THE EFFECTS OF MULTI-DIMENSIONAL COMPETITION ON EDUCATION MARKET OUTCOMES

A Dissertation

by

MUSTAFA UGUR KARAKAPLAN

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

August 2012

Major Subject: Economics

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Approved by:

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ABSTRACT

The Effects of Multi-Dimensional Competition on Education Market Outcomes.

(August 2012)

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Co-Chairs of Advisory Committee: Dr. Timothy J. Gronberg
Dr. Li Gan

In this dissertation, I analyze the effects of competition in education markets. In my first essay, I analyze the effects of different concentration measures on school personnel salaries. I find evidence that principals have more bargaining power over their salaries than teachers in Washington that through rent-sharing, principals start getting positive returns from increasing concentration at lower levels of concentration than that of teachers. Moreover, I present that the pattern of teacher salaries versus concentration in Washington is similar to that in Texas, but the inflection point in Washington is at substantially lower levels of concentration—a finding which can be attributed to Washington's being a union state versus Texas's being a right-to-work-state.

In my second essay, I examine the effects of various measures of competition on school district cost inefficiency in a stochastic frontier framework. My results show that cost frontier is U-shaped in Texas with large positive returns to the scale over a relatively big range and mild diseconomies of scale over an extended range. In addition, I find that school district cost inefficiency increases significantly when market concentration increases. Furthermore, I present the competitive effect/scale effect trade-off through a couple of simulation exercises.

The findings from both of my studies show that the effects of competition are barely sensitive to measuring the competition with different sets of relevant competitors. On the other hand, sensitivity of the effects of competition to using different definitions of the education markets is significant. Yet, the range of these estimated effects is relatively small, and the sign and the significance of the effect of competition generally do not change when a meaningful definition of education markets is employed to measure concentration.

Furthermore, I present that the concentration measures employed in my essays are endogenous. I control for the endogeneity with several instrumental variables including degrees of lagged educational outputs in the neighboring schools, lagged education market characteristics, and counts of streams. My results imply that the hypothesized effects of competition may be underestimated due to the endogeneity. While the plausibility of competitive effect's being underestimated bolsters the importance of the competitive effects I find, it also strengthens my criticism of using uni-dimensional concentration indices as indicators of competition in the education markets.

NOMENCLATURE

2SLS	Two-stage least squares
ACC	All public schools and accredited private schools
ADA	Average daily attendance
ALL	All public schools and all private schools
APR	All public schools and approved private schools
BLS	U.S. Bureau of Labor Statistics
CBSA	Core Based Statistical Area
CCD	Common Core of Data, National Center for Education Statistics
CWI	Comparable wage index
DEA	Data envelopment analysis
f.o.b.	Free-on-board
GMM	Generalized method of moments
GNIS	Geographic Names Information System, U.S. Geological Survey
HHI	Herfindahl-Hirschman index of market concentration
ISD	Independent School District
IV	Instrumental variables
LEP	Limited English proficiency
MRP	Marginal revenue product
NCES	National Center for Education Statistics
OLS	Ordinary least squares
OMB	U.S. Office of Management and Budget

OSPI	Office of Superintendent of Public Instruction, Washington
PSS	Private School Universe Survey, National Center for Education Statistics
PUB	Only public schools
R15	15-mile radius circle
R25	25-mile radius circle
R2T	The Race to the Top program
R50	50-mile radius circle
SASS	Schools and Staffing Survey, National Center for Education Statistics
SDA	Seventh-Day Adventist Church
TAKS	Texas Assessment of Knowledge and Skills
TEA	Texas Education Agency
TEPSAC	Texas Private School Accreditation Commission
USGS	U.S. Geological Survey
WADA	Weighted average daily attendance

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1. INTRODUCTION

Competition is often overlooked as a determinant of outcomes in the education market. While there are important studies in the economics of education literature that examine the effects of competition, such as Hoxby (2000), Sass (2006), Taylor (2010), Millimet and Collier (2008), and Booker et al. (2008), many studies such as Duncombe and Yinger (2007) pay little or no attention to the influence of competition. Moreover, even though there are studies addressing competition in education markets, the validity and the applicability of the chosen competition measures are subject to question. One well-known example of this kind of skepticism is exemplified in Rothstein (2007) critique of Hoxby (2000), a critique that cast doubt on Hoxby's findings.

The effects of competition in the education market is an active corner of recent conversation, and convincing evidence, either proving or refuting theoretical competitive predictions in education markets is yet to be developed. But what is the education market? Who is competing with whom and for what and how? What is the degree of competition? How can competition be measured and does competition and its measures change over time? These are some of the questions we can ask once we begin analyzing the effects competition in the education markets.

Competition is a multi-dimensional concept. One shortcoming in the existing literature is that the competition measures are uni-dimensional. That is to say, the measures are composed of only a single feature of competition. This deficiency in the

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This dissertation follows the style of *The Review of Economics and Statistics*.

literature manifests itself in the common practice of using Herfindahl indices of market concentration as the measure of competition.

A Herfindahl index is basically a measure of the size of the competitors with respect to the market. Herfindahl indices are generally employed as indicators of the market structure. For instance, Herfindahl indices based on the total number of students in school districts in relevant education markets are common in the economics of education literature. Because a Herfindahl index is based on the market shares of the competitors, it is a uni-dimensional measure of competition which overlooks other important characteristics of competition. For example, in the existence of different types of competitors, a single uni-dimensional Herfindahl index may be associated with multiple degrees of competition in different settings, and therefore, can overstate or understate the actual degree of competition.

Moreover, the definition of the relevant education market is problematic as well. Understanding the delineation of the education market is essential for any analysis of competition, because measures of competition in a market are created from variables measured within that market. For example, taking core based statistical areas or other governmental divisions of land as distinct education markets could be misleading. These boundaries may be arbitrarily determined, or they may be established for the ease of governmental transactions or for the ease of use by statistical agencies in accumulating and presenting statistics, and therefore may be irrelevant to creating a measure of competition in education. Also, considering school districts as separate education markets could be misleading since Tiebout mobility suggests that inter-district competition may be more important than intra-district competition.

In this dissertation, I try to discover the true nature of competition in education markets. In my first essay, I analyze the effects of different concentration measures on school personnel salaries. My second essay is an examination of the effects of various measures of competition on school district cost inefficiency. The findings from both of my essays show that the effects of competition are barely sensitive to measuring the competition with different sets of competitors. On the other hand, sensitivity of the effects of competition to using different definitions of the education markets is significant. But I find that the range, over which the estimated effects of competition with different definitions of markets vary, is relatively small, and the sign and the significance of the effect of competition generally do not change when a meaningful definition of markets is employed to measure concentration.

Furthermore, I present that the concentration measures employed in my essays are endogenous. I control for the endogeneity with several instrumental variables including degrees of lagged educational outputs in the neighboring schools, lagged education market characteristics, and counts of streams. My results imply that the effects of competition may be underestimated due to the endogeneity. While the plausibility of underestimated effects of competition further validates the significance of the competitive effects I present, it also strengthens my criticism of using uni-dimensional concentration indices as indicators of competition in the education markets.

2. COMPETITION AND SCHOOL PERSONNEL SALARIES

Taylor (2010) uses Texas public school teacher data and finds that competition-based school reform may have an important effect on their wages. Her original idea is that if school districts act as typical oligopsonists while hiring teachers, then wages of the teachers may increase as the degree of competition among schools increase. Nevertheless, if school districts act as typical monopolist while supplying educational services, then wages of the teachers may decrease as the degree of competition among schools increase. Her results present that as the level of competition increases, wages of most of the teachers increase. However, she also find that the same change in the level of competition decreases the wages of teachers located in education markets with relatively high concentration ratios.

In this essay, I use a panel data from Washington State's Office of Superintendent of Public Instruction and analyze this reasoning with different education personnel, with the intention to focus largely upon two groups of school personnel: teachers and principals. The influence of high levels of competition on wages of other education personnel would also be expected to be the same as or at least similar to that on teachers. On the other hand, the literature tells us that many different characteristics of teachers, such as their being the second-earner in the household, may differentiate the findings from that of other education personnel. My findings show that principals have more bargaining power over their salaries than teachers in Washington, that principals start getting positive returns from increasing concentration at lower levels of concentration than that of teachers. Moreover, I present that the pattern of teacher salaries versus concentration in Washington is similar to that in Texas, but the inflection point in Washington is at substantially lower levels of concentration—a finding which can be attributed to Washington's being a union state versus Texas's being a right-to-work-state. While the degree of competitive effect varies over a significant range when different measures of competition are employed, my general findings are fairly robust to using different competition measures or utilizing different estimation procedures to deal with the endogeneity of the concentration measure.

2.1. Introduction to the Markets

The standard journey between one's place of residence and place of work or full time study is called commuting. Before 19th century, due to the unavailability of access to modern forms of transportation such as bicycles, trains, cars or buses, most of the workers had to live in walking distance from their workplace. In this day's industrialized societies many people travel every day to their workplaces which are far away from their own villages, towns or even cities. This may sometimes happen because of individuals' own preferences, but sometimes they may just do so because of the high cost of accommodation in city centers.

The arrival of new commuting methods has had a very big influence on our lives. The most significant effect is that the change has permitted the villages, towns or cities to get bigger to such dimensions which were not possible before. This, in turn, has led to the creation of the urban periphery. Today, most of the big cities are encircled by typical commuter belts, which are also named as metropolitan areas. A metropolitan area can be defined as the agglomeration of one or a limited number of contiguous built-up metropolises with a hub characteristic, and peripheral zones which are under the influence of these hubs in terms of commerce or employment. Hence, the borders of a metropolitan area may expand farther than its urban periphery conditional on the degree of the influence of the hubs and integration of the other constituent parts.

However, there may be inconsistencies in the parameters of metropolitan areas. In the United States, the U.S. Office of Management and Budget (OMB) defines metropolitan and micropolitan statistical areas, or the collective term "Core Based Statistical Areas", which is used for collecting, organizing and publishing Federal statistics by Federal statistical agencies. By OMB (2007) definition, each metropolitan and micropolitan area contains one or more counties including the core urban area, and the neighboring counties that have a high degree of economic and social integration with the urban core.[1]

Do these metropolitan statistical areas necessarily determine the labor market areas? In the past, economists have not devoted much attention to the determination of the markets. The problem was stated by Horowitz (1981) that “because economists, from Adam Smith forward, have with confidence and enthusiasm, although not necessarily with shared views, written about markets, it is plausible to expect that they would have

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[1] The degree of integration is measured by commuting to work. A metropolitan area holds an urban core with a population of 50,000 or more, and a micropolitan area holds an urban core with a population of at least 10,000 but less than 50,000 (U.S. Census Bureau). These definitions embrace about 93 percent of the U.S. population, about 83 percent of which is in metropolitan statistical areas, and about 10 percent of which is in micropolitan statistical areas. 1,092 of the 3,141 counties in the United States are in the 363 metropolitan statistical areas in the United States. 694 counties are in the 577 micropolitan statistical areas, and 1,355 counties are not inside the categorization. (OMB, 2007)

had quite a bit to contribute to the resolution of the market-definition issue.” In the same way, it was noted by Stigler (1982) that “Except for a casual flirtation with cross elasticities of demand and supply, the determination of markets has remained an undeveloped area of economic research at either the theoretical or empirical level.”

The mainstream economics defines the notion of market as a formation of buyers and sellers trading any kind of goods, services or information. Whether it is bartering or exchanging for money, it is natural to have a rate of exchange between the quantities of the traded things. Since the market makes it possible to trade, and facilitates the allocation and distribution of the resources in a society, the market can be suggested as the structure where the rate of exchange, that is price, is determined. The other side of the relationship between market and price suggests a key role of price in defining geographic or product markets. For example, considering the transportation costs, if a certain good, service or information has a single price over a geographical region, then this implies that the transactions at any location in this geographical region is taken to be a perfect substitute for transactions at any other location in the same geographical region by either buyers or sellers or both. Although it was possible to focus on the determination of spatial dimension of the markets in this sense, the literature generally concentrated on the determination of product markets to examine the degree of competition between products and sustain antitrust laws.

2.1.1. The Markets for Products

The product markets were traditionally determined by using the cross-price elasticities of demand, since they are associated with the degree of substitutability of two different products. The primary efforts to determine the markets by cross-price elasticities of demand emerge in the book, Price Theory, of Bain (1952). The U.S. case law (1953) explains the method as follows:

“For every product substitutes exist. But a relevant market cannot meaningfully encompass that infinite range. The circle must be drawn narrowly to exclude any other product to which, within reasonable variations in price, only a limited number of buyers will turn; in technical terms, products whose ‘cross-elasticities of demand’ are small.”

Since the cross-price elasticities of demand can measure the sensitivity of the change in demand for a product in a certain location, to changes in the price of the product in a different location, the degree of sensitivity can be adopted to delineate the geographic markets. Nevertheless, this approach of market determination goes through a number of weaknesses. The most important of all is that it is not clear how much the cross price elasticity of demand has to be so that the two goods can be suggested to be of the same market. A monopolist with a goal of profit maximization would usually increase the prices of its product up to the level at which the other products turn to be close substitutes resulting in the well-known cellophane trap, named after the U.S. cellophane case (1956). Therefore, in such cases of misuse of dominance, estimating the cross price elasticities of demand using the current market prices would bring incorrect conclusion.

Another problem of this approach is that the tests for the cross price elasticities of demand have rigorous data requirements and introduce extra difficulty (Stigler and Sherwin, 1985). To give an example, Werden (1998) utilizes the case of breakfast cereals where there are various kinds of brands and notices that the cross price elasticities of demand between any pair of cereal brand is very small. Werden states that the question of whether one good is in the same market as another good concentrates only on the degree of competitiveness between individual substitutes instead of on the degree of competitiveness of among all substitutes.

A regression based approach to determine markets is proposed by Horowitz (1981). This partial adjustment approach intends to show the fact that equilibrium price adjustments may not happen immediately across goods of the same market or across geographic areas. The assumption of the model is that there exists some imperceptible but stable long-run equilibrium price variation between the geographic areas or goods, and it takes time to approach to this equilibrium price variation. Horowitz utilizes a partial adjustment model to find the long run equilibrium price variation and the speed of this adjustment. However, there are several limitations of this model. First of all, this method obviously requires using a high frequency data, which would not be available for the good or service under examination. Also, as stated by Stigler and Sherwin (1985), this method does not introduce a valid approach to equilibrium because there is no appropriate way to choose the time interval to which price quotations relate and the critical variables in the model do not supply information about the rate of approach or the number of markets involved. Other major shortcomings of the model are argued by

Slade (1986). First, the approach can generate invalid outcomes if there is autocorrelation, a trend or a systematic cyclical movement in prices. Secondly, in terms of the dynamic adjustment, this approach is unreasonably restrictive because the adjustment is assumed to follow a specific pattern, although an assumption of dynamic stability of price differentials would be sufficient. Nevertheless, there cannot be an a priori knowledge of the existence of a stable long run price variation since the shipments of products work in both directions and the variation in prices may include transportation costs.

In the same article, Slade (1986) suggests another methodology which is based on the notion of Granger causality of Granger (1969), Sims (1972) and Wu (1983). This methodology would allow testing the hypothesis that the price variations in a good or geographic area have perceptible consequences on the price variations in some other goods or geographical areas. The Granger causality literature suggests that if significantly improved predictions of Y can be obtained when X is included as an explanatory variable along with all of the other explanatory variables than the case when X is excluded, then the variable X "causes" the variable Y. Since Granger causality tests supply a practical tool to have an understanding of the linear prediction and the feedback system among variables, these tests are frequently utilized in the literature and often interpreted as tests of correlation between variables. However, due to the econometric drawbacks of this approach, such tests are not appropriate to determine significant results (Kimmel, 1987). Unless the data portray a two-dimensional system, this method cannot generate any clear finding about the relationship between the variables. Also the causality tests are prone to be extremely responsive to the specification of the model as indicated by Kaserman and Zeisel (1996). For that reason, if significant explanatory variables are not included to the model, the causality test results would become biased, which is very likely under the certain limitations in the data. Finally, this methodology needs high frequency data, which is unfortunately not available for labor and other factors of production.

Shrieves (1978), Horowitz (1981), and Stigler and Sherwin (1985) propose the use of price correlations to determine markets. The logic is that the prices of substitute goods cannot independently move too much out of the line. Since the degree of substitutability of the products is represented in the price data, the spatial dimension of markets can be examined by looking at the price correlations of a certain product in several different locations over a geographic area. The idea is expressed by Areeda, Turner and Hovenkamp (1978) that “separate markets are indicated for a given product where its price in separate areas differs and where price movements are relatively uncorrelated.” Likewise, Benson (1980) indicate that “the only way to really determine whether or not two firms are in the same geographic market is examination of reactions by one firm to price changes of another.” Furthermore, it is reported by Massey and O'Hare (1996) that the pricing actions of the firms in the past are sometimes used by the EU Commission as a practical indicator of the relevant markets.

Nevertheless, price correlations exhibit particular limitations for the intention of determining markets for competition analysis. There will be a perfect correlation between prices of two goods if a certain percentage change in the price of one good causes a consistent percentage change in the price of the other good. Moreover, because of the possibility of having high levels of correlation, although the goods under examination are not good substitutes, this approach may produce unreliable outcomes. As explained in Slade (1986), if the mutually causal factors are not held constant, the correlations will be spurious. Specifying a structural model can correct this problem. Nonetheless, this specification may diminish the ease, and in turn the superiority of this approach to the cross-price elasticity of demand approach, which is suggested by Kaserman and Zeisel (1996).

The two seminal articles of Elzinga and Hogarty (1973, 1978) argue that in most of the cases, the only data set that is necessary to determine the geographical markets is the physical shipment data. They note that the shipment data should be organized so that it will be in two categories at the same time: the origin and the destination. To assess the boundaries of geographical markets they suggest an estimation procedure, Elzinga-Hogarty test, of at least four steps, in which they calculate the percentage of a physical product produced in an area that is consumed in that area and the percentage of the physical product consumed in an area that is produced in that area. If the levels of both percentages are above 75 per cent, then the geographic area under examination is proposed to be a single market. The critical value, 75 per cent, is explained to be arbitrary which only reflects their view of acceptable cost of estimation. Hence, they imply that a higher or a lower benchmark can be substituted for the suggested 75 per cent benchmark to be suitable for the objectives of other studies.

Following their estimation procedure, Elzinga and Hogarty (1973) mention that it is possible to find two separate geographical market areas. If that is the case, then they suggest that it represents a geographic market extension merger. They also state that it is possible to find two overlapping areas for geographically separate firms. In this case, they propose that if the shipments of the overlapping area constitute more than 25 percent of the shipments of either area, then the entire area including the overlapping and non-overlapping parts can be counted as one geographical market area.

