districts cover grades 9 through 12. However, about 10 percent of elementary districts do not include grades 7 and 8, and a similar percentage of high school districts include those grades.

The number of grades in a district affects its tax-price for spending per pupil. To illustrate, consider an area served by an elementary district for kindergarten through grade 8 and a high school district for grades 9 through 12. Suppose the elementary district has two students per parcel and the high school district has one student per parcel. Now suppose the two districts merge and form a unified district serving all grades from kindergarten through grade 12. The unified district has three students per parcel and thus a higher tax-price than either of the two districts from which it was formed. But should demand be less? It seems reasonable to assume that the spending a voter would demand in the unified district equals the sum of his spending demands for the elementary and secondary districts. In the appendix, we demonstrate that this assumption implies three restrictions on the demand function. First, the price and income elasticities (ε and η) are the same for elementary, secondary, and unified districts. Second, to deal with the issues raised by the measurement of tax-price in different types of school districts, the demand function must be augmented to include the log of the number of grades in the district. Third, the coefficient on the log of grades is the negative of the price elasticity of demand. With these three restrictions, the demand function is

$$(5)\qquad \ln(e) = \alpha + \varepsilon \ln(p) + \eta \ln(y) + (\varepsilon + 1)\ln(c) - \varepsilon \ln(g),$$

where g is the number of grades served by the district.

If two-thirds of homeowners in a district demand more spending per pupil than provided by the state, a district could secure the votes necessary to levy a parcel tax. The demand for spending per pupil in a district increases with the income of residents, so the critical voter is the homeowner in the 33^{rd} percentile of the income distribution,

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an income we denote by y^*. If the demand of the critical voter, e^*, exceeds the current level of spending, e^0, the district could propose the tax rate $p(e^* - e^0)$ and secure support from at least two-thirds of voters. If e^* is significantly higher than e^0, the district has other viable options. It could secure a higher plurality than two-thirds by proposing a lower tax rate. It could also propose a higher tax rate and still secure support from two-thirds of voters, an outcome predicted by the agenda setting model proposed by Romer and Rosenthal (1979). In what follows, we assume districts propose the tax rate preferred by the critical voter.

From this point, we follow the usual latent variable approach to derive the specification of a probit model. We assume that the demand of the critical voter in district i is

$$\text{(6)} \quad \ln(e)_i = \alpha + \varepsilon \ln(p)_i + \eta \ln(y^*)_i + (\varepsilon + 1)\ln(c)_i - \varepsilon \ln(g)_i + v_i,$$

where $\ln(p)_i$ is the log of students per parcel in district i, $\ln(y^*)_i$ is the 33rd percentile in the distribution of log full fiscal income among homeowners in district i, $\ln(c)_i$ is the log of the cost index for district i, $\ln(g)_i$ is the log of the number of grades in district i, and v_i is a normally distributed error term with mean zero and standard deviation σ. A district levies a parcel tax if this demand exceeds the log of spending per pupil without the parcel tax in district i, $\ln(e^0)_i$. The probability that district i levies a parcel tax is then

$$\text{(7)} \quad \pi_i = N\left[\beta_0 + \beta_1 \ln(p)_i + \beta_2 \ln(y^*)_i + \beta_3 \ln(c)_i + \beta_4 \ln(g)_i + \beta_5 \ln(e^0)_i\right],$$

where N is the cumulative normal distribution, $\beta_0 = \alpha/\sigma$, $\beta_1 = \varepsilon/\sigma$, $\beta_2 = \eta/\sigma$, $\beta_3 = (\varepsilon + 1)/\sigma$, $\beta_4 = -\varepsilon/\sigma$, and $\beta_5 = -1/\sigma$.

Though price and income elasticities are not directly estimated, they can be derived as ratios of estimated coefficients. In particular, $\varepsilon = -\beta_1/\beta_5$ and $\eta = -\beta_2/\beta_5$. By construction, β_5 is negative. Because the price elasticity of demand is negative and the income elasticity is positive, β_1 should be negative, and β_2 should be positive. The coefficient β_3 depends on the price elasticity of demand. If demand is inelastic ($0 > \varepsilon > -1$), β_3 must be positive. An increase in the cost of resources increases expenditures. If demand is elastic, β_3 is negative. Lastly, our assumption about how a district's grade-span affects demand implies that β_4 is positive.

While this familiar model provides a baseline for our analysis, it does not incorporate five important factors. First, the model assumes that every district resident is a homeowner. In fact, many residents rent their homes instead of owning. Renters do not pay the parcel tax directly, but a parcel tax may be passed forward to them in the form of higher rent.[8] The revenue from the tax will make local schools more attractive, increasing the demand for housing in the district. Unless the supply of housing is perfectly

[8] In general, the owner of a multi-unit apartment building located on one parcel pays the same tax as the owner of a single-family home. In a handful of districts, the parcel tax for a multi-unit apartment increases with the number of units. In at least one district, the parcel tax for condominium complexes increases with the number of units in the complex.