Nonetheless, the accuracy of the results the shipments data produces is questioned in the literature. Werden (1981) suggests that although using shipment data is practical to determine the markets, it is not sufficient enough to determine the separation of the markets because free-on-board (f.o.b.) prices and transportation costs are not taken into account. Therefore, while the Elzinga-Hogarty method have an advantage of precision due to its reproducibility, the method cannot be claimed to be superior to other methods due to the possibility of getting erroneous outcomes (Werden, 1981). However, it may not be proper to propose the absolute cost of transportation or f.o.b. values as key variables. Elzinga (1981) explains that if the transportation costs are high enough to impede the movement of the product or if there are legal barriers which are effective, then shipment data would reflect these.

Furthermore, the existence or nonexistence of such physical shipment is not a necessary or sufficient condition to determine if the area in question is a separate market (Stigler and Sherwin, 1985). Stigler and Sherwin suggest that there is a possibility of having price discrimination between two separate markets between which are large flows of trade, which may in turn cause price variation isolated from transportation costs. Without altering their prices toward equilibrium, manufacturers can detect and profit from the variations in demand elasticities between the two geographical areas. Moreover, as discussed earlier and as Kaserman and Zeisel (1996) presents, neither theoretical nor practical validation for the critical values suggested by Elzinga and Hogarty are available. Kaserman and Zeisel also note that the pricing of the producers depends on the shipment possibilities from outside of a geographic area. However, regardless of these limitations of Elzinga-Hogarty procedure, investigation of observed flows of shipment can still be argued as an effective method to identify the geographic markets. Especially if the question under investigation is about the determination of the labor markets, utilizing the Elzinga-Hogarty approach would be a sensible approach, since labor market analogy of shipments of the goods is the commuting behavior of labor, that is, job migration.

2.1.2. Determination of the Markets for Labor

Determination of labor markets, being a geographic market in essence, has been under separate examination in the literature since Carroll (1949). The literature expresses that one of the essential elements of the theories of urban geographic structure is the relationship between home and work. That is, there is a general consensus that commuting patterns inform us about the structure of labor markets. However, the models in this commuting literature are not complete enough to understand the partial effects of commuting behavior on market delineation. Although these unsophisticated models ignore many significant issues in the labor market definition, they still give us limited insights about the spatial structure of the markets.

The earliest economic models of labor markets in Wingo (1961), Kain (1962), Alonso (1964) and Muth (1969) have drawn attention to the trade-off between accommodation costs and commuting costs. These models specifically hypothesize that households select their residence location by minimizing the total of residential and commuting costs. The trade-off represents the clash between the households' willingness to be closer to their location of work and their willingness to have better accommodation and amenities in terms of prices. That is, housing and employment preferences of individuals are suggested to be at the core of urban spatial structure.

If the residential structure of the cities can be assumed to be monocentric, then these models with the trade-off approach can be helpful to delineate the labor markets. However, as Berry and Kim (1993) points out, because of the complex structure of U.S. metropolitan areas, monocentric models are not suitable enough to determine the labor markets. Still, the concept of the trade-off between housing location and the workplace is relevant to polycentric models. Gordon, Kumar and Richardson (1989) state that the significance of accessibility and economic competition as determinants of the urban structures cannot be rejected. As explained in Clark and Kuijpers-Linde (1994), the evolution in the connections between residences and jobs is very important to understanding the commuting behavior and polycentric urban structures. Nevertheless, the distribution of employment opportunities is suggested to generate a more complex behavioral reaction to the relationship between house and workplace.

As Getis (1969) presents, there can be an “indifference zone” in which the households are indifferent to access to work. That is, since the distance to work is only one out of numerous variables affecting the commuting behavior of households (Quigley and Weinberg, 1977), it can be constant within certain geographical zones. Also, Brown (1975) reports that if the job location of the household changes to somewhere outside of the original work zone the household become more prone to move than if the new job location stays in the original work zone. Moreover, according to Clark and Burt (1980) if a household is far away from their workplace, when they move, they tend to be closer to where they work.

Cervero and Wu (1997) examine the residential location and commuting in the polycentric San Francisco Bay Area. They show that employment in the central cities produces longer commuting times than employment in suburban areas. Studies like Doorn and Van Rietberger (1990), Bell (1991), Cervero and Landis (1992), and Wachs et al. (1993) analyze the effects of workers’ relocation to the suburbs on the commuting times and distances. Their results generally propose that commuting structure adjusts to the changing metropolitan structure which can also be an automatic process to minimize the time to commute and congestion.

Simpson (1987) points out that due to the unavailability of panel data, most of the studies cannot allow for the dynamic nature of the labor market structure. Many of the studies such as Smart (1974), Ball (1980), Coombes and Openshaw (1982), Coombes, Green and Openshaw (1986), Laan (1991), Kristensen (1998), (Schmitt and Henry, 2000), Casado-Diaz (2000), Laan and Schalke (2001), Papps and Newell (2002), Coombes, Raybould and Wymer (2005), and Cladera, Bergadà and Roper (2005) use cross sectional data, and delineate or re-delineate the static structure of labor market areas. However, due to the unavailability of panel data, these studies could not capture the dynamic formation of the labor markets.

Levinson (1997) uses job-duration and residence duration to deal with the absence of panel data. Levinson (1998) presents that the recency of the change in the employment of the individual would affect the commuting time and distance. Since individuals who have a long duration of employment and residence have stayed stable spatially, they are argued to have shorter than average commutes. Although the relationship between residential location and workplace is set up well, commuting tolerance can only be one of several variables affecting the move, which weakens the model.

Ommeren, Rietveld and Nijkamp (1997), Ommeren (1998), Ommeren, Rietveld and Nijkamp (1999), Rouwendal and Rietveld (1994), and Rouwendal (1999) examine the relationship between the house and the workplace by utilizing a structure in which employment and residential changes are interconnected. The findings in these studies present that the increases in current commuting distances are associated with higher chances of changing the employment or housing. That is, individuals modify their residence and jobs to decrease the commuting distance. Moreover, job location is suggested to be more responsive to the commuting distance than residential location, mostly because moving the house is more costly. Ommeren, Rietveld and Nijkamp (1997) and Clark and Withers (1999) discuss the causal effect of job changes on residential mobility, and they find contradictory results. While Ommeren, Rietveld and Nijkamp (1997) claim no significant effect; Clark and Withers (1999) suggest a positive causal effect of job change on residential change. Although conflicting conclusions are present, this branch of the literature stresses the significance of the house and the workplace interconnection.

If the decisions of the workers in two worker households bind each other's decisions, then individuals do not minimize commuting distances individually. In this case, spatial dimension of the markets can only be assessed by considering the households' joint decision process. The literature on dual labor market attachments examines the commuting behavior of households with one and two workers, and presents that constrains of partners within a household bind each other's decision process. It is reported by Freedman and Kern (1997) that women's employment constraints affect the households' house and workplace location. Abraham and Hunt (1997) presents that women in general could be expected to have shorter commuting distances than that of men in two worker households. Sermons and Koppelman (1999) show that in two worker households, the residential and workplace locations are interdependent for women. MacDonald (1999) explains the difference in the commuting distance of men and women by low wages and dual roles of women. Clark, Huang and Withers (2003) uses a multimodal model with two worker households. Their findings comply with the literature that in two worker households, women's commuting distance is shorter than that of men, and women are more prone than are men to minimize their commuting distance if the residential location changes.

As presented in Martin (2000), workers commonly reveal their preferences to be in a certain location. These strong ties to location, in turn, cause the local labor to be fixed spatially and the associated possibility to have variations in wages and other characteristics in the local labor markets. Moreover, since the workers are prone to be residentially immobile, this kind of sorting would be expected to generate segments within labor markets. Consequently, this segmentation within labor markets breeds labor markets embedded in labor markets, in which variations in wages, worker attributes and work provisions are sustained over time. Boyd et al. (2005) use New York state data and show that teachers prefer their workplace to be close to their hometown and similar to it in other characteristics. Therefore, the inside story of the spatial fixity of workers may also be telling us that the recent residence preferences are connected to childhood residence.

2.1.3. Monopsony in Labor Markets

In addition to all of the complications associated with the analysis of labor market delineation, one should also be cautious about how labor markets may demonstrate dissimilar economic structures when categorized under different job titles. For example if the local labor markets of a job category are not competitive, employers can take advantage of employees' high moving costs. Such a form of imperfect competition can be explained in a monopsony setting, where only one buyer faces many sellers –or in a more realistic oligopsony setting, in which competition for the factors of production is between small numbers of firms.

The term “monopsony” first appears in the book “The Economics of Imperfect Competition.” of Robinson (1933). When Joan Robinson and Bertrand Hallward coined the term, Robinson’s idea was to describe the differences of labor markets with a single buyer firm. Ever since the introduction of the model, many undergraduate text books give place to this model, though with a dubious shade due to the questionability of the single-buyer supposition. However today, especially after the recent developments in the literature, the term “labor monopsony” is widely used with less skepticism. Boal and Ransom (1997) explain and cite various examples of how competitive models are not satisfactory enough to identify the labor markets, and how job-hunt behavior of the individuals produce an upward sloping labor supply in the short run for the firm.

What can a monopsony model explain? Excess demand, for instance, is an enigma, for a competitive model. However, vacancies in a firm can easily be explained with an upward sloping labor supply in a monopsony model as explained by Archibald (1954) and demonstrated in Yett (1975) with the support of vacancies in the U.S. nurse market. Another puzzle for competitive models is the fact that there exists persistent differential between wages of equally productive labor at equally appealing positions, as mentioned in Dickens and Katz (1987). On the other hand, wage discrepancy within markets is a fundamental characteristic of monopsonistic equilibria. Wage discrimination, even after the observed productivity discrepancy is controlled, can as well be explained within a monopsonistic model if the elasticity of the labor supply of the groups other than white men can be demonstrated to be less than that of white men. Likewise, a positive effect of minimum wages on aggregate employment can disagree with what competitive models argue, but it is rationalized well by monopsonistic models. However, as stated by Brown and Medoff (1989), Green, Machin and Manning (1992), what seems to be the major mystery for competitive models is the relationship between the size and the location of the employer and the wages of the employees. Boal and Ransom (1997) present that the explanation of the relationship would be difficult even with some of the monopsony models. For example, what are the effects of the size of a public institution on wages? What would be the consequences of consolidating two public institutions on wages? Or, how would the wages get affected if the job is in an isolated corner of the world? How can these correlations be explained?

2.1.4. Monopsony in Education Labor Markets

Economists have been aware of the situation that holders of factors of production, which are typically utilized in isolated locations, or in the production of public goods or services, can confront monopsony conditions. Bish and O'Donoghue (1970) point out that studies such as Samuelson (1954), Musgrave (1959), Sharp and Escarraz (1964), Williams (1966), Brainard and Dolbear (1967), Buchanan (1968), and Brennan (1969) report incorrect inferences because these studies analyze the socially optimum level of public good consumption by considering only the constant-cost situations, and overlook the problem of the possible monopsony setting. Shibata (1973) states that the potential monopsony situation can take place in the constant cost setting too, and he signifies the importance of evaluating both cases considering monopsony equilibrium.

Moreover, there are various studies in the literature investigating the monopsony effects specifically in certain job markets. Hurd (1973), Link and Landon (1975), Feldman and Scheffler (1982), Adamache and Sloan (1982), and Bruggink et al. (1985) highlight the monopsony power of the hospital industry and the level of employer concentration and the earnings of nurses. Additionally, Sullivan (1989) presents estimates of the inverse elasticity of supply of nursing services to a single hospital, which is a natural measure of the importance of monopsony power. He also examines the dependence of the inverse elasticity on several factors such as the duration of the pertinent time interval, whether or not the location of the hospital is in a big metropolitan region and the oligopsony setting taking into account the interactions among hospitals, and finds remarkably high monopsony effects in the nurse markets.

Borcherding (1971) draws attention to the fact that some of the military skills are solely exploited by the U.S. Government, and hence face a monopsony situation. Ransom (1993) presents that contrary to what could be expected for other jobs, higher seniority brings lower wages for university faculty because of the monopsonistic approach of the universities. Fleisher and Kniesner (1980), Boal (1995), Filer, Hamermesh and Rees (1996), Kaufman and Hotchkiss (2006), McConnell, Brue and MacPherson (2007), and Ehrenberg and Smith (2009) give the example of the isolated mining towns of the nineteenth and twentieth century as the classical labor monopsony. Since the coal mines are remotely located in rough territories, relocation is costly, and hence is the monopsony encountered by the coal miners.

Together with the nurses, some military personnel, the university faculty and the coal miners, teachers, as well, can find themselves in such an unfavorable situation of monopsony. Schools are teachers’ workplace. However, other than the eleven percent[2] of the teachers on the national scale, who work in private schools, teachers are employed by the school districts and not by the individual schools. That is, the number of competitors for teachers is significantly less than the number of schools. As a result of this weak competition, monopsony or oligopsony can reign in several areas.

The first suggestion of monopsonistic teacher labor markets is presented in Landon and Baird (1971). Succeeding articles by Baird and Landon (1972), Lipsky and Drotning (1973), Thornton (1975), Gustman and Clement (1977), Cole (1977), and Holmes (1979) produced conflicting results about the connection between the monopsony power of the school districts and teacher wages.

Luizer and Thornton (1986) present indications of monopsonistic characteristics of the local teacher labor markets in Pennsylvania. Merrifield (1999) shows that in Texas, teachers in less competitive labor markets have relatively lower salaries. Similarly, Vedder and Hall (2000) explain that increased competition from private schools increases the public school teachers’ wage rates in Ohio. Medcalfe and Thornton (2006), on the other hand, present that there is no evidence that teachers’ salaries are less in less competitive labor markets in Georgia. Finally, using data from Texas school districts, Taylor (2010) finds that as the level of competition increases, wages of most of the teachers increase. Her original idea, however, is that while school districts may act

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[2] In 2009-2010, there are 437,414 private school teachers in the United States compared to about 3.2 million public school teachers.

like typical oligopsonists in teacher labor market, they also may have some monopoly power in the education services market, and if teachers are getting some of the rents due to this monopoly power, then increased competition in the education market may reduce teachers' pay. Rent-sharing by workers is examined by Blanchflower, Oswald and Sanfey (1996), Hildreth and Oswald (1997), and Black and Strahan (2001). Taylor (2010), nonetheless, presents the possibility of two different market structures—oligopsony in teacher labor markets and monopoly in education services market—playing opposite roles in determining the teacher earnings, that her findings also show that in relatively concentrated markets, increase in competition leads lower teacher wages.

In this study, I will analyze the same reasoning with other education personnel, with the intention to focus largely upon principals. The influence of high levels of competition on wages of other education personnel would also be expected to be the same as or at least similar to that on teachers. On the other hand, the literature tells us that many different characteristics of teachers, such as their being the second-earner in the household, may differentiate the findings from that of other education personnel. I check the sensitivity of the results using various kinds of competition measures. In order to generate result comparable with Taylor (2010), I utilize an econometric methodology similar to hers, and analyze the results of the ordinary least squares (OLS), instrumental variables (IV) and generalized method of moments (GMM) estimations using a panel data set including Washington school district employee information.

One main difference between Taylor (2010) and this study is that Texas is a right-to-work state, whereas Washington is not. Unions may constitute a force working to balance the market power of the employers. Hence, the high level of unionization in Washington is likely determinant of wages. In fact, many studies in the literature such as Lemke (2004) or Kingdon and Teal (2010) find that there is about a 7-10% wage premium to public sector unions. On the other hand, some other studies such as Kleiner and Petree (1988) or Lovenheim (2009) find that unionization has no significant positive effect on wages. That is, the literature provides mixed findings about the effects of unions on wages. My study provides a comparison of a right-to-work state with a union state to provide a better understanding of the effects of unions on wages of employees in the education markets.

2.2. Models of Education Personnel Wage Determination

2.2.1. Wages in an Oligopsony Model

If the school districts act like oligopsonists, we can use Boal and Ransom (1997) Cournot model of oligopsony to model the educational labor markets. In this model, each school district would maximize their profits which can be written as

$$\max_{L_i} R_i(L_i) - w(L) \cdot L_i \tag{1}$$

where school districts choose their own level of employment, L_i, to maximize the difference between their revenue, R_i, and their cost, which is a function of the inverse labor supply function, $w(L)$, that the total employment by all public districts, L, determines a single market wage. The first-order condition for each school district is

$$\frac{\partial R_i}{\partial L_i} - \frac{\partial w(L)}{\partial L} \cdot L_i - w(L) = 0 \tag{2}$$

In equation (2), $\partial R_i/\partial L_i$ is the value of the marginal product of labor to the school district, or their marginal revenue product (MRP_i). We can rearrange equation (2) to get a measure of exploitation a la Arthur Pigou, that is

$$\mathrm{E}_i \equiv \frac{MRP_i - w}{w} = \frac{\partial w}{\partial L} \cdot \frac{L_i}{w} = \varepsilon^{-1} \cdot \frac{L_i}{L} \tag{3}$$

where ε is the wage elasticity of labor supply. Using equation (3), we can write an employment-weighted average of school district exploitations as

$$\mathrm{E} = \sum_{i=1}^{n} \frac{\mathrm{E}_i \cdot L_i}{L} = \varepsilon^{-1} \cdot \sum_{i=1}^{n} \left(\frac{L_i}{L}\right)^2 \tag{4}$$

Here, the sum of squared shares of employment is a Herfindahl index of market concentration, which we will denote as H. Then we can rewrite equation (4) to isolate w as

$$w = \sum_{i=1}^{n} \frac{MRP_i \cdot L_i}{L \cdot (\varepsilon^{-1} \cdot H + 1)} \tag{5}$$

As explained in Boal and Ransom (1997), the relationship between w and H is not static. That is, w and H are endogenous market outcomes determined by the number of school districts and their marginal revenue product. However, if we assume that total market demand and labor supply are fixed, then a negative relationship between w and H would suggest an oligopsony.

2.2.2. Wages in a Rent Sharing Model

If the public school districts act like oligopolist when providing the educational services, any rents generated by a district can be shared by that district's employees. Rent-sharing district employees can be modeled by using the model in Blanchflower, Oswald and Sanfey (1996). In their bargaining model, wages are determined in the following maximization problem

$$\max_{w,n} \phi \cdot \ln\{[u(w) - u(\bar{w})] \cdot L\} + (1 - \phi) \cdot \ln \pi \tag{6}$$

where $\phi \in [0,1]$ is the bargaining power of the employees of the district, $u(\cdot)$ is the utility function of each employee, w is the wage in the industry, $\bar{w}$ is the expected opportunity wages outside the industry, L is employment, and π is the profit. The first-order conditions are

$$w\colon \frac{\phi \cdot u'(w)}{[u(w) - u(\bar{w})] \cdot L} - \frac{(1 - \phi)}{\pi} = 0 \tag{7}$$

and

$$L\colon \frac{\phi}{L} + \frac{(1 - \phi) \cdot [R'(L) - w]}{\pi} = 0 \tag{8}$$

where $R(\cdot)$ is the revenue function. Equation (7) can be rewritten as

$$\frac{u(w) - u(\bar{w})}{u'(w)} = \frac{\phi \cdot \pi}{(1 - \phi) \cdot L} \tag{9}$$

Here, if we substitute $u(w) + (\bar{w} - w) \cdot u'(w)$ in place of $u(\bar{w})$, we would get

$$w \cong \bar{w} + \frac{\phi}{(1 - \phi)} \cdot \frac{\pi}{L} \tag{10}$$

where $\phi/(1-\phi)$ is the relative bargaining strength of the employees and π/L is the rents per employee. We can assume that capital is quasi-fixed in the short-run. So we can write the rents per employee as

$$\frac{\pi}{L}=\sum_{i=1}^{n}(MRP_i-w^o)\cdot\frac{L_i}{L}=\overline{MRP}-w^o \qquad (11)$$

where w^o is the going wage in the local economy, and $\overline{MRP}$ is the employment weighted average marginal revenue product. Since the expected opportunity wages outside the industry is a function of the going wage and unemployment in the local economy, U, we can write equation (10) as

$$w\cong c(w^o,\,U)+\frac{\phi}{(1-\phi)}\cdot(\overline{MRP}-w^o) \qquad (12)$$

In equation (12), wages increase as rents increase. In education markets, school district inefficiencies can be a source for economic rents. District inefficiency, in turn, is a function of competition in the education market, where efficiency increases with more competition. Therefore, we can expect that wages in a rent-sharing model is negatively related to the level of competition in the education services market.

2.2.3. Wages in a Union Model

According to the Schools and Staffing Survey (SASS) of National Center for Education Statistics, almost all of the public school teachers in Washington are in a union or employee’s association. This is mainly because Washington is not a right-to-work state. A right-to-work law protects the employee rights to choose whether or not they want to become a member of a union or financially support it. For example, Taylor (2010) examines the determinants of teacher pay in Texas, which is a right-to-work state. However, when a state does not have a right-to-work law, a state of forced unionism may prevail in that state. The unions in a state may counteract the power of the oligopsonistic school districts.

As explained by Lovenheim (2009), the literature does not provide a complete theoretical model of education market unions. Hence, in theory, we do not know for sure how the effects of a teachers union on teacher pay or other educational variables would be. We can assume that the main goal of a union is to maximize the total welfare of its members, but then that would be a function of many variables such as the number of members with jobs, their hours of work, their level of benefits as well as their wage rates. Hence, basic models of unionization, which do not take into account the simultaneous collective bargaining over multiple outcomes, cannot give us unique predictions. Empirical examination would give us an idea about the effects of unionization, but states such as Washington do not have variation in union membership. Therefore, in this study, I compare my results using Washington data with Taylor (2010) results to have an understanding of the impact of forced unions and right-to-work laws on teacher and principal wage rates.[3]

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[3] The teachers unions and the principal union in Washington are separate organizations and these unions may have different levels of wage bargaining power. In fact, in this study, I present evidence that principals union has more bargaining power than teachers union in Washington.

2.2.4. Reduced Form Models

Reduced form models of the wages in a classical oligopsonistic education market, and the wages in the rent-sharing model are very similar. Assuming that the labor supply in the education market is a function of expected opportunity wages, the reduced form of wages in an oligopsonistic education market can be written as

$$w_o = w_o(H, Z, w^o, U) \tag{13}$$

where Z includes the variables, which affect the marginal revenue of public school districts, such as the factors determining the education production technology or the local education demand. In the rent-sharing model, we can assume that the Herfindahl index of market concentration is one of the determinants of economic rents in the education market through school inefficiency, and write the reduced form of wages in a rent-sharing model as

$$w_r = w_r(H, Z, w^o, U, \phi) \tag{14}$$

There are two important differences between equations (13) and (14): First, the oligopsonistic model predicts that holding other variables constant, the effect of education market concentration on wages is negative. The same effect, however, is predicted to be positive in the rent-sharing model. The second difference between the equations is that the rent-sharing model includes an element, ϕ, which is the bargaining power of the employees. This term would be useful to capture the effects of unionization in the labor market. Nevertheless, if there is no variation in the unionization across the labor markets, this distinction between the equations would not be consequential. One possibility is that different employee types in the education markets may have different rates of unionization, which would cause a significant change in the overall findings. For example, if the level of public school teacher unionization is different than the level of public school administrator unionization, then if the effects of concentration index on the wages of teachers and administrators are different, that difference may partially be attributed to the different levels of unionization in those employee groups.

2.3. Data

The main data for this analysis come from the state of Washington Office of Superintendent of Public Instruction (OSPI) school personnel database, and National Center for Education Statistics' (NCES) Common Core of Data (CCD) and Private School Universe Survey (PSS). The U.S. Office of Management and Budget (OMB) identifies 21 Core Based Statistical Areas (CBSA) in the state of Washington.[4] These CBSAs include 12 metropolitan statistical areas and 9 micropolitan statistical areas. There are 39 counties in Washington, 13 of which do not belong to any CBSAs. The number of public schools in Washington is about 2000, which are operated by about 300 public school districts.[5] Moreover, the number of private schools in Washington is over 400. About 100 of these private schools are operated by three separate Dioceses or the Seventh-Day Adventist Church (SDA) in Washington. Hence, the number of private school districts is less than the number of private schools if these school systems are counted as districts. In the 2003-2004 school year, the smallest public school district has

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[4] Two of these CBSAs—Portland-Vancouver-Beaverton and Lewiston metropolitan statistical areas—cross state borders and include counties from either Oregon or Idaho. I exclude the counties in these cross-border CBSAs to avoid complications while calculating the concentration measures.

[5] The number of public school districts is more than 400 before 2001.

9 students, and the biggest has 46,636 students. The average public school district enrollment in the same year is 3460. The smallest private school district has 5 students and the biggest private school district has 20,366 students in the 2003-2004 school year. Mean private school enrollment in that school year is 549. Therefore, we can say that the range of education market structures is quite wide in Washington.

The unit of analysis in this study is the public school district personnel. OSPI collects and publishes detailed information on the earnings of public school district personnel and their characteristics. The OSPI personnel records indicate individuals' gender, ethnicity, major duty assignment, years of experience, percent of certified contracted time in major duty, public school district, and building assignment. The OSPI records present that there are about 30,000 elementary and secondary teachers, and about 1,700 principals and administrators in each school year between the 1997-1998 school year and the 2005-2006 school year in Washington.

An important part of my analysis is determining the education market area. The market needs to be clearly defined to measure $H, Z, w^o,$ and U from equations (13) and (14). I follow the literature and assume that the education markets are the CBSAs identified by the OMB. Therefore, I treat each CBSA as a separate education market. In case an education personnel's location of work is not in any of these CBSAs, I assume that their school district's county is a distinct education market.

The H variable is the Herfindahl-Hirschman index of market concentration (HHI). In this study, the Herfindahl index of market concentration of an education market is the sum of squared enrollment shares of all of the public and private school districts in that education market. In Washington, the Herfindahl index of market concentration has a great variation across education markets. For example, in the 2005-2006 school year, Seattle-Tacoma-Bellevue CBSA's Herfindahl index of market concentration is 0.033. On the other hand, in the same school year, Garfield County's Herfindahl index of market concentration is 1. Along with the HHI, in order to control for a possible nonlinear relationship between the HHI and the salaries, my model incorporates the square of the HHI.

The Z variable vector includes the characteristics of the education market which affects the marginal revenue product of the districts in that education market. The determinants of educational production technology and the local demand for education other than the market concentration can be in this vector of variables. The literature presents that the size of a school district is an important element in determining the educational production technology. Moreover, the relationship between cost of education production and its size does not need to be linear. Hence, I add the average district enrollment in the labor market and its square in the Z vector as two factors of the education technology. Voter demographics would determine the local education demand. I get the median earnings, the percent of families with school-age children, the percent of population older than 65, the percent of the adult population with a high school degree but no higher degrees, and the percent of the adult population with a bachelor's degree or higher degrees from Census 2000, and I include these variables in Z as the factors determining the education demand in the labor market.

The prevailing wage in the labor markets and the local unemployment rate are the factors which determine the expected wage. For w^o, I use the comparable wage index (CWI) from NCES and Taylor and Fowler (2006). For U, I use the unemployment rates provided by the Bureau of Labor Statistics (BLS).

In addition to these variables, salaries of the public school district personnel may be a function of school district-specific characteristics or individual-specific characteristics for compensating differentials. For instance, smaller school districts would be expected to have smaller class sizes, which would be perceived as easier to teach, manage or administer, which would in turn result in their employing the personnel with reduced salary rates. Conversely, it may be the case that school districts with a student body that is generally perceived as too difficult to teach or administer can hire their personnel only with a premium. Moreover, because of the higher cost of living and commuting costs in metropolitan areas, school districts located in the center of these areas may be expected to cover up these costs with increase salary rates to be able to hire. In order to control for these effects, I used the district size definitions in the State of Washington, Joint Legislative Audit & Review Committee’s School District Cost and Size Study (2010) and include two district size indicators: small districts have an enrollment less than 1,000 students, and medium districts have an enrollment more than or equal to 1,000 and less than or equal to 10,000. According to these definitions, there are 145 small, 120 medium and 31 large districts in Washington in 2005-2006 school year. Additionally, I include the percentage of students in the district eligible to get free or reduced lunch, the percentage of migrant students in the district, the percentage of

Hispanic students in the district, and the percentage of black students in the district as student demographics of districts. Furthermore, my model contains a variable measuring the distance from the employee’s school district to the center of the closest metropolitan area.

Finally, in order to control for individual-specific characteristics, my model includes indicator variables for the individuals’ highest degree (bachelor’s degree, master’s degree, and doctorate degree), assignment to a Special Education program, ethnicity, gender, and assignment to a high school grade. I also include a dummy variable for the personnel who are in their first year in the district. In addition to that, I add the personnel’s years of experience and its square, and their percent of certified contracted time in their major duty. There are two personnel categories in my study: the first personnel category is teachers, including all major duty elementary, secondary and other teachers in the OSPI records; the second personnel category is principals, including all major duty elementary and secondary principals, elementary and secondary vice principals, and other school administrators in the OSPI records. All of the specifications in this study contain dummy variables for each school year available in the data set. Table 1 and Table 2 provide descriptive statistics on the variables used in this analysis.

TABLE 1.—DESCRIPTIVE STATISTICS, TEACHER CATEGORY (MULTIPLE PAGES)

Variable	Mean	Standard Deviation	Minimum	Maximum
Total final salary	47,882	9,974	29,131	73,024
HHI	0.134	0.115	0.033	1
Average district enrollment	6,925	3,455	212	10,441
Median income	25,351	4,458	9,488	30,088
Percent households with school aged children	0.285	0.015	0.23	0.307
Percent population over age 65	0.112	0.022	0.085	0.226
Percent adults with high school degree only	0.6	0.068	0.488	0.701
Percent adults with at least bachelor's degree	0.267	0.088	0.122	0.44
Unemployment rate	5.963	1.686	1.6	13.5
Comparable wage index	1.102	0.153	0.766	1.387
Metropolitan area	0.608	0.488	0	1
1997-1998 school year	0.103	0.304	0	1
1998-1999 school year	0.101	0.301	0	1
1999-2000 school year	0.106	0.307	0	1
2000-2001 school year	0.108	0.31	0	1
2001-2002 school year	0.116	0.321	0	1
2002-2003 school year	0.117	0.321	0	1
2003-2004 school year	0.115	0.319	0	1
2004-2005 school year	0.118	0.323	0	1
2005-2006 school year	0.117	0.321	0	1
Small district	0.053	0.225	0	1
Medium district	0.383	0.486	0	1
Percent low income students	0.21	0.218	0	0.973
Percent migrant students	0.008	0.046	0	0.962
Percent Hispanic students	0.11	0.154	0	1
Percent black students	0.06	0.07	0	0.25
Distance from major metropolitan areas	23.4	16.7	1.6	128
Years of experience	13.8	9.2	0	53.8
Bachelor's degree	0.429	0.495	0	1
Master's degree	0.556	0.497	0	1
Doctorate degree	0.006	0.077	0	1
Special Education	0.092	0.289	0	1
Certified contracted time in major duty	0.915	0.185	0	1
Asian	0.026	0.158	0	1

TABLE 1.—DESCRIPTIVE STATISTICS, TEACHER CATEGORY (MULTIPLE PAGES)

Variable	Mean	Standard Deviation	Minimum	Maximum
Black	0.016	0.127	0	1
Hispanic	0.021	0.144	0	1
Indian	0.008	0.087	0	1
Female	0.749	0.434	0	1
New in district	0.035	0.184	0	1
High school	0.384	0.486	0	1

Number of observations = 276,795

TABLE 2.—DESCRIPTIVE STATISTICS, PRINCIPAL CATEGORY (MULTIPLE PAGES)

Variable	Mean	Standard Deviation	Minimum	Maximum
Total final salary	82,212	9,691	64,528	113,603
HHI	0.124	0.112	0.033	1
Average district enrollment	7,264	3,361	260	10,441
Median income	25,681	4,230	9,488	30,088
Percent households with school aged children	0.285	0.014	0.23	0.307
Percent population over age 65	0.111	0.021	0.085	0.226
Percent adults with high school degree only	0.6	0.068	0.488	0.701
Percent adults with at least bachelor's degree	0.27	0.088	0.122	0.44
Unemployment rate	5.909	1.628	1.6	11.9
Comparable wage index	1.114	0.147	0.766	1.387
Metropolitan area	0.649	0.477	0	1
1997-1998 school year	0.089	0.285	0	1
1998-1999 school year	0.091	0.288	0	1
1999-2000 school year	0.104	0.305	0	1
2000-2001 school year	0.112	0.316	0	1
2001-2002 school year	0.115	0.319	0	1
2002-2003 school year	0.119	0.324	0	1
2003-2004 school year	0.119	0.324	0	1
2004-2005 school year	0.126	0.331	0	1
2005-2006 school year	0.125	0.331	0	1
Small district	0.022	0.148	0	1
Medium district	0.395	0.489	0	1
Percent low income students	0.214	0.214	0	0.972
Percent migrant students	0.008	0.043	0	0.539

TABLE 2.—DESCRIPTIVE STATISTICS, PRINCIPAL CATEGORY (MULTIPLE PAGES)

Variable	Mean	Standard Deviation	Minimum	Maximum
Percent Hispanic students	0.104	0.14	0	0.946
Percent black students	0.064	0.074	0	0.25
Distance from major metropolitan areas	22.2	16.4	1.6	128
Years of experience	19.5	8.2	0	46.5
Bachelor's degree	0.027	0.163	0	1
Master's degree	0.93	0.256	0	1
Doctorate degree	0.042	0.201	0	1
Special Education	0.014	0.116	0	1
Certified contracted time in major duty	0.971	0.129	0	1
Asian	0.029	0.169	0	1
Black	0.056	0.23	0	1
Hispanic	0.028	0.164	0	1
Indian	0.013	0.112	0	1
Female	0.486	0.5	0	1
New in district	0.071	0.257	0	1
High school	0.098	0.298	0	1

Number of observations = 15,524

We can write the specification for each personnel category as:

$$\begin{aligned}\ln(W_{idmt}) = \alpha_1 H_{mt} + \alpha_2 H_{mt}^2 + \alpha_{3j} Z'_{mt} + \alpha_4 w_{mt}^o + \alpha_5 U_{mt} + \alpha_{6k} D'_{dt} \\ + \alpha_{7l} P'_{it} + \varepsilon_{idmt}\end{aligned} \tag{15}$$

where the dependent variable is the natural logarithm of the current total final salary of the individual i at the school district d in the education market m in the school year t. D is a vector of district-specific variables, P is a vector of personnel-specific variables, ε_{idmt} is the error term, and $\alpha = (\alpha_1, \alpha_2, \alpha_{3j}, \alpha_4, \alpha_5, \alpha_{6k}, \alpha_{7l})$ is the parameter vector to be estimated.

2.4. Regression Results

Since the variables in Z vector, Herfindahl index, unemployment rate, and comparable wage index do not change within the education markets, I correct the standard errors by stacking the observations in CBSA clusters and generating a CBSA cluster-robust covariance matrix estimator. Table 3 report the OLS estimation results of the model in (15). The estimation results with the teacher category illustrate that there is a significant relationship between the HHI and total teacher salaries, and the relationship is of nonlinear pattern for both of the personnel categories. That is, when the concentration in the education market is low, the salaries of the personnel decrease as competition in the education market decreases, but when the concentration is high, the salaries of the personnel increase as competition in the education market decreases. The estimation results with the principal category, on the other hand, show no significant relationship between the HHI and total principal salaries. The local minimums of the wages with respect to the HHI are different for different personnel: For teachers, the salaries increase with concentration if HHI exceeds 0.35. On the other hand, for principal, the salaries begin to increase with concentration once HHI is more than 0.68, but the test for joint significance of HHI terms rejects such a relationship.