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elastic, this increase in demand will increase rents. Of course, renters may not perceive this effect, a form of fiscal illusion. In that case, renters should be expected to favor any parcel tax proposal (Oates, 2005). Fiscal illusion seems likely to us, and thus we expect that the probability of a successful parcel tax election will be positively related to the percentage of district residents who rent. However, renters are less likely to vote in local elections than are homeowners and thus may have little effect on the outcome of a parcel tax election (DiPasquale and Glaeser, 1999). To estimate the effect of renters on parcel tax elections, we add the percentage of residents who rent as an exogenous variable in our probit model.

The second factor is older homeowners without school-age children who do not benefit directly from local public schools. The legislation authorizing parcel taxes for school districts allows districts to exempt homeowners age 65 or older. Hill and Kiewiet (2015) report that nine out of ten proposals after 2001 provided this exemption and, as pointed out by Wildasin (1979) and Sonstelie and Portney (1980), these homeowners may benefit indirectly through the capitalization effect. The benefit of higher school quality net of the additional taxes to fund that improvement increases the willingness to pay of future homeowners to live in a district. This increase may be capitalized into home values. In effect, current homeowners reap the net benefits of future homeowners. To the extent that capitalization effects influence voting behavior, older homeowners or households without children in public schools represent the interests of future community residents who have similar demands for school quality as current homeowners with children in local public schools.

The extent of these capitalization effects depends on the price elasticity of a district's housing supply. If supply is perfectly inelastic, net benefits should be fully capitalized, and homeowners without children have a strong incentive to represent the preferences of future residents. If supply is elastic, however, capitalization may be incomplete, and the incentives less influential. The extent to which capitalization affects voting outcomes has been estimated by Hilber and Mayer (2009). Their analysis hinges on the assumption that the price elasticity of a district's housing supply can be represented by the percentage of the district's land that is currently developed. Housing supply is relatively inelastic if a district has a high percentage of developed land, and thus the likelihood that capitalization matters increases with the percentage of developed land. To test this idea, Hilber and Mayer add three variables to a standard median voter model of school spending. The first is the percentage of older residents in a district, the second is the percentage of developed land in the district, and the third is the interaction between those two percentages. The coefficient on the first term should be negative, and the coefficient on the third should be positive, predictions verified by their empirical analysis. Following Hilber and Mayer, we amend our model by including the percentage of residents age 65 or older, the percentage of parcels in a district that are developed, and the interaction between those two percentages.

The third factor is economies of size in the production of educational quality. Our baseline model assumes that quality is measured by resources per student, but previous research has found economies of size for small school districts (Andrews, Duncombe,

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and Yinger, 2002). For those districts, a proportionate increase in both students and resources increases quality. To account for this factor, our baseline model is amended to include two variables — average daily attendance and the square of attendance.

A fourth factor is political ideology, which we control for with the percentage of voters in the county that voted for Barack Obama in the 2008 presidential election. Previous research has found this variable to be correlated with parcel taxes (Hill and Kiewiet, 2015).

The fifth and final factor that we use to refine our baseline model is the degree to which a school district's land area overlaps with the surrounding city. Fischel (2010) proposes that when school district boundaries are congruent to city boundaries, the two can coordinate the provision of public goods. For example, the city may use zoning regulations to ensure that improved school quality is capitalized into home values. This kind of coordination could make increased school spending more desirable to voters. Similarly, if a city already has an infrastructure for proposing and passing political propositions, school districts may utilize those resources and decrease the cost of proposing a parcel tax. To account for these possibilities, we include measures of the congruency between school district and city borders.

IV. DATA AND RESULTS

We apply this model to a cross-section of California school districts in 2009–2010. In that year, there were 963 public school districts in California. Ninety districts received parcel tax revenue from an election held before 2009, and eight more districts approved a new parcel tax levy in either 2009 or 2010. Our model seeks to explain why these 98 districts chose to levy a parcel tax and why the remaining 865 did not.

The tax-price of school resources is the product of pupils per parcel and the cost of a unit of school resources. We obtained data on the number of parcels from the private firm, DataQuick.[9] For each county, the company acquires data on every parcel from the county's assessor. The resulting database lists the tax rate area for each parcel. A tax rate area is a collection of parcels that pay property tax revenue to the same collection of local governments. Geographically, it is an intersection of local government boundaries. Using data from the California State Board of Equalization, we determined the school district of every tax rate area in California and thus the total number of parcels in each school district in 2009–2010. We did not identify parcels as residential, commercial, or industrial property because parcel taxes are not allowed to differentially collect from different classes of property. For the number of students in each district, we used average daily attendance as reported to the California Department of Education.

For the cost of resources, we estimated the cost to each district of the statewide average for resources per student. In 2009–2010, 85.5 percent of current operating expenditures of California public schools were spent on the salaries and benefits of school employees. The salary and benefits of school employees reflect local labor market conditions, which

[9] DataQuick is now part of CoreLogic, http://www.corelogic.com/landing-pages/dataquick.aspx.

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vary substantially from the lower wage areas of northern and interior California to the higher wage areas of the San Francisco Bay Area and Southern California (Rose and Sengupta, 2007). To represent these conditions, we used the Comparable Wage Index produced by the National Center of Education Statistics (Taylor, Glander, and Fowler, 2007). The index measures salaries of college graduates in a district's regional labor market. The index excludes salaries of educators, making it independent of school district finances and salary schedules. We divided the index by the statewide average to form a labor cost index with a mean value of unity. We assumed that other resources, such as books, computers, and supplies, have the same price throughout the state. Our measure of the cost of resources for district *i* is

$$(8) \quad c_i = 0.145 + 0.855 u_i ,$$

where u_i is the standardized cost index for district *i*. The value c_i is the cost to district *i* of the statewide vector of resources per pupil as a percentage of the statewide cost of that vector.

The revenue attributed to each district comes from the financial reports districts filed with the California Department of Education for 2009–2010.[10] Most revenue sources flow directly to school districts. Special education revenue is an exception, however. Most California school districts cooperate with other districts to provide special education services. This cooperation is coordinated through a consortium, which often involves a county office of education. Some districts in a consortium may provide few special education services themselves, depending on other districts or the county office to provide those services. To represent the special education resources available to every district, we totaled all special education revenue in a district's consortium and prorated that total among all districts in the consortium in proportion to their attendance. We used the same approach for the 58 California school districts that belong to one of the eight consortiums that provide common transportation services to students. Finally, we excluded revenue for a number of programs not directly related to the core educational services of students in kindergarten through high school. We excluded revenue for adult education, child care and pre-school, vocational education, and nutrition. We also excluded revenue for school facilities and the temporary federal aid to school districts under the American Recovery and Reinvestment Act. Because we are attempting to explain whether a district imposes a parcel tax, we excluded parcel tax revenue. The Department of Education also reports enrollment in every grade level for each district, giving the number of grades in each district.

To determine full fiscal income, we used the expression in (2): $y = w + (pcq^0 - t^0)$. For *w*, we used income reported in the school district aggregation of the 2010 American Community Survey Five-Year Estimates (ACS). The ACS reports the number of homeowners in each district that fall into each of ten income categories. We set the income of each homeowner equal to the average of the upper and lower limits defining its category. To estimate an average income for homeowners in the top category, we

[10] 2009–2010 SACS Unaudited Actual Data, http://www.cde.ca.gov/ds/fd/fd/

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used the aggregate income of all homeowners and the number and average income in each of the other nine categories. For pcq^0, we used the product of parcels per student and the district's revenue per pupil excluding parcel tax revenue. The parameter t^0 is the taxes a voter pays to support the existing level of spending in his or her school district. To estimate this tax for homeowners in each income category, we used results from the microsimulation model of the Institute of Taxation and Economic Policy (2013). For each state, the Institute estimates the property, sales, and state income tax paid by taxpayers in each of five income categories. Using those estimates and the percentages of property, sales, and state income tax revenue allocated to California public schools, we determined the total tax for public schools paid by taxpayers in each of the five groups as a percentage of their income. We then used those tax rates to estimate t^0 for each of the ten Census categories, thus yielding an estimate of full fiscal income for the average homeowner in each of those ten categories. We converted these averages to natural logarithms and used those values to calculate the mean and the standard deviation of the log of full fiscal income for the homeowners in each school district. Assuming the distribution of full fiscal income is log normal, we used this mean and standard deviation to estimate the 33rd percentile of this distribution.

We also collected data for the extensions to our model. For the percentage of developed land in a district, we used the Dataquick data to determine the percentage of parcels in a district that are developed. The ACS provides the percentage of households that rent and the percentage of residents age 65 years or older. The voting data are from the California Secretary of State.

To measure border congruency between school districts and cities, we overlay 2010 school district boundaries with Census Place boundaries, both from the Census TIGER geographic reference files. Next, we calculated the amount of land area for each school district that lies within city boundaries. Of the 963 school districts in California, 880 share a portion of their land area with at least one city.

Fischel (2010) defines six different degrees of congruency between cities and school districts. We collapsed that hierarchy into two classes. Our "high congruency" class consists of Fischel's top three degrees of congruency. It includes districts in which the intersection between a city and a school district is 75 percent of the land area of both the school district and the city. It also includes situations in which a city is entirely enclosed by a school district and the city is at least half of the land area of the district. Thirty-nine districts fall into the high congruency class.

Our "low congruency" class consists of Fischel's lowest three degrees of congruency. Districts fall into this class if their boundaries intersect with a city boundary, but the intersection is not significant enough to constitute high congruency. The low congruency class contains 840 districts. Eighty-eight districts have no intersection with a city boundary and serve as the omitted category in the regression analysis.[11]

[11] Fischel suggests that measures of congruency should also incorporate population density. In his work, he uses the program Google Earth, which overlays school district and city boundaries with aerial photos, to visually assess population congruency. We only use land area to construct our measures of congruency.

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Table 1 presents summary statistics for the variables in our model. As our model predicts, districts with a parcel tax have fewer students per parcel and higher income than districts without a tax. Table 2 presents the parameter estimates for our probit model.

The majority of coefficient estimates in Table 2 have the signs predicted by the model developed in the previous section. The tax-price and revenue coefficients are negative and significantly different from zero. The income and grade coefficients are positive, as predicted. The coefficient for the cost index is positive, consistent with inelastic demand.