TABLE 3.—LINEAR ESTIMATION OF THE MAIN SPECIFICATION (MULTIPLE PAGES)

	Teacher	Principal
HHI	-0.157*** (0.041)	-0.089 (0.062)
HHI, squared	0.222*** (0.065)	0.066 (0.054)
Average district enrollment	0.004 (0.006)	0.024*** (0.007)
log(Median income)	-0.046** (0.017)	-0.034 (0.029)
Percent households with school aged children	-0.036 (0.213)	0.231 (0.261)
Percent population over age 65	0.065 (0.118)	0.332* (0.180)
Percent adults with high school degree only	0.251*** (0.084)	0.157 (0.113)
Percent adults with at least bachelor's degree	0.059 (0.057)	0.162* (0.083)
Unemployment rate	-0.002 (0.001)	0.002 (0.003)
Comparable wage index	0.173*** (0.061)	-0.000 (0.068)
Metropolitan area	0.009 (0.005)	0.018** (0.008)
1997-1998 school year	7.973*** (0.151)	8.496*** (0.281)
1998-1999 school year	7.968*** (0.151)	8.510*** (0.280)
1999-2000 school year	8.008*** (0.152)	8.546*** (0.280)
2000-2001 school year	8.024*** (0.152)	8.580*** (0.276)
2001-2002 school year	8.045*** (0.154)	8.624*** (0.273)
2002-2003 school year	8.070*** (0.153)	8.660*** (0.273)
2003-2004 school year	8.074*** (0.152)	8.668*** (0.273)
2004-2005 school year	8.074*** (0.151)	8.684*** (0.273)

TABLE 3.—LINEAR ESTIMATION OF THE MAIN SPECIFICATION (MULTIPLE PAGES)

	Teacher	Principal
2005-2006 school year	8.082*** (0.150)	8.716*** (0.272)
Small district	-0.043*** (0.005)	-0.099*** (0.010)
Medium district	-0.022*** (0.003)	-0.040*** (0.006)
Percent low income students	0.013 (0.014)	-0.029 (0.021)
Percent migrant students	0.011 (0.013)	0.023 (0.015)
Percent Hispanic students	0.036** (0.016)	0.032 (0.038)
Percent black students	-0.100*** (0.029)	0.045* (0.026)
log(Distance from major metropolitan areas)	-0.005 (0.005)	-0.006 (0.005)
Years of experience	0.038*** (0.001)	0.005*** (0.000)
Years of experience, squared	-0.001*** (0.000)	-0.000*** (0.000)
Bachelor’s degree	-0.048*** (0.005)	-0.021 (0.029)
Master’s degree	0.058*** (0.004)	-0.002 (0.026)
Doctorate degree	0.074*** (0.009)	0.033 (0.028)
Special Education	-0.011*** (0.001)	-0.020* (0.011)
Certified contracted time in major duty	0.014*** (0.002)	0.047*** (0.011)
Asian	0.007*** (0.001)	0.007 (0.005)
Black	-0.002 (0.003)	0.002 (0.001)
Hispanic	-0.006*** (0.002)	0.001 (0.004)
Indian	-0.002 (0.005)	-0.012 (0.010)

TABLE 3.—LINEAR ESTIMATION OF THE MAIN SPECIFICATION (MULTIPLE PAGES)

	Teacher	Principal
Female	-0.027***	-0.012***
	(0.002)	(0.002)
New in district	-0.022***	-0.019***
	(0.001)	(0.002)
High school	0.019***	-0.012**
	(0.002)	(0.005)
Observations	276,795	15,524
R^2	0.9998	0.9999
$\alpha_1 = 0 \ and \ \alpha_2 = 0$	p = 0.0023	p = 0.3602
$\alpha_1 + \alpha_2 = 0$	p = 0.0484	p = 0.3715

Note: The dependent variable is log(Total final salary). Standard errors are in parentheses. Triple asterisk (***) means significance at the 1% level. Double asterisk (**) means significance at the 5% level. Single asterisk (*) means significance at the 10% level.

The existence of the nonlinear relationship between competition and personnel salaries indicates that there are multiple forces shaping the pattern. As I discussed before, oligopsony power of the school districts would pull down the salaries of the personnel, while the rent-sharing and the power of the unions would increase the wages. The results indicate that the oligopsony effect dominates the rent-sharing and union power effects in relatively less concentrated education markets. In relatively less competitive markets, however, rent-sharing and union power effects dominate the oligopsony effect. Taylor (2010) finds that the HHI at which teacher salaries start increasing is 0.54 in Texas. In Washington, however, I find the local minimum to be at 0.35. Texas is a right-to-work state, but Washington is a union state. The difference between these two states can be attributed to the increase in the teachers' bargaining power due to unionization.

In order to have a better understanding of the effects of HHI on school district personnel wages, I handle the endogeneity problem due to the simultaneity of HHI and wages. In order to alleviate the endogeneity problem, instruments such as those presented in Hoxby (2000) can be used. Hoxby explains that streams played an important role in the delineation of the school district boundaries in the eighteen and nineteen centuries and hence these natural boundaries are key determinants of supply of school districts even though they are not limiting the student transportation today. In a comment, Rothstein (2007) offers alternative categories of streams grouped into two different size categories as instruments. I follow Hoxby and Rothstein and use the U.S. Geological Survey (USGS) Geographic Names Information System (GNIS) data to create two categories of streams based on the length of the streams defining streams longer than 3.5 miles as large, and others as small.[6] I consider using the counts of the two different types of streams in a district's county as two separate instruments for our endogenous concentration measure.

Other than these two instrumental variables, I use the land area of the education market and the total enrollment per square mile in the education market as instrumental variables for the HHI. These instruments would capture the profit potential of the education markets, which is explored in Grosskopf, Hayes and Taylor (2004). I measure the total enrollment per square mile in the education market with a one year lag in order

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[6] The data I use is the one Rothstein mentions in his comment as the "alternative version of GNIS data" which includes coordinates of two points for each stream in each county: one of the points is the origin where that stream starts traversing that county, and the other point is the destination where that stream ends traversing that county. The length between these two points is calculated by using the haversine formula.

to ensure its exogeneity to the current school year. Summary statistics of all of the instrumental variables I employ are presented in Table 4.

TABLE 4.—DESCRIPTIVE STATISTICS OF THE INSTRUMENTAL VARIABLES

Variable	Mean	Standard Deviation	Minimum	Maximum
Teacher Category				
Count of small streams in the district's county	140.5	91.8	0	379
Count of large streams in the district's county	65.8	36.5	0	226
Total land area of the education market	3,887.9	2,112.9	174.9	5,894.0
Total enrollment per square mile in the market	59.72	37.16	0.48	116.93
Number of observations = 276,795				
Principal Category				
Count of small streams in the district's county	145.2	88.3	0	379
Count of large streams in the district's county	66.6	33.2	0	226
Total land area of the education market	4,040.3	2,112.6	174.9	5,894.0
Total enrollment per square mile in the market	62.77	35.97	0.48	116.93
Number of observations = 15,524				

The first and second columns of Table 5 report the two-stage least squares (2SLS) estimation results of the model in (15). The endogeneity test statistic is 17.314 for the HHI and its square—the two potentially endogenous regressors—in the teacher column, and 17.263 in the principal column. The probability of the exogeneity of the regressors is equal to 0.0002 in both cases. Hence, the test shows that the HHI and its square need to be treated as endogenous. The Partial R^2 of Shea (1997) is 0.2434 for the

HHI and 0.0733 for the squared HHI indicating that both of the endogenous regressors are not weakly identified. Still, I also test the relevance of potentially endogenous regressors with Anderson and Rubin (1949) and Stock and Wright (2000) tests which are robust in the presence of weak instruments. The tests reject the null hypothesis suggesting that endogenous regressors are not irrelevant. Finally, Hansen's J statistic is 26.171 so the test does not reject the joint null hypothesis that the instruments for HHI and its square are valid.

According to the 2SLS results, teachers' salaries begin to increase with concentration at a relatively similar level of HHI at 0.36. This would mean that the bargaining power of the teachers union in Washington is about the same as that in the OLS estimation results. On the other hand, 2SLS results indicate that principals' salaries begin to increase by concentration if concentration is more than 0.23. This finding is significantly different than the corresponding finding in the OLS estimation. Here, we see that principals may have significantly more bargaining power than what is suggested by the OLS results. Moreover, since 0.23 is smaller than 0.36, the inference is that the principals union may actually have relatively more bargaining power than the teachers union in Washington, or that the number of available principals in the market is significantly smaller than the number of teachers, which may give the principals relatively more bargaining power. It should also be noted that the results show that other variables being constant, the salaries of both teachers and principals are greater in a perfectly concentrated market than in a perfectly competitive market.

TABLE 5.—IV AND GMM ESTIMATIONS OF THE MAIN SPECIFICATION (MULTIPLE PAGES)

	2SLS		GMM	
	Teacher	Principal	Teacher	Principal
HHI	-0.208***	-0.193***	-0.172***	-0.187***
	(0.032)	(0.046)	(0.030)	(0.046)
HHI, squared	0.289***	0.416***	0.316***	0.420***
	(0.066)	(0.117)	(0.066)	(0.116)
Average district enrollment	0.003	0.027***	0.010***	0.028***
	(0.003)	(0.004)	(0.002)	(0.003)
log(Median income)	-0.044***	-0.051***	-0.057***	-0.056***
	(0.011)	(0.019)	(0.010)	(0.018)
Percent households with school aged children	-0.039	0.400**	-0.132	0.381**
	(0.104)	(0.162)	(0.102)	(0.160)
Percent population over age 65	0.057	0.366***	0.042	0.374***
	(0.058)	(0.098)	(0.058)	(0.097)
Percent adults with high school degree only	0.270***	0.185***	0.223***	0.188***
	(0.045)	(0.062)	(0.043)	(0.062)
Percent adults with at least bachelor’s degree	0.073**	0.226***	0.075**	0.230***
	(0.031)	(0.051)	(0.031)	(0.051)
Unemployment rate	-0.002	0.005**	-0.000	0.006***
	(0.001)	(0.002)	(0.001)	(0.002)
Comparable wage index	0.161***	0.028	0.136***	0.042
	(0.028)	(0.043)	(0.028)	(0.040)
Metropolitan area	0.005	0.016***	0.012***	0.017***
	(0.003)	(0.005)	(0.003)	(0.005)
1997-1998 school year	7.975***	8.527***	8.094***	8.550***
	(0.073)	(0.142)	(0.067)	(0.138)
1998-1999 school year	7.971***	8.541***	8.091***	8.563***
	(0.072)	(0.141)	(0.067)	(0.138)
1999-2000 school year	8.011***	8.575***	8.134***	8.597***
	(0.072)	(0.140)	(0.066)	(0.137)
2000-2001 school year	8.028***	8.603***	8.155***	8.624***
	(0.072)	(0.137)	(0.065)	(0.135)
2001-2002 school year	8.049***	8.640***	8.176***	8.659***
	(0.071)	(0.135)	(0.065)	(0.133)
2002-2003 school year	8.075***	8.671***	8.205***	8.689***
	(0.070)	(0.134)	(0.063)	(0.132)
2003-2004 school year	8.080***	8.678***	8.209***	8.696***
	(0.069)	(0.134)	(0.063)	(0.132)
2004-2005 school year	8.080***	8.695***	8.210***	8.713***
	(0.069)	(0.133)	(0.062)	(0.130)

TABLE 5.—IV AND GMM ESTIMATIONS OF THE MAIN SPECIFICATION (MULTIPLE PAGES)

	2SLS		GMM	
	Teacher	Principal	Teacher	Principal
2005-2006 school year	8.089*** (0.069)	8.729*** (0.131)	8.216*** (0.062)	8.746*** (0.129)
Small district	-0.044*** (0.003)	-0.102*** (0.006)	-0.044*** (0.003)	-0.100*** (0.006)
Medium district	-0.022*** (0.002)	-0.039*** (0.003)	-0.023*** (0.002)	-0.039*** (0.003)
Percent low income students	0.012 (0.010)	-0.023 (0.015)	0.002 (0.010)	-0.022 (0.015)
Percent migrant students	0.012 (0.022)	0.034 (0.029)	0.029 (0.022)	0.034 (0.028)
Percent Hispanic students	0.039*** (0.010)	0.025 (0.019)	0.026*** (0.008)	0.023 (0.019)
Percent black students	-0.106*** (0.020)	0.036 (0.032)	-0.114*** (0.020)	0.036 (0.032)
log(Distance from major metropolitan areas)	-0.005** (0.002)	-0.009*** (0.003)	-0.002 (0.002)	-0.009*** (0.003)
Years of experience	0.038*** (0.000)	0.005*** (0.001)	0.038*** (0.000)	0.005*** (0.001)
Years of experience, squared	-0.001*** (0.000)	-0.000*** (0.000)	-0.001*** (0.000)	-0.000*** (0.000)
Bachelor’s degree	-0.048*** (0.004)	-0.022 (0.021)	-0.053*** (0.003)	-0.023 (0.021)
Master’s degree	0.058*** (0.004)	-0.003 (0.020)	0.055*** (0.003)	-0.004 (0.020)
Doctorate degree	0.074*** (0.005)	0.033* (0.020)	0.065*** (0.005)	0.032 (0.020)
Special Education	-0.011*** (0.001)	-0.018** (0.007)	-0.012*** (0.001)	-0.018** (0.007)
Certified contracted time in major duty	0.014*** (0.002)	0.047*** (0.010)	0.013*** (0.002)	0.047*** (0.010)
Asian	0.007*** (0.002)	0.007** (0.003)	0.008*** (0.002)	0.008*** (0.003)
Black	-0.002 (0.002)	0.002 (0.002)	-0.004*** (0.002)	0.002 (0.002)
Hispanic	-0.006*** (0.001)	0.001 (0.003)	-0.006*** (0.001)	0.001 (0.003)
Indian	-0.002 (0.002)	-0.012** (0.006)	-0.004* (0.002)	-0.012** (0.006)

Table 5.—IV and GMM Estimations of the Main Specification (Multiple Pages)

	2SLS		GMM	
	Teacher	Principal	Teacher	Principal
Female	-0.027***	-0.013***	-0.029***	-0.013***
	(0.001)	(0.001)	(0.001)	(0.001)
New in district	-0.022***	-0.019***	-0.023***	-0.019***
	(0.001)	(0.003)	(0.001)	(0.003)
High school	0.019***	-0.013***	0.020***	-0.013***
	(0.001)	(0.003)	(0.001)	(0.003)
Observations	276,795	15,524	276,795	15,524
R^2	0.9998	0.9999	0.9998	0.9999
$\alpha_1 = 0 \; and \; \alpha_2 = 0$	p = 0.0000	p = 0.0002	p = 0.0000	p = 0.0002
$\alpha_1 + \alpha_2 = 0$	p = 0.0798	p = 0.0073	p = 0.0007	p = 0.0046

Note: The dependent variable is log(Total final salary). Standard errors are in parentheses. Triple asterisk (***) means significance at the 1% level. Double asterisk (**) means significance at the 5% level. Single asterisk (*) means significance at the 10% level.

Baum, Schaffer and Stillman (2003) explain that in the presence of arbitrary heteroskedasticity, the Generalized Method of Moments (GMM) estimator is more efficient than the standard IV estimator. I find that Pagan and Hall (1983) general test statistic rejects the null hypothesis of homoscedasticity. Therefore, I also estimate the second stage of the IV regression with GMM. The results from the second stage GMM regression are presented in the third and fourth columns of Table 5. As can be seen, according to the GMM estimation results, the HHI break point where teachers' wages start increasing with concentration is 0.27—lower than the break point level found with 2SLS. For the principals, GMM results verify the 2SLS finding that the break point is at 0.22. All in all, the GMM results, along with the OLS and 2SLS results, present that there is a u-shaped relationship between the salaries of teachers and principals, and the concentration of the education market. I found that the local minima of these u-shapes are at relatively lower concentration levels compared to the results of Taylor (2010), which is probably due to the personnel's increased bargaining power with the help of unions. Furthermore, I present that the break point concentration levels at which salaries start increasing with concentration are different for teachers and principals.

2.5. Sensitivity Analysis

The results presented in Table 3 and Table 5 may be sensitive to how competition in the education market is measured. The common approach in the literature is to use Herfindahl-Hirschman indices to measure the market concentration. However, different sets of potential competitors and the geographic definition of the market would change these indices, which, in turn, may change the coefficient estimates, signs and significance of the HHI variables in the regression.

First, the HHI used to generate the results in Table 3 and Table 5 assumes that public school districts and all of the private schools (ALL) belong to the set of potential competitors. This, however, may not be true if private schools are not direct competitors with the public school districts. Hence, measuring the HHI with only public schools (PUB) is one of the alternative approaches that I explore in this section.

Alternatively, the concentration measure may include approved private schools along with the public school districts (APR). In Washington, State Board of Education accepts applications from private schools to approve their standards of health, safety and education. That is, the approval of a private school may indicate that that school is a good substitute for public schools while other private schools which do not have any approval from the State Board of Education may not be considered so. So the potential market participants may include only the approved private schools along with the public schools districts.[7]

Furthermore, the assumption that the education markets are the CBSAs determined by the OMB may not be suitable. The OMB has certain guidelines based on urban core populations to determine the CBSAs. However, these guidelines do not necessarily delineate the education markets. Several alternative assumptions about the borders of the education markets can be made which would result in a completely different set of education markets. For instance, one equally plausible assumption can be that counties, instead of the CBSAs, are the separate education markets. This assumption would increase the number of education markets in a state, and would generate different concentration ratios for the counties within a CBSA.

It is also possible to define the district-specific markets by the spatial distribution of the competitors. Simple geometrical shapes such as circles around schools in a district can be used to delineate the relevant education markets for that district. In order to calculate the HHI with such a market definition, I assume that the relevant geographic market for each school district includes all of the districts with at least one school within a 15-mile radius circle (R15) around each of the district's own schools. Figure 1 illustrates this method. In the figure, rectangles represent school districts, and black spots represent schools. There are three schools in the district with the star. When circles of

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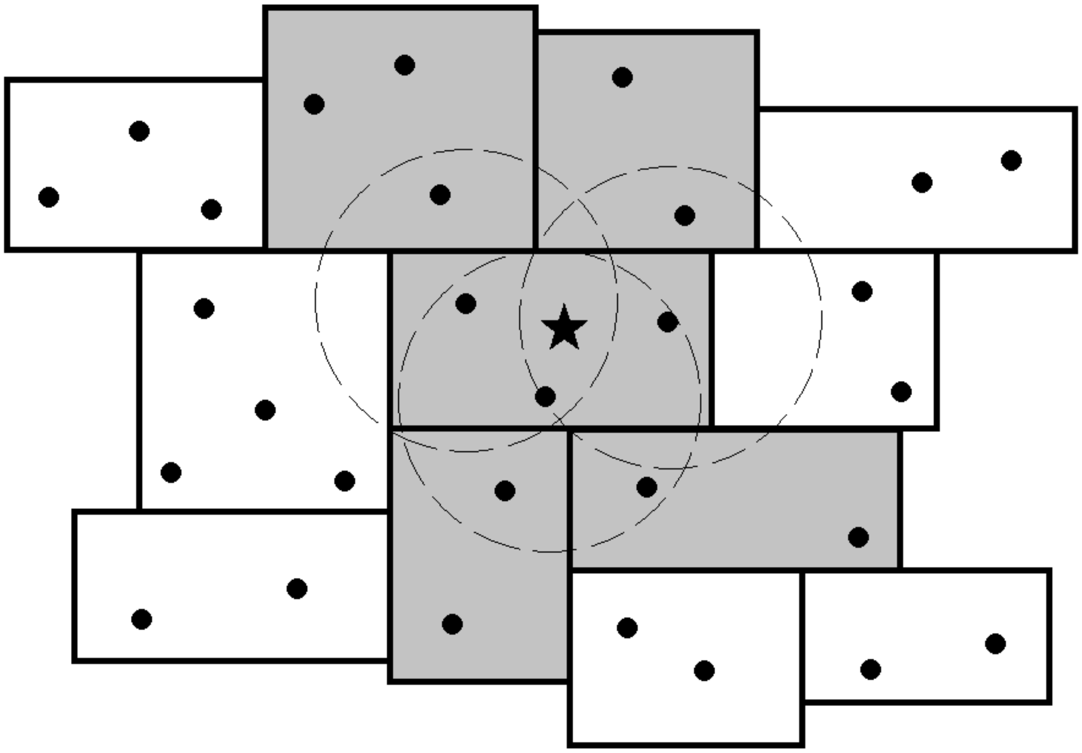
[7] Out of 594 private schools in 2011-2012 school year, 379 are approved by the Washington State Board of Education. Total private enrollment is 72,629. Enrollment in approved private schools: 57,268 which corresponds to %79 of the total private enrollment.

the specified radius are drawn around those schools, we see that four other districts surrounding the star district have schools in those circles. Those districts along with the star district are shaded in gray which represents the education market for the star district. Of course, 15-mile radius is arbitrarily chosen. In order to check the sensitivity on the measure with respect to the size of the radius, I generate two other indices with 25-mile radius (R25), and 50-mile radius (R50) criteria.

FIGURE 1.—THE DETERMINATION OF THE EDUCATION MARKETS WITH THE RADIAL METHOD



Finally, I explore the possibility of the rings in education markets, in which the schools at the outer rings contribute to the competition in the education market less than the schools at the core. This would somehow incorporate the distance between the competitors to the concentration measure. In a sense, rings measure is similar to the radial measure of competition that I assume that the relevant core for each school district includes all of the districts with at least one school within a 15-mile radius circle around each of the district's own schools. In addition to that, however, I also assume that the relevant periphery for each school district includes all of the districts with at least one school within a ring formed by a 15- mile radius and a 50-mile radius circle around each of the district's own schools. I assume that the contribution of the districts in the periphery to the concentration index is by half of what would normally be counted in a Herfindahl index. Because of the peripheral contribution, the ring HHI of concentration for a district would always be smaller than (or in some cases equal to) the 15-mile radius HHI of concentration. Table 6 displays the pairwise correlations between the different HHIs presented in this section, and Table 7 reports their summary statistics.

TABLE 6.—PAIRWISE CORRELATIONS BETWEEN THE HHIs, WASHINGTON DATA

		a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p
HHI-CBSA-ALL	a	1.00															
HHI-R15-ALL	b	0.37	1.00														
HHI-R25-ALL	c	0.37	0.89	1.00													
HHI-R50-ALL	d	0.35	0.70	0.80	1.00												
HHI-County-ALL	e	0.85	0.33	0.32	0.27	1.00											
HHI-CBSA-PUB	f	0.99	0.35	0.36	0.35	0.84	1.00										
HHI-R15-PUB	g	0.39	0.94	0.86	0.78	0.35	0.38	1.00									
HHI-R25-PUB	h	0.38	0.80	0.89	0.87	0.33	0.38	0.89	1.00								
HHI-R50-PUB	i	0.34	0.60	0.69	0.92	0.26	0.35	0.72	0.87	1.00							
HHI-County-PUB	j	0.85	0.32	0.31	0.28	0.97	0.86	0.34	0.33	0.27	1.00						
HHI-CBSA-APR	k	0.99	0.36	0.37	0.35	0.85	0.99	0.38	0.38	0.35	0.86	1.00					
HHI-R15-APR	l	0.37	1.00	0.89	0.71	0.33	0.36	0.95	0.81	0.62	0.32	0.37	1.00				
HHI-R25-APR	m	0.38	0.88	0.99	0.83	0.33	0.37	0.86	0.91	0.73	0.32	0.38	0.89	1.00			
HHI-R50-APR	n	0.35	0.68	0.78	0.99	0.28	0.35	0.77	0.87	0.94	0.28	0.36	0.69	0.81	1.00		
HHI-County-APR	o	0.84	0.32	0.32	0.28	0.98	0.84	0.34	0.33	0.27	0.97	0.86	0.32	0.32	0.28	1.00	
HHI-Rings-ALL	p	0.38	0.98	0.92	0.81	0.33	0.37	0.96	0.86	0.71	0.33	0.38	0.99	0.92	0.79	0.33	1.00

Note: The tags following the HHI names denote the market definition and the set of competitors.

Table 7.—Descriptive Statistics of the HHIs, Washington Data

Variable	Mean	Standard Deviation	Minimum	Maximum
Teacher Category				
HHI (HHI-CBSA-ALL)	0.134	0.115	0.033	1
HHI-R15-ALL	0.059	0.114	0.007	1
HHI-R25-ALL	0.042	0.072	0.007	1
HHI-R50-ALL	0.023	0.034	0.007	0.642
HHI-County-ALL	0.177	0.116	0.069	1
HHI-CBSA-PUB	0.148	0.124	0.039	1
HHI-R15-PUB	0.071	0.125	0.01	1
HHI-R25-PUB	0.055	0.085	0.01	1
HHI-R50-PUB	0.036	0.048	0.012	0.728
HHI-County-PUB	0.196	0.123	0.09	1
HHI-CBSA-APR	0.136	0.116	0.033	1
HHI-R15-APR	0.06	0.115	0.007	1
HHI-R25-APR	0.044	0.074	0.007	1
HHI-R50-APR	0.024	0.037	0.008	0.67
HHI-County-APR	0.181	0.12	0.073	1
HHI-Rings-ALL	0.041	0.07	0.007	0.821
Number of observations = 276,795				
Principal Category				
HHI (HHI-CBSA-ALL)	0.124	0.112	0.033	1
HHI-R15-ALL	0.058	0.107	0.007	1
HHI-R25-ALL	0.042	0.07	0.007	0.983
HHI-R50-ALL	0.023	0.033	0.007	0.513
HHI-County-ALL	0.169	0.11	0.069	1
HHI-CBSA-PUB	0.138	0.122	0.039	1
HHI-R15-PUB	0.07	0.118	0.01	1
HHI-R25-PUB	0.055	0.084	0.01	1
HHI-R50-PUB	0.036	0.048	0.012	0.536
HHI-County-PUB	0.187	0.117	0.09	1
HHI-CBSA-APR	0.127	0.113	0.033	1
HHI-R15-APR	0.059	0.108	0.007	1
HHI-R25-APR	0.044	0.073	0.007	0.983
HHI-R50-APR	0.024	0.036	0.008	0.513
HHI-County-APR	0.173	0.113	0.073	1
HHI-Rings-ALL	0.04	0.066	0.007	0.757
Number of observations = 15,524				

Note: The tags following the HHI names denote the market definition and the set of competitors.

Table 8 through Table 15 present the GMM estimation results of the model in with different measures of competition. First, the results show that holding everything else constant, measuring the HHI with three different sets of competitors does not change the signs or significance of the results. For the teacher category, the location of the minimum wage with respect to the HHI is at HHI=0.29 in the HHI-CBSA-PUB column, and at HHI=0.27 in the HHI-CBSA-APR column. For the principal category, the location of the minimum wage with respect to the HHI is at HHI=0.24 in the HHI-CBSA-PUB column, and at HHI=0.22 in the HHI-CBSA-APR column. That is, the location of the local minimum with respect to HHI does not seem to change much as the sets of competitors used to measure the HHI change.

Secondly, employing different market definitions change the results. The results with the HHIs measured with the market defined as counties are somewhat similar to that with the market defined as CBSAs. Radial measures of the HHI present a non-linear relationship between personnel salaries and the HHI as well. The significance and the pattern of this relationship, however, are different than that when the market is defined as CBSAs, and they change as the size of the radius changes. To give an example, for the teacher category, the location of the minimum wage with respect to the HHI is at HHI=0.46 in the HHI-R15-ALL column and the HHI terms are jointly significant at the 1% level. In the HHI-R25-ALL column, however, teachers' minimum wage with respect to the HHI is at HHI=0.41 with a joint significance at the 10% level.

TABLE 8.—GMM ESTIMATION RESULTS WITH DIFFERENT HHIS – 1
(MULTIPLE PAGES)

	HHI-R15-ALL		HHI-R25-ALL	
	Teacher	Principal	Teacher	Principal
Specified HHI	-0.762***	-0.445	-1.620**	-0.937
	(0.235)	(0.283)	(0.699)	(0.719)
Specified HHI, squared	0.831***	0.908**	1.956**	2.216**
	(0.269)	(0.376)	(0.962)	(0.937)
Average district enrollment	-0.001	0.030***	-0.008	0.028***
	(0.006)	(0.007)	(0.010)	(0.009)
log(Median income)	0.020	0.014	0.072	0.019
	(0.034)	(0.057)	(0.065)	(0.080)
Percent households with school aged children	-0.274	0.322	-0.458	0.030
	(0.205)	(0.197)	(0.340)	(0.293)
Percent population over age 65	0.060	0.416***	-0.232	0.065
	(0.150)	(0.159)	(0.258)	(0.209)
Percent adults with high school degree only	-0.008	0.009	-0.090	-0.038
	(0.092)	(0.150)	(0.157)	(0.212)
Percent adults with at least bachelor’s degree	-0.227**	0.034	-0.350**	-0.034
	(0.092)	(0.157)	(0.166)	(0.243)
Unemployment rate	-0.008***	0.001	-0.011**	-0.003
	(0.003)	(0.004)	(0.005)	(0.006)
Comparable wage index	0.039	-0.072	-0.076	-0.161
	(0.067)	(0.093)	(0.145)	(0.146)
Metropolitan area	0.004	0.016*	-0.030	0.005
	(0.007)	(0.008)	(0.020)	(0.025)
1997-1998 school year	7.785***	8.130***	7.624***	8.367***
	(0.205)	(0.341)	(0.319)	(0.366)
1998-1999 school year	7.785***	8.146***	7.629***	8.387***
	(0.203)	(0.338)	(0.315)	(0.361)
1999-2000 school year	7.836***	8.187***	7.686***	8.432***
	(0.201)	(0.334)	(0.309)	(0.354)
2000-2001 school year	7.890***	8.221***	7.769***	8.480***
	(0.198)	(0.325)	(0.292)	(0.329)
2001-2002 school year	7.920***	8.272***	7.794***	8.537***
	(0.196)	(0.320)	(0.293)	(0.325)
2002-2003 school year	7.966***	8.316***	7.854***	8.591***
	(0.193)	(0.313)	(0.284)	(0.311)
2003-2004 school year	7.975***	8.325***	7.865***	8.605***
	(0.192)	(0.310)	(0.281)	(0.305)
2004-2005 school year	8.006***	8.350***	7.915***	8.638***
	(0.190)	(0.304)	(0.271)	(0.291)

TABLE 8.—GMM ESTIMATION RESULTS WITH DIFFERENT HHIS – 1
(MULTIPLE PAGES)

	HHI-R15-ALL		HHI-R25-ALL	
	Teacher	Principal	Teacher	Principal
2005-2006 school year	8.019***	8.386***	7.932***	8.676***
	(0.189)	(0.302)	(0.269)	(0.288)
Small district	-0.048***	-0.117***	-0.046***	-0.100***
	(0.006)	(0.013)	(0.007)	(0.008)
Medium district	-0.013***	-0.035***	-0.015***	-0.035***
	(0.004)	(0.004)	(0.005)	(0.004)
Percent low income students	0.012	-0.042**	0.043	-0.035
	(0.018)	(0.018)	(0.030)	(0.025)
Percent migrant students	0.091*	0.065	0.144	0.081
	(0.047)	(0.044)	(0.090)	(0.075)
Percent Hispanic students	0.003	0.039	-0.029	0.031
	(0.018)	(0.028)	(0.037)	(0.047)
Percent black students	-0.105***	0.030	-0.117***	0.023
	(0.021)	(0.034)	(0.030)	(0.038)
log(Distance from major metropolitan areas)	-0.001	-0.016***	0.004	-0.013*
	(0.006)	(0.006)	(0.008)	(0.008)
Years of experience	0.038***	0.005***	0.038***	0.005***
	(0.000)	(0.001)	(0.000)	(0.001)
Years of experience, squared	-0.001***	-0.000***	-0.001***	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
Bachelor’s degree	-0.049***	-0.020	-0.052***	-0.017
	(0.004)	(0.023)	(0.004)	(0.024)
Master’s degree	0.058***	-0.001	0.054***	0.001
	(0.004)	(0.022)	(0.004)	(0.022)
Doctorate degree	0.070***	0.033	0.068***	0.035
	(0.005)	(0.022)	(0.005)	(0.023)
Special Education	-0.010***	-0.017**	-0.010***	-0.022***
	(0.001)	(0.008)	(0.001)	(0.009)
Certified contracted time in major duty	0.017***	0.058***	0.016***	0.057***
	(0.002)	(0.012)	(0.002)	(0.011)
Asian	0.007***	0.005	0.007***	0.007***
	(0.002)	(0.003)	(0.002)	(0.003)
Black	-0.001	0.001	-0.000	0.001
	(0.002)	(0.002)	(0.002)	(0.002)
Hispanic	-0.007***	0.000	-0.006***	0.001
	(0.001)	(0.003)	(0.002)	(0.003)
Indian	-0.004	-0.015***	-0.003	-0.012**
	(0.003)	(0.005)	(0.003)	(0.005)

TABLE 8.—GMM ESTIMATION RESULTS WITH DIFFERENT HHIS – 1
(MULTIPLE PAGES)

	HHI-R15-ALL		HHI-R25-ALL	
	Teacher	Principal	Teacher	Principal
Female	-0.028***	-0.014***	-0.027***	-0.014***
	(0.001)	(0.001)	(0.001)	(0.001)
New in district	-0.020***	-0.020***	-0.020***	-0.020***
	(0.001)	(0.003)	(0.002)	(0.003)
High school	0.018***	-0.017***	0.018***	-0.012***
	(0.001)	(0.004)	(0.001)	(0.004)
Observations	276,795	15,524	276,795	15,524
R^2	0.9998	0.9999	0.9998	0.9999
$\alpha_1 = 0\ and\ \alpha_2 = 0$	p = 0.0040	p = 0.0237	p = 0.0671	p = 0.0352
$\alpha_1 + \alpha_2 = 0$	p = 0.6466	p = 0.0093	p = 0.5330	p = 0.0200

Note: The dependent variable is log(Total final salary). The tags following the HHI names denote the market definition and the set of competitors. Standard errors are in parentheses. Triple asterisk (***) means significance at the 1% level. Double asterisk (**) means significance at the 5% level. Single asterisk (*) means significance at the 10% level.

TABLE 9.—GMM ESTIMATION RESULTS WITH DIFFERENT HHIS – 2 (MULTIPLE PAGES)

	HHI-R50-ALL		HHI-County-ALL	
	Teacher	Principal	Teacher	Principal
Specified HHI	-3.824*	-1.669	-0.318***	-0.379***
	(2.157)	(1.130)	(0.066)	(0.091)
Specified HHI, squared	14.081	10.990	0.504***	0.582***
	(13.380)	(7.915)	(0.103)	(0.147)
Average district enrollment	0.007	0.031***	0.007***	0.023***
	(0.010)	(0.010)	(0.003)	(0.003)
log(Median income)	0.099	-0.011	-0.048***	-0.035*
	(0.080)	(0.045)	(0.012)	(0.019)
Percent households with school aged children	-0.230	0.279	0.044	0.665***
	(0.420)	(0.289)	(0.123)	(0.185)
Percent population over age 65	-0.315	0.141	0.096	0.450***
	(0.453)	(0.392)	(0.070)	(0.098)
Percent adults with high school degree only	-0.171	0.054	0.283***	0.285***
	(0.247)	(0.124)	(0.054)	(0.064)
Percent adults with at least bachelor’s degree	-0.274*	0.137	0.121***	0.287***
	(0.165)	(0.112)	(0.035)	(0.057)
Unemployment rate	-0.006	0.005	-0.000	0.005**
	(0.004)	(0.003)	(0.001)	(0.002)
Comparable wage index	-0.177	-0.078	0.108***	-0.028
	(0.206)	(0.108)	(0.033)	(0.042)
Metropolitan area	-0.046*	0.011	0.011***	0.014***
	(0.025)	(0.021)	(0.004)	(0.005)
1997-1998 school year	7.370***	8.357***	7.971***	8.322***
	(0.348)	(0.285)	(0.091)	(0.162)
1998-1999 school year	7.379***	8.375***	7.969***	8.337***
	(0.341)	(0.282)	(0.090)	(0.161)
1999-2000 school year	7.441***	8.414***	8.014***	8.374***
	(0.330)	(0.279)	(0.089)	(0.161)
2000-2001 school year	7.493***	8.450***	8.035***	8.408***
	(0.328)	(0.263)	(0.088)	(0.158)
2001-2002 school year	7.520***	8.491***	8.061***	8.452***
	(0.317)	(0.268)	(0.087)	(0.156)
2002-2003 school year	7.581***	8.529***	8.091***	8.487***
	(0.303)	(0.262)	(0.085)	(0.155)
2003-2004 school year	7.593***	8.541***	8.099***	8.497***
	(0.298)	(0.261)	(0.085)	(0.155)
2004-2005 school year	7.652***	8.571***	8.097***	8.514***
	(0.284)	(0.246)	(0.084)	(0.154)

TABLE 9.—GMM ESTIMATION RESULTS WITH DIFFERENT HHIS – 2
(MULTIPLE PAGES)