Table 1

Sample Means for Explanatory Variables
(Sample Standard Deviations in Parentheses)

Variable	All Districts	With Tax	Without Tax
Students per parcel	0.33 (0.38)	0.28 (0.17)	0.33 (0.39)
33rd percentile homeowner full fiscal income[1]	$50,385 ($19,395)	$74,330 ($23,096)	$47,672 ($16,928)
Cost index	0.94 (0.13)	1.10 (0.10)	0.92 (0.13)
Number of grades	10.16 (2.64)	10.22 (2.53)	10.16 (2.65)
Revenue per pupil	$10,384 ($7,129)	$11,347 ($11,165)	$10,274 ($6,517)
Percent age 65 or older	0.17 (0.07)	0.18 (0.07)	0.17 (0.07)
Percent of land developed	0.85 (0.16)	0.93 (0.09)	0.85 (0.17)
Percent renters	0.35 (0.14)	0.34 (0.14)	0.35 (0.14)
Average daily attendance	5,776 (20,449)	5,503 (7,869)	5,806 (21,416)
Percent voted Obama in 2008	0.55 (0.13)	0.72 (0.06)	0.53 (0.12)
High city congruency	0.04 (0.20)	0.17 (0.38)	0.03 (0.16)
Low city congruency	0.87 (0.33)	0.82 (0.39)	0.88 (0.33)
Number of districts	963	98	865

[1] Summary statistics are calculated for exp(33rd percentile of log of homeowner full fiscal income).

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Table 2

Coefficient Estimates, Standard Errors in Parenthesis
(Probit Model: Districts with Parcel Tax Revenue in 2009–2010)

Explanatory Variables	
Log students per parcel (β_1)	–1.07*** (0.22)
Log 33rd percentile homeowner income (β_2)	1.89*** (0.42)
Log cost index (β_3)	3.86*** (1.01)
Log number of grades (β_4)	1.10*** (0.40)
Log revenue per pupil (β_5)	–0.70** (0.33)
Constant (β_0)	–29.42*** (5.73)
Percent age 65 or older	3.72 (9.09)
Percent of land developed	4.38** (2.24)
Percent age 65 or older × percent of land developed	–3.48** (10.50)
Percent renters	–0.20 (0.77)
Attendance/100,000	–1.25 (1.43)
$(\text{Attendance}/100{,}000)^2$	0.15 (0.91)
Percent voted Obama in 2008	7.36** (1.21)
High city congruency	1.43** (0.63)
Low city congruency	0.96* (0.55)
Observations	963

Notes: Asterisks denote significance at the 1% (***), 5% (**), and 10% (*) levels.

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The percentage of age 65 and older voters has a positive and insignificant effect on passing a parcel tax, but the coefficient on the percentage of developed land is positive, consistent with the capitalization of school quality into land values. The coefficient for the percent developed land interacted with the percentage of older voters is negative and significant, which is inconsistent with older residents favoring additional school spending when it is more likely to be capitalized into property values. The sign of the coefficient on renters is also inconsistent with expectation, but insignificant.

The coefficient on attendance is negative and the coefficient on attendance squared is positive, consistent with diminishing economies of size. However, neither attendance variable is significantly different from zero, and a likelihood ratio test of the hypothesis that both coefficients are zero has a p-value of 0.67. The coefficient on the percentage of voters in the county that voted for Obama in 2008 is positive and significant, suggesting that politically liberal voters favor parcel taxes.

Finally, the two congruency measures are positive and significant. The high congruency coefficient is about 50 percent larger than the low congruency coefficient, although we cannot reject that the two coefficients are equal. These estimates provide evidence in favor of the hypothesis that school districts may benefit from overlapping with city borders (Fischel, 2010).

The baseline model developed in (6) of the previous section implies two relationships among coefficients. The first comes from our assumption about how the number of grades in a school district should affect the likelihood of a parcel tax. That assumption implies that the coefficient for the log of tax-price (β_1) should equal the negative of the coefficient for the log of the number of grades in a district (β_4). In fact, the estimates of the two coefficients are opposite in sign and similar in absolute value. The p-value for the hypothesis that the two coefficients sum to zero is 0.93, indicating that the hypothesis cannot be rejected at conventional significance levels.

The second relationship concerns the coefficient estimates for the log of tax-price, the log of the cost index, and the log of revenue per pupil. In particular, the probit model implies that $\beta_3 + \beta_5 - \beta_1 = 0$. For the estimated coefficients in Table 2 the sum is 4.24, and the hypothesis that this sum is zero can be rejected at the 1 percent significance level. The rejection of this model restriction may suggest that the cost index does not accurately capture the cost of resources in a school district.

These estimates support the notion that districts turn to the parcel tax when the demand for school spending by residents exceeds the revenue provided by the state. The likelihood of a parcel tax is significantly related to the primary demand variables, tax-price and income, and negatively related to revenue per pupil. With the coefficient estimates in Table 2, an increase in the log of critical income equal to the standard deviation of that variable in our sample increases the probability that a district levies a parcel tax by 27 percentage points. A decrease in the log of students per parcel equal to its sample standard deviation increases the probability of a tax by 29 percentage points. For revenue per pupil, a decrease of one standard deviation increases the probability of a tax by 4 percentage points.

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The coefficient estimates in Table 2 imply price and income elasticities of the demand for educational quality. The price elasticity is β_1/β_5, and the income elasticity is β_3/β_5. These formulas yield a price elasticity estimate of –1.55, and an income elasticity estimate of 2.71. The confidence intervals for both estimates are large, however. Using the delta method, the 95 percent confidence interval for the price elasticity is [–2.67, –0.43]. For the income elasticity, this interval is [0.13, 5.30].

Elasticity estimates from other studies are smaller in absolute value than our estimates, but well within our confidence intervals. Bergstrom, Rubinfeld, and Shapiro (1982) summarize estimates from ten studies. Two-thirds of the price elasticity estimates are less than 0.5 in absolute value. Rubinfeld, Shapiro, and Roberts (1987), Brasington (2002), Rockoff (2010), and Duncombe and Yinger (2011) also estimate elasticities less than 0.5 in absolute value. None of these studies finds an income elasticity greater than 1.35.

While our wide confidence intervals imply that we cannot reject the hypothesis that the elasticities in our study are the same as those in other studies, the differences in point estimates are a concern. Some of those differences may be due to biases inherent in other studies. In those studies, marginal revenue comes from the property tax. In that case, a household's tax-price depends on the value of its home relative to the total value of all property in the community. Tax-prices vary among residents, and identifying the tax-price of the median voter is a challenge. Furthermore, tax-prices are correlated with income, making it difficult to separate price and income effects. And, since public services and taxes affect property values, tax-prices may depend on government fiscal decisions. In contrast, with the parcel tax, the tax-price is the same for every homeowner and is easily measured, eliminating many of the challenges with property tax studies. Coefficient estimates would be expected to be higher in absolute value if using this estimation strategy reduces measurement error without introducing biases that were not present in other studies.

In addition, the income elasticity implied by our model may be higher than in other studies because it is picking up something special about Bay Area districts that is not included in the model. Districts in the Bay Area were the first to levy parcel taxes, and many also have relatively high incomes. Because income is positively related to demand, we should expect high income districts to be the first to levy parcel taxes. But, if districts in the Bay Area were more likely to levy a parcel tax because of other variables not included in our model, income would be correlated with these missing variables, which would tend to bias the income coefficient upward.

To investigate this possibility, we have estimated the model with a dummy variable for Bay Area districts. The results are in the second column of Table 3. For comparison, the first column contains estimates without including the Bay Area dummy. The coefficient on the Bay Area dummy variable is positive and statistically significant, but including that variable does not change other coefficient estimates by much. For the price elasticity, the point estimate remains –1.55 with a 95 percent confidence interval of [–2.73, –0.36]. For the income elasticity, the point estimate is 2.73 and the confidence interval widens to include zero, at [–0.06, 5.54].

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Table 3

Coefficient Estimates, Standard Errors in Parenthesis
(Probit Model: Districts with Parcel Tax Revenue in 2009–2010)

Explanatory Variable	All Districts	All Districts	Bay Area	Other Districts
Log students per parcel (β_1)	–1.07***	–1.00***	–0.72	–1.34***
	(0.22)	(0.22)	(0.45)	(0.31)
Log 33rd percentile homeowner income (β_2)	1.89***	1.77***	1.24*	1.94***
	(0.42)	(0.42)	(0.74)	(0.62)
Log cost index (β_3)	3.86***	1.57	6.77*	0.41
	(1.01)	(1.23)	(3.61)	(1.50)
Log number of grades (β_4)	1.10***	1.08***	0.97*	1.05**
	(0.40)	(0.36)	(0.59)	(0.49)
Log revenue per pupil (β_5)	–0.70**	–0.65**	–0.88	–0.52
	(0.33)	(0.33)	(0.66)	(0.42)
Constant (β_0)	–29.42***	–27.17***	–11.84	–32.68***
	(5.73)	(5.75)	(10.20)	(8.15)
Percent 65 or older	3.72	2.52	–3.39	–2.20
	(9.09)	(8.58)	(12.02)	(15.65)
Percent of land developed	4.38**	3.77*	0.84	4.49
	(2.24)	(2.20)	(3.77)	(3.48)
Percent age 65 or older × percent of land developed	–3.48**	–1.91	5.46	2.93
	(4.74)	(9.98)	(14.91)	(17.88)
Percent renters	0.20	–0.16	–1.52	–0.09
	(0.77)	(0.77)	(1.39)	(1.07)
Attendance/100,000	–1.25	–1.65	–6.82	29.18**
	(1.43)	(1.52)	(6.40)	(14.09)
(Attendance/100,000)^2	0.15	0.23	19.78	–206.69*
	(0.91)	(0.84)	(19.43)	(107.00)
Percent voted Obama in 2008	7.36**	6.29***	2.59	8.29***
	(1.21)	(1.23)	(4.07)	(1.68)
High city congruency	1.43**	1.25**	0.80	0.93
	(0.63)	(0.61)	(0.51)	(0.75)
Low city congruency	0.96*	0.76		0.26
	(0.55)	(0.27)		(0.61)
Bay Area dummy variable		0.75***		
		(0.27)		
Observations	963	963	110	853

Notes: Asterisks denote significance at the 1% (***), 5% (**), and 10% (*) levels.