	HHI-R50-ALL		HHI-County-ALL	
	Teacher	Principal	Teacher	Principal
2005-2006 school year	7.672*** (0.274)	8.611*** (0.249)	8.105*** (0.084)	8.550*** (0.152)
Small district	-0.046** (0.020)	-0.100** (0.044)	-0.047*** (0.003)	-0.106*** (0.006)
Medium district	-0.020*** (0.007)	-0.037*** (0.005)	-0.024*** (0.002)	-0.040*** (0.003)
Percent low income students	0.038 (0.053)	-0.028 (0.050)	-0.007 (0.010)	-0.038*** (0.014)
Percent migrant students	0.137 (0.098)	0.039 (0.064)	0.033 (0.025)	0.037 (0.031)
Percent Hispanic students	-0.021 (0.032)	0.036 (0.041)	0.029*** (0.009)	0.041** (0.019)
Percent black students	-0.161*** (0.042)	0.034 (0.054)	-0.111*** (0.021)	0.055* (0.033)
log(Distance from major metropolitan areas)	-0.020 (0.022)	-0.013 (0.012)	-0.003 (0.002)	-0.008*** (0.003)
Years of experience	0.038*** (0.000)	0.005*** (0.001)	0.039*** (0.000)	0.005*** (0.001)
Years of experience, squared	-0.001*** (0.000)	-0.000** (0.000)	-0.001*** (0.000)	-0.000*** (0.000)
Bachelor’s degree	-0.050*** (0.004)	-0.021 (0.023)	-0.052*** (0.003)	-0.021 (0.021)
Master’s degree	0.055*** (0.005)	-0.001 (0.022)	0.055*** (0.003)	-0.002 (0.020)
Doctorate degree	0.071*** (0.006)	0.033 (0.023)	0.065*** (0.005)	0.036* (0.020)
Special Education	-0.010*** (0.001)	-0.018* (0.009)	-0.012*** (0.001)	-0.017** (0.008)
Certified contracted time in major duty	0.017*** (0.002)	0.057*** (0.013)	0.014*** (0.002)	0.046*** (0.010)
Asian	0.008*** (0.002)	0.008*** (0.003)	0.008*** (0.002)	0.006** (0.003)
Black	-0.000 (0.003)	0.001 (0.003)	-0.003* (0.002)	0.001 (0.002)
Hispanic	-0.005*** (0.002)	0.001 (0.003)	-0.006*** (0.001)	-0.001 (0.003)
Indian	-0.002 (0.015)	-0.013 (0.015)	-0.002 (0.002)	-0.011* (0.006)

TABLE 9.—GMM ESTIMATION RESULTS WITH DIFFERENT HHIS – 2
(MULTIPLE PAGES)

	HHI-R50-ALL		HHI-County-ALL	
	Teacher	Principal	Teacher	Principal
Female	-0.027***	-0.013***	-0.028***	-0.013***
	(0.001)	(0.003)	(0.001)	(0.001)
New in district	-0.021***	-0.019***	-0.023***	-0.019***
	(0.002)	(0.004)	(0.001)	(0.003)
High school	0.018***	-0.014	0.019***	-0.014***
	(0.001)	(0.009)	(0.001)	(0.003)
Observations	276,795	15,524	276,795	15,524
R^2	0.9998	0.9999	0.9998	0.9999
$\alpha_1 = 0 \ and \ \alpha_2 = 0$	p = 0.0329	p = 0.3153	p = 0.0000	p = 0.0001
$\alpha_1 + \alpha_2 = 0$	p = 0.3667	p = 0.1863	p = 0.0000	p = 0.0009

Note: The dependent variable is log(Total final salary). The tags following the HHI names denote the market definition and the set of competitors. Standard errors are in parentheses. Triple asterisk (***) means significance at the 1% level. Double asterisk (**) means significance at the 5% level. Single asterisk (*) means significance at the 10% level.

TABLE 10.—GMM ESTIMATION RESULTS WITH DIFFERENT HHIS – 3 (MULTIPLE PAGES)

	HHI-CBSA-PUB		HHI-R15-PUB	
	Teacher	Principal	Teacher	Principal
Specified HHI	-0.169***	-0.183***	-1.315***	-0.585*
	(0.029)	(0.044)	(0.416)	(0.309)
Specified HHI, squared	0.296***	0.381***	1.346***	1.006**
	(0.060)	(0.104)	(0.480)	(0.408)
Average district enrollment	0.010***	0.028***	-0.004	0.027***
	(0.002)	(0.003)	(0.008)	(0.006)
log(Median income)	-0.057***	-0.052***	0.086	0.042
	(0.010)	(0.017)	(0.060)	(0.061)
Percent households with school aged children	-0.127	0.375**	-0.134	0.224
	(0.100)	(0.156)	(0.370)	(0.223)
Percent population over age 65	0.031	0.354***	-0.040	0.364**
	(0.059)	(0.096)	(0.281)	(0.178)
Percent adults with high school degree only	0.226***	0.183***	-0.158	-0.015
	(0.043)	(0.062)	(0.158)	(0.151)
Percent adults with at least bachelor’s degree	0.079***	0.225***	-0.392***	-0.005
	(0.030)	(0.050)	(0.151)	(0.152)
Unemployment rate	0.000	0.006***	-0.012**	0.003
	(0.001)	(0.002)	(0.005)	(0.004)
Comparable wage index	0.135***	0.038	-0.078	-0.062
	(0.027)	(0.040)	(0.127)	(0.094)
Metropolitan area	0.012***	0.017***	-0.026*	0.007
	(0.003)	(0.004)	(0.016)	(0.013)
1997-1998 school year	8.086***	8.528***	7.450***	7.948***
	(0.065)	(0.139)	(0.358)	(0.379)
1998-1999 school year	8.082***	8.541***	7.455***	7.965***
	(0.065)	(0.139)	(0.355)	(0.377)
1999-2000 school year	8.126***	8.576***	7.512***	8.005***
	(0.064)	(0.138)	(0.350)	(0.372)
2000-2001 school year	8.146***	8.602***	7.580***	8.035***
	(0.063)	(0.136)	(0.345)	(0.367)
2001-2002 school year	8.167***	8.637***	7.617***	8.083***
	(0.062)	(0.134)	(0.341)	(0.362)
2002-2003 school year	8.195***	8.667***	7.681***	8.127***
	(0.061)	(0.133)	(0.334)	(0.355)
2003-2004 school year	8.200***	8.674***	7.696***	8.136***
	(0.060)	(0.133)	(0.332)	(0.353)
2004-2005 school year	8.201***	8.691***	7.748***	8.169***
	(0.060)	(0.132)	(0.325)	(0.346)

TABLE 10.—GMM ESTIMATION RESULTS WITH DIFFERENT HHIS – 3
(MULTIPLE PAGES)

	HHI-CBSA-PUB		HHI-R15-PUB	
	Teacher	Principal	Teacher	Principal
2005-2006 school year	8.207***	8.725***	7.767***	8.206***
	(0.060)	(0.130)	(0.323)	(0.344)
Small district	-0.044***	-0.101***	-0.041***	-0.112***
	(0.003)	(0.006)	(0.009)	(0.012)
Medium district	-0.023***	-0.039***	-0.005	-0.033***
	(0.002)	(0.003)	(0.008)	(0.005)
Percent low income students	0.004	-0.020	0.017	-0.041**
	(0.010)	(0.015)	(0.024)	(0.016)
Percent migrant students	0.029	0.036	0.199**	0.097*
	(0.022)	(0.028)	(0.096)	(0.053)
Percent Hispanic students	0.025***	0.021	-0.027	0.024
	(0.008)	(0.019)	(0.031)	(0.030)
Percent black students	-0.116***	0.035	-0.183***	0.011
	(0.019)	(0.032)	(0.038)	(0.035)
log(Distance from major metropolitan areas)	-0.002	-0.009***	-0.015	-0.024***
	(0.002)	(0.003)	(0.010)	(0.008)
Years of experience	0.038***	0.005***	0.038***	0.005***
	(0.000)	(0.001)	(0.000)	(0.001)
Years of experience, squared	-0.001***	-0.000***	-0.001***	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
Bachelor’s degree	-0.052***	-0.023	-0.049***	-0.018
	(0.003)	(0.021)	(0.004)	(0.024)
Master’s degree	0.055***	-0.004	0.056***	0.000
	(0.003)	(0.020)	(0.004)	(0.022)
Doctorate degree	0.066***	0.032	0.073***	0.034
	(0.005)	(0.020)	(0.005)	(0.023)
Special Education	-0.012***	-0.018**	-0.010***	-0.017**
	(0.001)	(0.007)	(0.001)	(0.008)
Certified contracted time in major duty	0.013***	0.047***	0.018***	0.057***
	(0.002)	(0.010)	(0.003)	(0.012)
Asian	0.008***	0.008***	0.006***	0.004
	(0.002)	(0.003)	(0.002)	(0.003)
Black	-0.004***	0.002	-0.000	0.001
	(0.001)	(0.002)	(0.002)	(0.002)
Hispanic	-0.006***	0.001	-0.005***	0.000
	(0.001)	(0.003)	(0.002)	(0.004)
Indian	-0.004*	-0.012**	-0.003	-0.013**
	(0.002)	(0.006)	(0.003)	(0.005)

TABLE 10.—GMM ESTIMATION RESULTS WITH DIFFERENT HHIS – 3
(MULTIPLE PAGES)

	HHI-CBSA-PUB		HHI-R15-PUB	
	Teacher	Principal	Teacher	Principal
Female	-0.029***	-0.013***	-0.027***	-0.014***
	(0.001)	(0.001)	(0.001)	(0.001)
New in district	-0.023***	-0.019***	-0.019***	-0.019***
	(0.001)	(0.003)	(0.002)	(0.003)
High school	0.020***	-0.013***	0.018***	-0.017***
	(0.001)	(0.003)	(0.001)	(0.004)
Observations	276,795	15,524	276,795	15,524
R^2	0.9998	0.9999	0.9998	0.9999
$\alpha_1 = 0 \ and \ \alpha_2 = 0$	p = 0.0000	p = 0.0002	p = 0.0067	p = 0.0305
$\alpha_1 + \alpha_2 = 0$	p = 0.0005	p = 0.0039	p = 0.8870	p = 0.0154

Note: The dependent variable is log(Total final salary). The tags following the HHI names denote the market definition and the set of competitors. Standard errors are in parentheses. Triple asterisk (***) means significance at the 1% level. Double asterisk (**) means significance at the 5% level. Single asterisk (*) means significance at the 10% level.

TABLE 11.—GMM ESTIMATION RESULTS WITH DIFFERENT HHIS – 4 (MULTIPLE PAGES)

	HHI-R25-PUB		HHI-R50-PUB	
	Teacher	Principal	Teacher	Principal
Specified HHI	-1.807**	-1.324*	-3.616***	-1.638**
	(0.714)	(0.715)	(1.240)	(0.717)
Specified HHI, squared	2.726**	2.454**	12.247**	7.559**
	(1.209)	(1.148)	(4.950)	(3.109)
Average district enrollment	0.004	0.031***	0.000	0.019**
	(0.007)	(0.007)	(0.008)	(0.009)
log(Median income)	0.106	0.077	0.129**	-0.004
	(0.070)	(0.084)	(0.063)	(0.037)
Percent households with school aged children	-0.422	-0.081	-0.348	0.081
	(0.406)	(0.365)	(0.364)	(0.218)
Percent population over age 65	-0.360	0.090	-0.437	0.087
	(0.328)	(0.277)	(0.312)	(0.283)
Percent adults with high school degree only	-0.122	-0.153	-0.141	0.020
	(0.170)	(0.211)	(0.165)	(0.091)
Percent adults with at least bachelor’s degree	-0.343**	-0.164	-0.297**	0.036
	(0.157)	(0.213)	(0.140)	(0.082)
Unemployment rate	-0.010*	-0.003	-0.004	0.004*
	(0.005)	(0.005)	(0.004)	(0.002)
Comparable wage index	-0.176	-0.226	-0.140	0.011
	(0.174)	(0.191)	(0.116)	(0.076)
Metropolitan area	-0.047**	-0.019	-0.036**	0.016
	(0.024)	(0.028)	(0.017)	(0.012)
1997-1998 school year	7.389***	7.990***	7.132***	8.428***
	(0.368)	(0.422)	(0.341)	(0.222)
1998-1999 school year	7.397***	8.014***	7.140***	8.443***
	(0.363)	(0.415)	(0.337)	(0.220)
1999-2000 school year	7.459***	8.062***	7.199***	8.475***
	(0.356)	(0.405)	(0.331)	(0.217)
2000-2001 school year	7.530***	8.123***	7.249***	8.514***
	(0.344)	(0.388)	(0.325)	(0.209)
2001-2002 school year	7.567***	8.181***	7.277***	8.550***
	(0.341)	(0.380)	(0.323)	(0.209)
2002-2003 school year	7.635***	8.243***	7.334***	8.586***
	(0.329)	(0.366)	(0.315)	(0.204)
2003-2004 school year	7.651***	8.262***	7.347***	8.596***
	(0.326)	(0.360)	(0.312)	(0.203)
2004-2005 school year	7.713***	8.313***	7.411***	8.629***
	(0.315)	(0.344)	(0.298)	(0.195)

TABLE 11.—GMM ESTIMATION RESULTS WITH DIFFERENT HHIS – 4
(MULTIPLE PAGES)

	HHI-R25-PUB		HHI-R50-PUB	
	Teacher	Principal	Teacher	Principal
2005-2006 school year	7.740*** (0.311)	8.356*** (0.339)	7.439*** (0.292)	8.664*** (0.193)
Small district	-0.042*** (0.009)	-0.097*** (0.010)	-0.048*** (0.009)	-0.095*** (0.016)
Medium district	-0.009 (0.007)	-0.031*** (0.006)	-0.014*** (0.005)	-0.037*** (0.004)
Percent low income students	0.021 (0.024)	-0.030 (0.021)	0.025 (0.025)	-0.020 (0.023)
Percent migrant students	0.169* (0.091)	0.121 (0.075)	0.153** (0.076)	0.083 (0.054)
Percent Hispanic students	-0.023 (0.029)	-0.003 (0.038)	-0.011 (0.021)	0.008 (0.026)
Percent black students	-0.193*** (0.048)	-0.011 (0.049)	-0.159*** (0.033)	0.048 (0.039)
log(Distance from major metropolitan areas)	-0.020** (0.009)	-0.020** (0.008)	-0.024*** (0.009)	-0.010* (0.005)
Years of experience	0.038*** (0.000)	0.005*** (0.001)	0.038*** (0.000)	0.005*** (0.001)
Years of experience, squared	-0.001*** (0.000)	-0.000*** (0.000)	-0.001*** (0.000)	-0.000*** (0.000)
Bachelor’s degree	-0.052*** (0.004)	-0.011 (0.025)	-0.049*** (0.004)	-0.020 (0.023)
Master’s degree	0.053*** (0.004)	0.005 (0.024)	0.056*** (0.004)	-0.002 (0.022)
Doctorate degree	0.070*** (0.005)	0.040* (0.024)	0.074*** (0.005)	0.035 (0.022)
Special Education	-0.010*** (0.001)	-0.022** (0.009)	-0.010*** (0.001)	-0.012 (0.009)
Certified contracted time in major duty	0.018*** (0.002)	0.053*** (0.012)	0.018*** (0.002)	0.053*** (0.011)
Asian	0.006*** (0.002)	0.005* (0.003)	0.007*** (0.002)	0.006** (0.003)
Black	-0.000 (0.002)	-0.000 (0.003)	-0.002 (0.002)	0.000 (0.003)
Hispanic	-0.004** (0.002)	0.001 (0.003)	-0.005*** (0.002)	0.001 (0.003)
Indian	-0.003 (0.003)	-0.009 (0.006)	-0.005 (0.006)	-0.017* (0.009)

TABLE 11.—GMM ESTIMATION RESULTS WITH DIFFERENT HHIS – 4 (MULTIPLE PAGES)

	HHI-R25-PUB		HHI-R50-PUB	
	Teacher	Principal	Teacher	Principal
Female	-0.027***	-0.014***	-0.027***	-0.013***
	(0.001)	(0.001)	(0.001)	(0.002)
New in district	-0.020***	-0.020***	-0.020***	-0.018***
	(0.002)	(0.003)	(0.002)	(0.003)
High school	0.018***	-0.011**	0.018***	-0.016***
	(0.001)	(0.004)	(0.001)	(0.005)
Observations	276,795	15,524	276,795	15,524
R^2	0.9998	0.9999	0.9998	0.9999
$\alpha_1 = 0 \; and \; \alpha_2 = 0$	p = 0.0384	p = 0.0869	p = 0.0031	p = 0.0519
$\alpha_1 + \alpha_2 = 0$	p = 0.1196	p = 0.0299	p = 0.0213	p = 0.0153

Note: The dependent variable is log(Total final salary). The tags following the HHI names denote the market definition and the set of competitors. Standard errors are in parentheses. Triple asterisk (***) means significance at the 1% level. Double asterisk (**) means significance at the 5% level. Single asterisk (*) means significance at the 10% level.

TABLE 12.—GMM ESTIMATION RESULTS WITH DIFFERENT HHIS – 5 (MULTIPLE PAGES)

	HHI-County-PUB		HHI-CBSA-APR	
	Teacher	Principal	Teacher	Principal
Specified HHI	-0.359*** (0.063)	-0.384*** (0.085)	-0.170*** (0.030)	-0.187*** (0.045)
Specified HHI, squared	0.520*** (0.093)	0.552*** (0.129)	0.314*** (0.065)	0.418*** (0.116)
Average district enrollment	0.007*** (0.003)	0.023*** (0.003)	0.010*** (0.002)	0.028*** (0.003)
log(Median income)	-0.042*** (0.011)	-0.029 (0.018)	-0.058*** (0.010)	-0.055*** (0.018)
Percent households with school aged children	0.090 (0.123)	0.668*** (0.179)	-0.129 (0.101)	0.386** (0.159)
Percent population over age 65	0.103 (0.071)	0.454*** (0.098)	0.042 (0.058)	0.374*** (0.097)
Percent adults with high school degree only	0.306*** (0.051)	0.279*** (0.060)	0.223*** (0.043)	0.187*** (0.062)
Percent adults with at least bachelor's degree	0.148*** (0.037)	0.303*** (0.054)	0.076** (0.031)	0.229*** (0.051)
Unemployment rate	-0.001 (0.001)	0.005** (0.002)	0.000 (0.001)	0.006*** (0.002)
Comparable wage index	0.088*** (0.032)	-0.045 (0.041)	0.137*** (0.028)	0.041 (0.040)
Metropolitan area	0.008** (0.004)	0.013*** (0.005)	0.012*** (0.003)	0.017*** (0.004)
1997-1998 school year	7.910*** (0.090)	8.288*** (0.157)	8.092*** (0.067)	8.546*** (0.138)
1998-1999 school year	7.910*** (0.089)	8.304*** (0.157)	8.089*** (0.067)	8.559*** (0.138)
1999-2000 school year	7.955*** (0.088)	8.343*** (0.156)	8.132*** (0.066)	8.593*** (0.137)
2000-2001 school year	7.977*** (0.088)	8.375*** (0.154)	8.153*** (0.065)	8.620*** (0.135)
2001-2002 school year	8.003*** (0.086)	8.419*** (0.152)	8.174*** (0.065)	8.655*** (0.133)
2002-2003 school year	8.035*** (0.085)	8.455*** (0.151)	8.202*** (0.063)	8.685*** (0.131)
2003-2004 school year	8.042*** (0.084)	8.465*** (0.151)	8.206*** (0.063)	8.691*** (0.131)
2004-2005 school year	8.045*** (0.084)	8.485*** (0.149)	8.208*** (0.062)	8.709*** (0.130)

Table 12.—GMM Estimation Results with Different HHIs – 5
(Multiple Pages)

	HHI-County-PUB		HHI-CBSA-APR	
	Teacher	Principal	Teacher	Principal
2005-2006 school year	8.052*** (0.083)	8.521*** (0.148)	8.213*** (0.062)	8.742*** (0.129)
Small district	-0.047*** (0.003)	-0.107*** (0.006)	-0.044*** (0.003)	-0.101*** (0.006)
Medium district	-0.024*** (0.002)	-0.040*** (0.003)	-0.023*** (0.002)	-0.039*** (0.003)
Percent low income students	-0.006 (0.010)	-0.034** (0.014)	0.002 (0.010)	-0.021 (0.015)
Percent migrant students	0.034 (0.024)	0.038 (0.030)	0.028 (0.022)	0.034 (0.028)
Percent Hispanic students	0.032*** (0.009)	0.039** (0.018)	0.026*** (0.008)	0.023 (0.019)
Percent black students	-0.118*** (0.019)	0.046 (0.032)	-0.115*** (0.020)	0.036 (0.032)
log(Distance from major metropolitan areas)	-0.004* (0.002)	-0.009*** (0.003)	-0.002 (0.002)	-0.009*** (0.003)
Years of experience	0.038*** (0.000)	0.005*** (0.001)	0.038*** (0.000)	0.005*** (0.001)
Years of experience, squared	-0.001*** (0.000)	-0.000*** (0.000)	-0.001*** (0.000)	-0.000*** (0.000)
Bachelor's degree	-0.052*** (0.003)	-0.021 (0.021)	-0.052*** (0.003)	-0.023 (0.021)
Master's degree	0.055*** (0.003)	-0.002 (0.020)	0.055*** (0.003)	-0.004 (0.020)
Doctorate degree	0.065*** (0.005)	0.035* (0.020)	0.065*** (0.005)	0.032 (0.020)
Special Education	-0.012*** (0.001)	-0.017** (0.007)	-0.012*** (0.001)	-0.018** (0.007)
Certified contracted time in major duty	0.013*** (0.002)	0.046*** (0.010)	0.013*** (0.002)	0.047*** (0.010)
Asian	0.007*** (0.002)	0.006** (0.003)	0.008*** (0.002)	0.008*** (0.003)
Black	-0.003* (0.002)	0.001 (0.002)	-0.004*** (0.001)	0.002 (0.002)
Hispanic	-0.007*** (0.001)	-0.001 (0.003)	-0.006*** (0.001)	0.001 (0.003)
Indian	-0.002 (0.002)	-0.011* (0.006)	-0.004* (0.002)	-0.012** (0.006)

TABLE 12.—GMM ESTIMATION RESULTS WITH DIFFERENT HHIS – 5 (MULTIPLE PAGES)

	HHI-County-PUB		HHI-CBSA-APR	
	Teacher	Principal	Teacher	Principal
Female	-0.028***	-0.013***	-0.029***	-0.013***
	(0.001)	(0.001)	(0.001)	(0.001)
New in district	-0.023***	-0.019***	-0.023***	-0.019***
	(0.001)	(0.003)	(0.001)	(0.003)
High school	0.019***	-0.014***	0.020***	-0.013***
	(0.001)	(0.003)	(0.001)	(0.003)
Observations	276,795	15,524	276,795	15,524
R^2	0.9998	0.9999	0.9998	0.9999
$\alpha_1 = 0 \; and \; \alpha_2 = 0$	p = 0.0000	p = 0.0000	p = 0.0000	p = 0.0002
$\alpha_1 + \alpha_2 = 0$	p = 0.0000	p = 0.0005	p = 0.0005	p = 0.0044

Note: The dependent variable is log(Total final salary). The tags following the HHI names denote the market definition and the set of competitors. Standard errors are in parentheses. Triple asterisk (***) means significance at the 1% level. Double asterisk (**) means significance at the 5% level. Single asterisk (*) means significance at the 10% level.

TABLE 13.—GMM ESTIMATION RESULTS WITH DIFFERENT HHIS – 6 (MULTIPLE PAGES)

	HHI-R15-APR		HHI-R25-APR	
	Teacher	Principal	Teacher	Principal
Specified HHI	-0.785***	-0.433	-1.806**	-1.026
	(0.244)	(0.273)	(0.767)	(0.716)
Specified HHI, squared	0.819***	0.885**	2.249**	2.320**
	(0.269)	(0.361)	(1.145)	(0.987)
Average district enrollment	-0.003	0.030***	-0.008	0.028***
	(0.007)	(0.007)	(0.010)	(0.009)
log(Median income)	0.028	0.015	0.104	0.033
	(0.036)	(0.058)	(0.076)	(0.086)
Percent households with school aged children	-0.305	0.303	-0.502	-0.013
	(0.220)	(0.197)	(0.398)	(0.326)
Percent population over age 65	0.011	0.407***	-0.324	0.036
	(0.167)	(0.157)	(0.310)	(0.226)
Percent adults with high school degree only	-0.004	0.016	-0.116	-0.058
	(0.093)	(0.145)	(0.177)	(0.211)
Percent adults with at least bachelor’s degree	-0.232**	0.038	-0.378**	-0.056
	(0.094)	(0.151)	(0.180)	(0.240)
Unemployment rate	-0.008***	0.001	-0.012**	-0.003
	(0.003)	(0.004)	(0.005)	(0.006)
Comparable wage index	0.027	-0.073	-0.152	-0.194
	(0.071)	(0.094)	(0.176)	(0.167)
Metropolitan area	-0.000	0.015	-0.043*	-0.000
	(0.008)	(0.009)	(0.024)	(0.027)
1997-1998 school year	7.745***	8.115***	7.448***	8.287***
	(0.212)	(0.345)	(0.378)	(0.401)
1998-1999 school year	7.746***	8.132***	7.456***	8.309***
	(0.211)	(0.342)	(0.372)	(0.394)
1999-2000 school year	7.797***	8.172***	7.517***	8.355***
	(0.209)	(0.338)	(0.365)	(0.387)
2000-2001 school year	7.854***	8.207***	7.606***	8.407***
	(0.204)	(0.328)	(0.346)	(0.360)
2001-2002 school year	7.884***	8.257***	7.632***	8.465***
	(0.203)	(0.324)	(0.346)	(0.356)
2002-2003 school year	7.932***	8.301***	7.701***	8.522***
	(0.199)	(0.316)	(0.334)	(0.340)
2003-2004 school year	7.941***	8.310***	7.713***	8.537***
	(0.198)	(0.313)	(0.331)	(0.334)
2004-2005 school year	7.975***	8.336***	7.769***	8.574***
	(0.195)	(0.307)	(0.319)	(0.318)

TABLE 13.—GMM ESTIMATION RESULTS WITH DIFFERENT HHIS – 6
(MULTIPLE PAGES)

	HHI-R15-APR		HHI-R25-APR	
	Teacher	Principal	Teacher	Principal
2005-2006 school year	7.987*** (0.194)	8.371*** (0.305)	7.790*** (0.316)	8.613*** (0.315)
Small district	-0.048*** (0.006)	-0.116*** (0.013)	-0.046*** (0.007)	-0.098*** (0.008)
Medium district	-0.012*** (0.005)	-0.035*** (0.004)	-0.014** (0.006)	-0.035*** (0.004)
Percent low income students	0.014 (0.018)	-0.042** (0.018)	0.047 (0.032)	-0.034 (0.024)
Percent migrant students	0.093* (0.050)	0.064 (0.043)	0.162* (0.098)	0.086 (0.072)
Percent Hispanic students	-0.000 (0.020)	0.040 (0.028)	-0.036 (0.041)	0.028 (0.046)
Percent black students	-0.108*** (0.022)	0.029 (0.034)	-0.135*** (0.035)	0.017 (0.040)
log(Distance from major metropolitan areas)	-0.001 (0.006)	-0.016*** (0.006)	0.001 (0.009)	-0.014* (0.007)
Years of experience	0.038*** (0.000)	0.005*** (0.001)	0.038*** (0.000)	0.005*** (0.001)
Years of experience, squared	-0.001*** (0.000)	-0.000*** (0.000)	-0.001*** (0.000)	-0.000*** (0.000)
Bachelor’s degree	-0.050*** (0.004)	-0.020 (0.023)	-0.052*** (0.004)	-0.015 (0.024)
Master’s degree	0.057*** (0.004)	-0.001 (0.022)	0.054*** (0.005)	0.002 (0.023)
Doctorate degree	0.070*** (0.005)	0.033 (0.022)	0.069*** (0.006)	0.037 (0.023)
Special Education	-0.010*** (0.001)	-0.017** (0.008)	-0.010*** (0.001)	-0.023*** (0.009)
Certified contracted time in major duty	0.017*** (0.002)	0.058*** (0.011)	0.017*** (0.002)	0.057*** (0.011)
Asian	0.007*** (0.002)	0.005 (0.003)	0.007*** (0.002)	0.007** (0.003)
Black	-0.001 (0.002)	0.001 (0.002)	0.000 (0.002)	0.001 (0.002)
Hispanic	-0.007*** (0.001)	0.000 (0.003)	-0.005*** (0.002)	0.000 (0.003)
Indian	-0.003 (0.003)	-0.015*** (0.005)	-0.003 (0.003)	-0.012** (0.005)

TABLE 13.—GMM ESTIMATION RESULTS WITH DIFFERENT HHIS – 6
(MULTIPLE PAGES)

	HHI-R15-APR		HHI-R25-APR	
	Teacher	Principal	Teacher	Principal
Female	-0.028***	-0.014***	-0.027***	-0.014***
	(0.001)	(0.001)	(0.001)	(0.001)
New in district	-0.020***	-0.020***	-0.020***	-0.020***
	(0.001)	(0.003)	(0.002)	(0.003)
High school	0.018***	-0.017***	0.018***	-0.012***
	(0.001)	(0.004)	(0.001)	(0.004)
Observations	276,795	15,524	276,795	15,524
R^2	0.9998	0.9999	0.9998	0.9999
$\alpha_1 = 0 \; and \; \alpha_2 = 0$	p = 0.0041	p = 0.0228	p = 0.0625	p = 0.0446
$\alpha_1 + \alpha_2 = 0$	p = 0.8324	p = 0.0097	p = 0.4969	p = 0.0254

Note: The dependent variable is log(Total final salary). The tags following the HHI names denote the market definition and the set of competitors. Standard errors are in parentheses. Triple asterisk (***) means significance at the 1% level. Double asterisk (**) means significance at the 5% level. Single asterisk (*) means significance at the 10% level.

TABLE 14.—GMM ESTIMATION RESULTS WITH DIFFERENT HHIS – 7 (MULTIPLE PAGES)

	HHI-R50-APR		HHI-County-APR	
	Teacher	Principal	Teacher	Principal
Specified HHI	-4.087*	-1.635	-0.307***	-0.364***
	(2.202)	(1.060)	(0.064)	(0.087)
Specified HHI, squared	15.762	10.185	0.478***	0.553***
	(12.089)	(6.295)	(0.099)	(0.140)
Average district enrollment	0.007	0.029***	0.007***	0.022***
	(0.010)	(0.009)	(0.003)	(0.003)
log(Median income)	0.131	-0.011	-0.043***	-0.028
	(0.093)	(0.044)	(0.012)	(0.019)
Percent households with school aged children	-0.163	0.322	0.048	0.660***
	(0.452)	(0.262)	(0.122)	(0.183)
Percent population over age 65	-0.390	0.135	0.092	0.438***
	(0.415)	(0.337)	(0.071)	(0.098)
Percent adults with high school degree only	-0.215	0.038	0.276***	0.272***
	(0.273)	(0.118)	(0.053)	(0.063)
Percent adults with at least bachelor’s degree	-0.296	0.130	0.117***	0.282***
	(0.184)	(0.092)	(0.036)	(0.056)
Unemployment rate	-0.005	0.006*	-0.001	0.005**
	(0.005)	(0.003)	(0.001)	(0.002)
Comparable wage index	-0.233	-0.069	0.101***	-0.042
	(0.221)	(0.108)	(0.032)	(0.042)
Metropolitan area	-0.053*	0.012	0.011***	0.014***
	(0.028)	(0.019)	(0.003)	(0.004)
1997-1998 school year	7.153***	8.369***	7.929***	8.279***
	(0.454)	(0.270)	(0.094)	(0.165)
1998-1999 school year	7.163***	8.386***	7.929***	8.296***
	(0.447)	(0.267)	(0.093)	(0.165)
1999-2000 school year	7.227***	8.424***	7.974***	8.333***
	(0.435)	(0.264)	(0.092)	(0.164)
2000-2001 school year	7.277***	8.459***	7.996***	8.368***
	(0.431)	(0.251)	(0.092)	(0.162)
2001-2002 school year	7.307***	8.501***	8.020***	8.411***
	(0.421)	(0.254)	(0.090)	(0.159)
2002-2003 school year	7.372***	8.538***	8.052***	8.447***
	(0.405)	(0.248)	(0.089)	(0.158)
2003-2004 school year	7.384***	8.548***	8.058***	8.457***
	(0.400)	(0.246)	(0.088)	(0.158)
2004-2005 school year	7.446***	8.578***	8.059***	8.476***
	(0.382)	(0.233)	(0.088)	(0.157)

TABLE 14.—GMM ESTIMATION RESULTS WITH DIFFERENT HHIS – 7
(MULTIPLE PAGES)

	HHI-R50-APR		HHI-County-APR	
	Teacher	Principal	Teacher	Principal
2005-2006 school year	7.472*** (0.370)	8.619*** (0.234)	8.068*** (0.087)	8.513*** (0.155)
Small district	-0.048*** (0.018)	-0.101*** (0.034)	-0.047*** (0.003)	-0.106*** (0.006)
Medium district	-0.018*** (0.007)	-0.037*** (0.004)	-0.024*** (0.002)	-0.040*** (0.003)
Percent low income students	0.032 (0.046)	-0.031 (0.039)	-0.005 (0.010)	-0.036** (0.014)
Percent migrant students	0.151 (0.106)	0.051 (0.061)	0.031 (0.025)	0.038 (0.031)
Percent Hispanic students	-0.016 (0.029)	0.034 (0.033)	0.028*** (0.009)	0.039** (0.018)
Percent black students	-0.167*** (0.043)	0.040 (0.048)	-0.116*** (0.020)	0.052 (0.033)
log(Distance from major metropolitan areas)	-0.026 (0.021)	-0.014 (0.010)	-0.003 (0.002)	-0.008*** (0.003)
Years of experience	0.038*** (0.000)	0.005*** (0.001)	0.038*** (0.000)	0.005*** (0.001)
Years of experience, squared	-0.001*** (0.000)	-0.000** (0.000)	-0.001*** (0.000)	-0.000*** (0.000)
Bachelor’s degree	-0.050*** (0.004)	-0.022 (0.023)	-0.052*** (0.003)	-0.020 (0.021)
Master’s degree	0.055*** (0.005)	-0.002 (0.022)	0.055*** (0.003)	-0.001 (0.020)
Doctorate degree	0.072*** (0.006)	0.032 (0.023)	0.065*** (0.005)	0.036* (0.020)
Special Education	-0.010*** (0.001)	-0.017* (0.009)	-0.012*** (0.001)	-0.017** (0.008)
Certified contracted time in major duty	0.017*** (0.002)	0.057*** (0.012)	0.014*** (0.002)	0.046*** (0.010)
Asian	0.007*** (0.002)	0.008*** (0.003)	0.008*** (0.002)	0.006** (0.003)
Black	-0.001 (0.002)	0.001 (0.003)	-0.003* (0.002)	0.001 (0.002)
Hispanic	-0.005*** (0.002)	0.001 (0.003)	-0.006*** (0.001)	-0.001 (0.003)
Indian	-0.004 (0.013)	-0.014 (0.012)	-0.002 (0.002)	-0.011* (0.006)

TABLE 14.—GMM ESTIMATION RESULTS WITH DIFFERENT HHIS – 7 (MULTIPLE PAGES)

	HHI-R50-APR		HHI-County-APR	
	Teacher	Principal	Teacher	Principal
Female	-0.027***	-0.013***	-0.028***	-0.013***
	(0.001)	(0.002)	(0.001)	(0.001)
New in district	-0.021***	-0.019***	-0.023***	-0.019***
	(0.002)	(0.003)	(0.001)	(0.003)
High school	0.017***	-0.015**	0.019***	-0.014***
	(0.001)	(0.008)	(0.001)	(0.003)
Observations	276,795	15,524	276,795	15,524
R^2	0.9998	0.9999	0.9998	0.9999
$\alpha_1 = 0\ and\ \alpha_2 = 0$	p = 0.0397	p = 0.2596	p = 0.0000	p = 0.0001
$\alpha_1 + \alpha_2 = 0$	p = 0.2426	p = 0.1135	p = 0.0000	p = 0.0010

Note: The dependent variable is log(Total final salary). The tags following the HHI names denote the market definition and the set of competitors. Standard errors are in parentheses. Triple asterisk (***) means significance at the 1% level. Double asterisk (**) means significance at the 5% level. Single asterisk (*) means significance at the 10% level.