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Columns 3 and 4 in Table 3 explore this issue in more detail. Column 3 presents coefficient estimates derived from a sub-sample consisting of all Bay Area districts.[12] Column 4 presents estimates from a sub-sample consisting of all districts outside the Bay Area. Many of the coefficient estimates from the two sub-samples are similar, but there are some noteworthy differences. In the Bay Area sub-sample, the coefficient on attendance is negative, and the coefficient on attendance squared is positive. Neither coefficient is significantly different from zero, however, and district size has a very small effect on the estimated likelihood of a parcel tax. For districts outside the Bay Area, the likelihood rises with district size until it reaches a maximum with 8,000 students, consistent with diseconomies of size. The coefficients on the cost and political ideology variable also differ between the samples, where the cost variable is significant and positive within the Bay Area but insignificant in the rest of the state. Outside of the Bay Area, political ideology affects the likelihood of a parcel tax, but it is not statistically significant in the Bay area regression. A likelihood ratio test of the hypothesis that all coefficients except the constant term are the same has a p-value of 0.04.

Table 4 presents the price and income elasticity estimates implied by the regression results in Table 3. It also presents p-values for the two parameter restrictions implied

Table 4

Elasticity Estimates and Hypothesis Tests

	All Districts		Bay Area	Other Districts
	Without Dummy	With Dummy		
Price elasticity				
Point estimate	–1.55	–1.55	–0.82	–2.58
95% confidence interval				
Lower bound	–2.67	–2.73	–1.74	–6.04
Upper bound	–0.43	–0.36	0.10	0.89
Income elasticity				
Point estimate	2.71	2.74	1.41	3.72
95% confidence interval				
Lower bound	0.13	–0.06	–1.04	–2.21
Upper bound	5.30	5.54	3.86	9.66
P-values for hypothesis tests				
$\beta_1 + \beta_4 = 0$	0.93	0.81	0.61	0.54
$\beta_3 + \beta_5 - \beta_1 = 0$	0.00	0.13	0.06	0.43
Observations	963	963	110	853

[12] In the Bay Area regression reported in Column 3 of Table 3, the low congruency variable is excluded because only four of the 110 districts in the Bay Area do not fall into either the low or high congruency classification. We include those four districts in the low congruency classification. These districts serve as the omitted category.

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by the baseline model. For the Bay Area sub-sample, the income elasticity estimate is 1.41. For the sub-sample of other districts, the estimate is 3.72. For the price elasticity, the estimates are –0.82 and –2.58. It is important to note, however, that the confidence intervals for price and income elasticities are large. Our method of inferring elasticities is indirect, involving the ratio of two estimated coefficients with significant standard errors. Because the standard error of the log of revenue per pupil is larger in each of the sub-sample regressions relative to the regression using the full sample, the confidence intervals for the sub-sample elasticity estimates are also large. Based on those intervals, we cannot reject the hypothesis that our price and income elasticity estimates are the same as others in the literature.

We have explored several other specifications that attempt to address obvious concerns with our probit model. One concern involves our assumption about how the number of grades in a district affects the demand for educational quality. The assumption led to the hypothesis that the coefficient on the tax-price term equals the negative of the coefficient on the grades term. We tested that hypothesis in each of our four specifications and were not able to reject it. Nevertheless, we estimated our model with a sample of only unified districts (kindergarten through grade 12). This restriction reduced the sample size to 333 districts. The estimated coefficients for tax-price and income are still significantly different from zero at the 1 percent level. The inferred income and price elasticities are substantially higher in absolute value, but the confidence intervals are much wider. For the income elasticity, the 95 percent confidence interval ranges from –12 to 24. Restricting the sample size to unified districts does not lead to more precise elasticity estimates.

We also tested our assumption that the critical voter is the homeowner in the 33rd percentile in the distribution of full fiscal income. While two-thirds of voters must approve a parcel tax, school boards, who place parcel tax proposals on the ballot, are elected by majority rule. Perhaps the median income voter is the critical voter. However, estimating the model with the median of full fiscal income had only a minor effect on coefficient estimates.

We also expanded our model by including the percentage of school-age children in a district that attend private schools. The estimated coefficient of this variable is positive but not significantly different from zero. More importantly, including this variable did not significantly affect the estimates of other coefficients.

Lastly, we explore the possibility that the high income elasticity may reflect Tiebout bias (Goldstein and Pauly, 1981). School districts that pass a parcel tax may attract high-income families, making household income an endogenous variable in our model. One response to this issue is an instrument for household income. We have not found an instrument that is appropriate for all districts in California, but we do have a plausible candidate for districts in the Bay Area. The candidate is elevation. In the Bay Area, many parcels in the hills overlooking the Bay provide outstanding views, which make them a desirable residential location. The competition for these locations drives up housing prices in these areas, and the willingness to pay for a view rises with income. The result is that the average income of a neighborhood tends to be correlated with its elevation. This relationship is demonstrated by the two maps in Figure 3. The top

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Figure 3

Income and Elevation

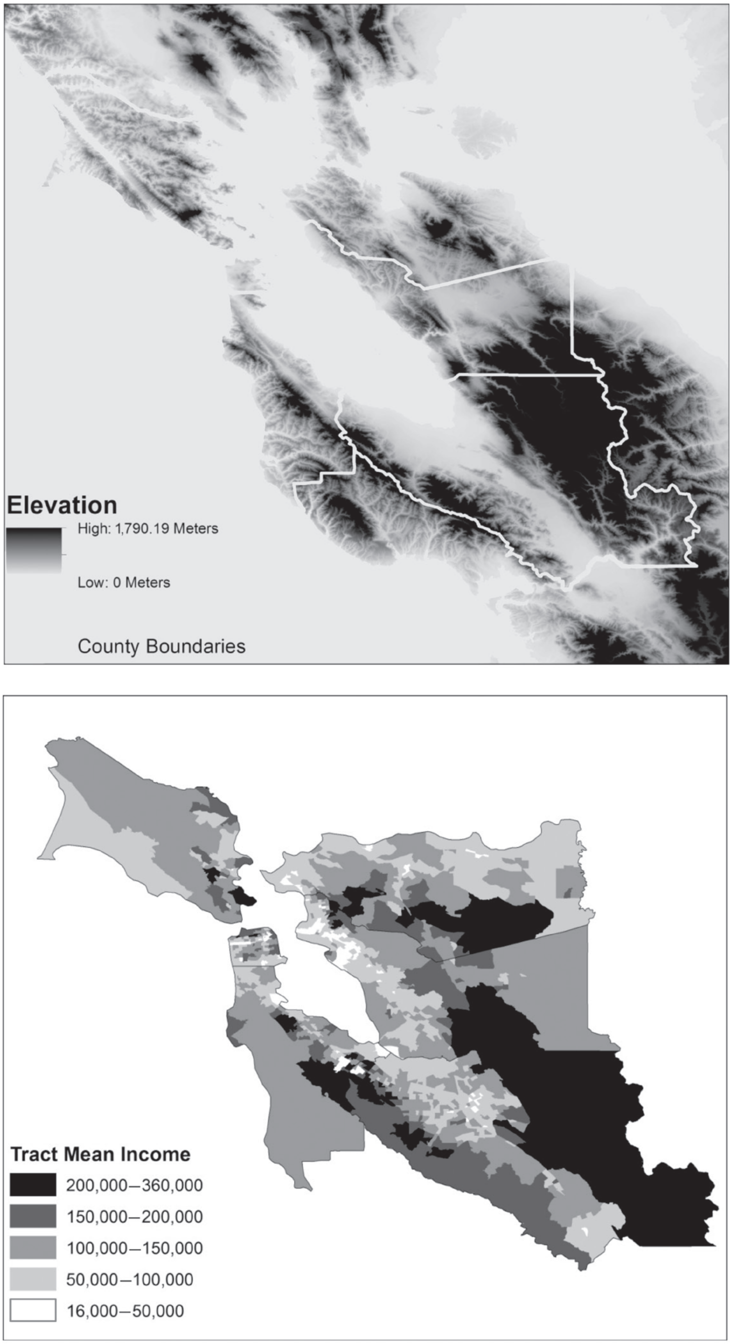

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Table 5

Coefficient Estimates, Standard Errors in Parenthesis
(Probit Model: Bay Area Districts with Parcel Tax Revenue in 2009–2010)

Explanatory Variable	Ordinary Probit	IV Probit
Log students per parcel (β_1)	–0.72 (0.45)	–0.67 (0.67)
Log 33rd percentile homeowner income (β_2)	1.24* (0.74)	0.92 (2.98)
Log cost index (β_3)	6.77* (3.61)	7.25 (5.57)
Log number of grades (β_4)	0.97* (0.59)	0.93 (0.68)
Log revenue per pupil (β_5)	–0.88 (0.66)	–0.82 (0.84)
Constant (β_0)	–11.84 (10.20)	–8.56 (31.48)
Percent age 65 or older	–3.39 (12.02)	–4.35 (14.79)
Percent of land developed	0.84 (3.77)	0.63 (4.21)
Percent age 65 or older × percent of land developed	5.46 (14.91)	7.04 (20.54)
Percent renters	–1.52 (1.39)	–1.79 (2.76)
Attendance/100,000	–6.82 (6.40)	–7.14 (9.96)
$(\text{Attendance}/100{,}000)^2$	–19.78 (19.43)	20.49 (20.35)
Percent voted Obama in 2008	2.59 (4.07)	2.65 (4.10)
High city congruency	0.80 (0.51)	0.84 (0.64)
Observations	110	110

Notes: Asterisks denote significance at the 1% (***), 5% (**), and 10% (*) levels.

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map shows elevation in the six Bay Area counties. The bottom map displays the mean household income of each census tract in those counties.

To construct an instrument for our analysis, we used ArcGIS to overlay school district boundaries on a topographical map. Using a standard tool in that program, we then calculated the average elevation of each school district. A simple regression of the mean log income of a school district on its average elevation has an F-statistic of 20, making elevation a plausible instrument for income. Elevation also had a significant coefficient in a first-stage regression of mean log income on elevation and other baseline variables. The coefficient on elevation had a t-statistic of 2.67. It also seems reasonable to us that elevation satisfies the other condition for a valid instrument: it should not be related to the demand for education quality other than through its association with the income of households.

Results from applying this instrument are reported in Table 5. The first column repeats the estimates from the ordinary probit model applied to Bay Area districts. The second column presents those estimates when elevation is used as an instrumental variable for the 33rd percentile of log full fiscal income. With the instrument for income, the income coefficient is a fourth of the estimate from the ordinary probit. However, the standard error of that coefficient is more than four times higher, and we could not reject the hypothesis that the income coefficients are the same in the two models.

The income elasticity implied by the IV probit estimates is 1.12, which is lower than the other estimates in Table 4. The 95 percent confidence interval for that elasticity is [–4.78, 7.02], however. Our method for correcting Tiebout bias does lower the income elasticity estimate, but the estimate has a huge confidence interval. The price elasticity estimate is –0.81 with a confidence interval of [–1.80, 0.18].

V. CONCLUSION

We conclude that the likelihood of levying a parcel tax is significantly related to the standard demand characteristics of price and income. It is also significantly related to the revenue provided to a district under the current system. Districts turn to the parcel tax because the demands of local residents are not met through the revenue allocations provided by the state.

While the use of the parcel tax has been limited to date, the recent reform of California's system could increase its popularity. This reform would channel most of the new state revenue for California schools to districts with high percentages of low-income students. It is a logical consequence of the state's high academic achievement standards for all students, standards much less likely to be met by students from low-income families. But the reform will certainly leave public schools in many high-income areas well short of the resources families in those areas demand and are willing to pay for. The parcel tax is an obvious reaction.

If the parcel tax becomes more widespread, it will attract more scrutiny. Was California wise to substitute the parcel tax for the property tax as a source of marginal revenue for

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schools? Although no other state has adopted it, suggesting a negative answer, the parcel tax may perform better than the property tax in some respects. Because the parcel tax is a tax on land, but not on structures, it creates less deadweight loss than a property tax. It may even be an effective policy to reduce urban sprawl (Banzhaf and Lavery, 2010).

A tax on land value, as proposed by Henry George (1879), is more equitable than a flat tax on every parcel, but land values are often difficult to determine. A parcel tax is easier to administer than a land value tax. A tax on square footage may be a good compromise between those two alternatives. It would be more equitable than the typical parcel tax, eliminate the incentive to assemble parcels, and yet still be relatively easy to administer. However, a tax per square foot does have one obvious deficiency — large parcels with little value. In the end, it may prove difficult to find an equitable tax on land without taxing its value.

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APPENDIX A: TAX-PRICE AND GRADES

California school districts may serve elementary grades, secondary grades, or all grades. To account for grade span in our specification of demand, we make the following assumption: If an elementary and secondary district unify to form one district serving all grades, the typical voter would demand the same spending in the unified district as the sum of spending the voter demanded for the separate elementary and secondary district.

To see the implication of this assumption, consider a special case. An area is served by an elementary district and a secondary district. The elementary district has g_1 grades, and the high school district has g_2 grades. Each grade has exactly m students. The cost of educational resources, c, is the same for both districts. The area contains n parcels.

The demand function for school spending is log-linear as in (4). For the elementary district that demand function is

$$\text{(A1)} \quad \ln(e_1) = \alpha_1 + (\varepsilon_1 + 1)\ln(c) + \varepsilon_1 \ln(g_1 m / n) + \eta_1 \ln(y).$$

For the secondary district, the demand for school spending is

$$\text{(A2)} \quad \ln(e_2) = \alpha_2 + (\varepsilon_2 + 1)\ln(c) + \varepsilon_2 \ln(g_2 m / n) + \eta_2 \ln(y).$$

For the unified district, the demand is

$$\text{(A3)} \quad \ln(e_3) = \alpha_3 + (\varepsilon_3 + 1)\ln(c) + \varepsilon_3 \ln(g_3 m / n) + \eta_3 \ln(y).$$

The assumption that demand for spending in the unified district is the same as the sum of demands for the elementary and secondary district implies that

$$\begin{aligned} \text{(A4)} \quad & \alpha_3 + (\varepsilon_3 + 1)\ln(c) + \varepsilon_3 \ln(g_3 m / n) + \eta_3 \ln(y) = \\ & (g_1 / g_3)[\alpha_1 + (\varepsilon_1 + 1)\ln(c) + \varepsilon_1 \ln(g_1 m / n) + \eta_1 \ln(y)] \\ & +(g_2 / g_3)[\alpha_2 + (\varepsilon_2 + 1)\ln(c) + \varepsilon_2 \ln(g_2 m / n) + \eta_1 \ln(y)]. \end{aligned}$$

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(A4) holds for all values of c and y, which implies that $\varepsilon_1 = \varepsilon_2 = \varepsilon_3 = \varepsilon$ and $\eta_1 = \eta_2 = \eta_3 = \eta$. The equalities of these coefficients reduce (A4) to

(A5) $\alpha_3 + \varepsilon \ln(g_3) = (g_1 / g_3)[\alpha_1 + \varepsilon \ln(g_1)] + (g_2 / g_3)[\alpha_2 + \varepsilon \ln(g_2)].$

For (A5) to hold for all values of g_1 and g_2, the following equality must hold

(A6) $\alpha_3 + \varepsilon \ln(g_3) = \alpha_1 + \varepsilon \ln(g_1) = \alpha_2 + \varepsilon_2 \ln(g_2).$

This implies that there exists a parameter value α such that

(A7) $\alpha_i = \alpha - \varepsilon \ln(g_i).$

Accordingly, the demand for school spending in a district (elementary, secondary, or unified) can be written as

(A8) $\ln(e) = \alpha + (\varepsilon + 1)\ln(c) + \varepsilon \ln(p) + \eta \ln(y) - \varepsilon \ln(g),$

where g is the number of grades in the district.

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