TABLE 15.—GMM ESTIMATION RESULTS WITH DIFFERENT HHIS – 8 (MULTIPLE PAGES)

	HHI-Ring-ALL	
	Teacher	Principal
Specified HHI	-1.328*** (0.408)	-0.730* (0.444)
Specified HHI, squared	2.440*** (0.831)	2.723** (1.097)
Average district enrollment	-0.001 (0.006)	0.030*** (0.006)
log(Median income)	0.025 (0.034)	0.010 (0.053)
Percent households with school aged children	-0.339 (0.235)	0.287 (0.210)
Percent population over age 65	-0.117 (0.174)	0.219 (0.201)
Percent adults with high school degree only	-0.003 (0.088)	0.025 (0.139)
Percent adults with at least bachelor's degree	-0.212** (0.083)	0.073 (0.139)
Unemployment rate	-0.007** (0.003)	0.003 (0.003)
Comparable wage index	-0.004 (0.078)	-0.097 (0.103)
Metropolitan area	-0.005 (0.009)	0.016 (0.010)
1997-1998 school year	7.828*** (0.191)	8.220*** (0.290)
1998-1999 school year	7.830*** (0.189)	8.238*** (0.287)
1999-2000 school year	7.883*** (0.187)	8.280*** (0.283)
2000-2001 school year	7.937*** (0.182)	8.308*** (0.275)
2001-2002 school year	7.967*** (0.181)	8.362*** (0.270)
2002-2003 school year	8.016*** (0.178)	8.405*** (0.263)
2003-2004 school year	8.025*** (0.177)	8.415*** (0.260)
2004-2005 school year	8.062*** (0.174)	8.440*** (0.254)

TABLE 15.—GMM ESTIMATION RESULTS WITH DIFFERENT HHIS – 8 (MULTIPLE PAGES)

	HHI-Ring-ALL	
	Teacher	Principal
2005-2006 school year	8.078*** (0.173)	8.479*** (0.252)
Small district	-0.049*** (0.007)	-0.123*** (0.018)
Medium district	-0.013*** (0.004)	-0.035*** (0.004)
Percent low income students	0.013 (0.021)	-0.053** (0.024)
Percent migrant students	0.103* (0.053)	0.060 (0.046)
Percent Hispanic students	0.000 (0.021)	0.048 (0.030)
Percent black students	-0.118*** (0.023)	0.033 (0.035)
log(Distance from major metropolitan areas)	-0.007 (0.007)	-0.021** (0.008)
Years of experience	0.038*** (0.000)	0.005*** (0.001)
Years of experience, squared	-0.001*** (0.000)	-0.000*** (0.000)
Bachelor’s degree	-0.050*** (0.004)	-0.022 (0.023)
Master’s degree	0.057*** (0.004)	-0.003 (0.022)
Doctorate degree	0.070*** (0.005)	0.029 (0.022)
Special Education	-0.010*** (0.001)	-0.016** (0.008)
Certified contracted time in major duty	0.017*** (0.002)	0.057*** (0.011)
Asian	0.007*** (0.002)	0.005 (0.003)
Black	-0.001 (0.002)	0.001 (0.002)
Hispanic	-0.006*** (0.001)	0.000 (0.003)
Indian	-0.005* (0.003)	-0.018*** (0.007)

TABLE 15.—GMM ESTIMATION RESULTS WITH DIFFERENT HHIS – 8 (MULTIPLE PAGES)

	HHI-Ring-ALL	
	Teacher	Principal
Female	-0.028***	-0.014***
	(0.001)	(0.002)
New in district	-0.020***	-0.020***
	(0.001)	(0.003)
High school	0.018***	-0.019***
	(0.001)	(0.005)
Observations	276,795	15,524
R^2	0.9998	0.9999
$\alpha_1 = 0 \; and \; \alpha_2 = 0$	p = 0.0046	p = 0.0313
$\alpha_1 + \alpha_2 = 0$	p = 0.0400	p = 0.0085

Note: The dependent variable is log(Total final salary). The tags following the HHI names denote the market definition and the set of competitors. Standard errors are in parentheses. Triple asterisk (***) means significance at the 1% level. Double asterisk (**) means significance at the 5% level. Single asterisk (*) means significance at the 10% level.

Furthermore, when the markets are defined as rings, the results show that the teachers' salaries begin to increase with concentration at HHI=0.27 and the principals' salaries begin to increase with concentration at HHI=0.13. While most of the measures of concentration I explore indicate a significant non-linear relationship between the personnel salaries and the HHI, different HHIs result in different levels of HHIs where the minimum wage occurs. The results in Table 8 to Table 15 present that the salaries of teachers start increasing when concentration exceeds the HHI level somewhere in the [0.13, 0.49] range, and the salaries of principals start increasing when concentration exceeds the HHI level somewhere in the [0.08, 0.35] range.

In conclusion, the findings in Table 8 through Table 15 indicate that the significance and the pattern of the relationship between salaries and concentration are not too sensitive to adding the private schools in the set of competitors. Changing the definition of education markets, on the other hand, changes the significance and the pattern of the relationship significantly. Yet, most of the measures of concentration I employ validate the non-linear relationship between the salaries of the school personnel and the concentration in the education market. Moreover, almost all of the results in the tables imply that salaries of principals start increasing at a lower level of concentration compared to the level at which teachers' salaries start increasing. This, again, may be an indication of principals' relatively higher bargaining power.

2.6. Concluding Remarks

I summarize the major findings of my analysis of the relationship between competition and education personnel salaries in Washington as follows: First, I find that the relationship between wages and market concentration is of a nonlinear pattern for both of the personnel categories. I present that when the concentration in the education market is low, the salaries of the personnel decrease as competition in the education market decreases, but when the concentration is high, the salaries of the personnel increase as competition in the education market decreases. Secondly, when I control for the endogeneity of the concentration measure, my findings show that the nonlinear pattern of the relationship is significant. Furthermore, I report evidence that principals have more bargaining power over their salaries than teachers in Washington, that principals start getting positive returns from increasing concentration at lower levels of concentration (at around 0.225) than that of teachers (at around 0.315). I also compare the pattern of teacher salaries versus concentration in Washington with that in Texas (at around 0.54), and show that the inflection point in Washington is at lower levels of concentration. This finding can be attributed to Washington's being a union state versus Texas's being a right-to-work-state.

Additionally, I test the sensitivity of my analysis to using different measures of competition. My results indicate that the effects of competition on wages are robust to measuring the competition with different sets of competitors. On the other hand, I find that the effect of concentration on education personnel salaries is rather sensitive to using different definitions of the education markets. When the education markets are defined in different ways, the effect of concentration on wages is not significant in a few cases, or if the concentration effect is significant, the nonlinear relationship between wages and concentration distorts to some extent. All in all, however, I find that the teacher salaries start increasing when market concentration exceeds the HHI level somewhere in the [0.13, 0.49] range, and the principal salaries start increasing when concentration exceeds the HHI level somewhere in the [0.08, 0.35] range.

3. COMPETITION AND SCHOOL DISTRICT CONSOLIDATION[8]

3.1. Introduction to the School District Consolidation

The famous education report of the 1960s, better-known as Coleman Report (1966), warned the USA about issues within the education system. The study was commissioned by the U.S. Department of Education and funded by the U.S. Department of Commerce to identify problems in the education system and to promote solutions. The massive report highlighted the importance of student background and socioeconomic status in determining educational outcomes, while predicting the ever-growing tragedy of the malfunctioning education system in the USA today.

The report of former President Ronald Reagan's National Commission on Excellence in Education was a second landmark in the U.S. education history. The title of the report was "A Nation at Risk" (1983), and the focus of the report was mainly the failing of the American education system and the threat associated with persistent mediocrity. This was yet another effort to alert the American people about the defective education system.

45 years have passed since the Coleman Report, and 28 years since "A Nation at Risk" but not much has changed in the U.S. education system. Many people, families, students, teachers, administrators and public officials are not happy with the current performance of the U.S. elementary and secondary public schools. Debates and disagreement has been ongoing, but the dissatisfaction and disappointment have

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[8] Some parts of this chapter represent joint work with Timothy J. Gronberg, Dennis W. Jansen, and Lori L. Taylor.

remained. Most of the problems identified in the Coleman Report or in “A Nation at Risk” have not been addressed well; they have gotten even more complicated leaving the U.S. far behind other nations. Below is a summary of the current state of the U.S. education system:

1- The American Recovery and Reinvestment Act (2009) was announced on July 24, 2009 by President Barack Obama. The Race to the Top (R2T) program is a part of the act, which is designed to promote reforms in state and local district K-12 education by distributing additional funds from a $4.35 billion budget.

2- According to the 2009 Programme for International Student Assessment (PISA), the U.S. is ranked 30th in math, 23rd in science, and 17th in reading. If the ranking is restricted to OECD countries, the U.S. is ranked 22nd in math, 15th in science, and 13th in reading. On December 6, 2010, President Barack Obama referred to these rankings as “our generation’s Sputnik moment” when he was addressing a group of community college students in North Carolina about continued investments in education. He stated that “in the race for the future, America is in danger of falling behind.” He emphasized that the U.S. cannot afford to cut back on education but has to spend even more because “[education has] the biggest impact on our economic growth”. On the same day, the U.S. Secretary of Education Arne Duncan titled the findings of PISA 2009 as “an absolute wake-up call for America”, and underlined his urge to become more serious about investing in education.

3- The goal of former President George W. Bush’s “No Child Left Behind Act” (2001) is to have all of the students in every school in every state—including disadvantaged and special education students—reach the same state proficiency level in math and reading by 2014. After 10 years, however, Barack Obama gave a speech on March 14, 2011 at Kenmore Middle School in Virginia about No Child Left Behind Act's (NCLB) successes and failures, and he revealed that 4 out of 5 schools in the U.S. will be labeled as failing according to NCLB. He explained this astonishing number as a result of the improper method used by NCLB to measure accomplishment. He stated that 15 states have lowered their standards so that they could meet the target on time and not get penalized, which is yet another reflection of how the system is degraded. He expressed the necessity to fix NCLB, and stressed that the reforms will cost money.

4- President Barack Obama announced that a new version of NCLB will be coming by August, 2011. At this point, we can only speculate about the success of the reincarnation of NCLB. One thing is clear, however: if the new act gets passed, it will be costly. Nevertheless, President Barack Obama proclaimed that the unavoidable costs of education reforms will be confronted by excluding education spending from the five-year freeze on annual domestic spending.

It seems that education in the U.S. is still failing to perform to expectations. While parents turn to charter schools, private schools, home-schooling and other attempted solutions, the U.S. government is still spending hundreds of billions of dollars to solve the chronic problem. Resources per pupil have been increased and teacher-student ratios have declined. Vouchers and charters have been promoted to encourage more competition among schools, in the hope of generating incentives for schools to improve. The federal government has been pushing states and school districts to try performance-based pay for teachers.

In addition to these attempts, re-delineation of school districts through consolidation and/or deconsolidation has been attempted with the idea of improving the education system. School districts have been consolidated with the expectation of cost saving, with the savings used to increase educational quality. The benefits of consolidation are based on cost economies. Public school districts, however, are cost inefficient institutions by realization. Hence the benefits of public school district consolidation depend on the cost efficiency of the districts as well as on scale economies. Cost efficiency, in turn, may be a function of the level of competition in the education market. Since consolidation decreases the number of available school districts in an education market while increasing district size, said consolidation may also change the level of competition in the education market. If consolidation decreases the level of competition, some or all of the cost savings from scale economies may turn into wasteful expenditures or inefficiency. In some cases, the impact of a decrease in the level of competition due to consolidation of school districts may cause such inefficiency that the outcome of consolidation regarding costs is not economically desirable compared to the initial situation.

Most of the studies in the literature concentrate on scale economies. In this study, we examine the second impact what we call *the competitive effect*. We follow the guidelines presented in Gronberg, Jansen and Taylor (2011a) and use a stochastic cost frontier model to evaluate how a traditional public school district would be affected by competition in the education market. Our findings show that the competitive effect is important to understand the net effect of consolidation on the economic performance of school districts, especially the cost of education. We present results showing that increases in the concentration cause the estimated cost inefficiency to increase. That is, more competition in the education market results in more district cost efficiency. Consolidation, however, reduces competition and therefore reduces efficiency.

We check the sensitivity of our findings to various alternative measures of competition. We use several measures of competition all of which are versions of a Herfindahl index of market concentration. The indices are based on different definitions of the education market and different sets of competitors and all of the indices are designed to capture certain dimensions of competition. We find that our results about the relationship between competition and school district efficiency are robust to alternative measures of competition.

3.1.1. History of the School District Consolidation in the USA

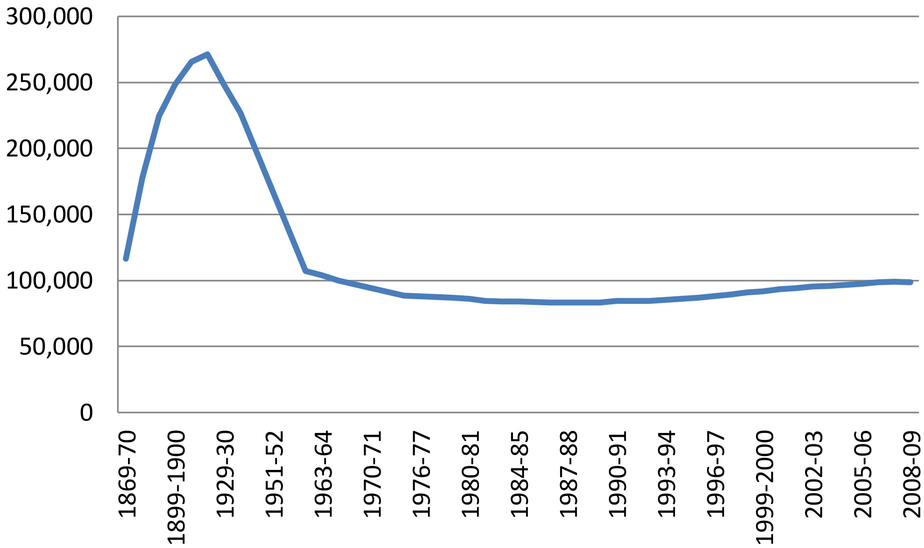
One of the most drastic changes in the public education system in the United States was the school district consolidation during the twentieth century. Tyack (1974) explains that traditionally, local school districts, which are the major division of American public education, were unofficial and unauthorized in organizational structure, and small in size. In the 1800s, the communities owned the rural schools. On many occasions, schools were the heart of the communities so that people considered them as their extended families. Nevertheless, the community schools were voluntary organizations, and therefore they were different than and incidental to the family. For example, attendance of the students shows a big discrepancy between two subsequent days or seasons because of the conditions of the weather, the degree of the need for workers at home, and the fondness or fright aroused by the teacher. As stated in Howell (2005), towards the end of the nineteenth century, more and more people started noticing the problems in the public education system. Finally, starting in the 1890s and increasing the impetus in the early 1900s, the reformers organized a confrontation with the rural education problem. They considered random assignment, assortment and administration of the teachers, control and regulation problems, and voluntary school attendance, and curriculum, equipment and building problems, as indicators of much more complicated problems. For the most part, what was not working in this education system was that country people operated their schools without knowing what would be suitable for their evolving society. (Tyack, 1974)

The progress of school district consolidation is only a component of a bigger movement on the way to the professionalization of education which started in the late nineteenth century. The administrative progressives of the period viewed the concentration of power over education in the hands of experts as a treatment for the parochialism of rural education organizations and the corruption of urban education structures. First, the cities started to consolidate schools and districts to change the political education systems into professional education systems. Rural areas followed cities in consolidation movement to transform their retrogressive school systems to efficient institutions. Consolidation, of course, meant larger schools, which actually was the main aim of the reform in education. Ellwood P. Cubberley (1919), who was the most important education reformist of the period, advocated three key claims supportive of school district consolidation. Firstly, the ratio of school officials and administrators to teachers was needlessly high in small schools. According to Cubberley, larger schools allocated the administration more efficiently. Secondly, consolidation would allow specialization by separating children with respect to their grades. While teachers in small schools had to be good at every grade and subject, teachers in larger schools would be able to specialize by grades and subjects. Moreover, larger schools would let students concentrate in different fields by offering specialized training to them. Finally, consolidation can make superior services and amenities available at lower cost. Overall, according to Cubberley and the other progressive colleagues, consolidation was promising economies of scale in management, education, and amenities.

The number of schools districts and schools in the U.S. started to decrease sharply in the beginning of 1920s, which reflects the victory of Cubberley and the other reformists. Until the 1930s, most of the local school districts were controlling no more than two small schools. However, from 1939 to 1984, the number of school districts decreased from 117,108 to 15,747, through a fast evolution in the direction of professionalization and centralization. In other words, consolidation eliminated more than 90 percent of the school districts that had survived until the 1930s. In the same era, the number of public schools decreased from 226,762 to 84,178, more than a 60 percent decrease, and total enrollment in elementary and secondary public schools increased roughly from 25 million to 40 million, a 60 percent increase. (U.S. Department of Education, National Center for Education Statistics, Digest of Education Statistics, 2010)

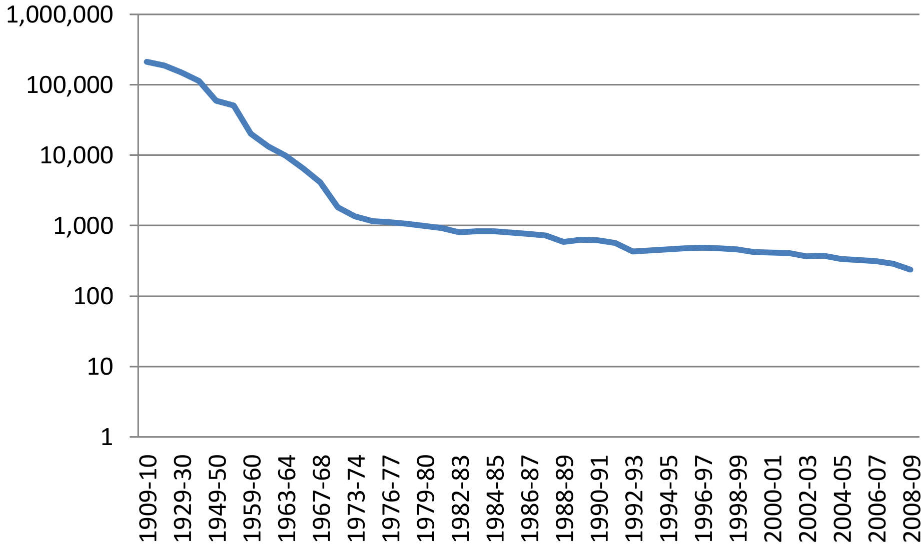
Figure 2 shows the decline in the number of public schools from 271,319 in 1920 to 83,165 in 1989. With the decrease, number of schools with one teacher also decreased precipitously. Figure 3 shows that the number declined from 212,448 in 1910 to 237 in 2009. During the same period the number of students in attendance and total enrollment was increasing. Figure 4 reports that average daily attendance of all students in public elementary and secondary schools increased from 15 million students in the beginning of 1920s to 46 million students towards the end of 2000s. Figure 5 shows that total enrollment in elementary and secondary schools increases roughly from 7.5 million students to 50 million students between 1870 and 2008. Figure 6 reports that while the number of schools decreases the average enrollment per school increases. During the time period from 1939 to 2008, the enrollment per school increases from about 100 to 500. Since many other factors can affect the enrollment rates such as wars or recession periods, the rapid increase in enrollment between 1950 and 1970 would also be due to the baby boom and the coinciding institutional consolidation movements of the period.

Figure 2.—Number of Public Schools, 1869-2010



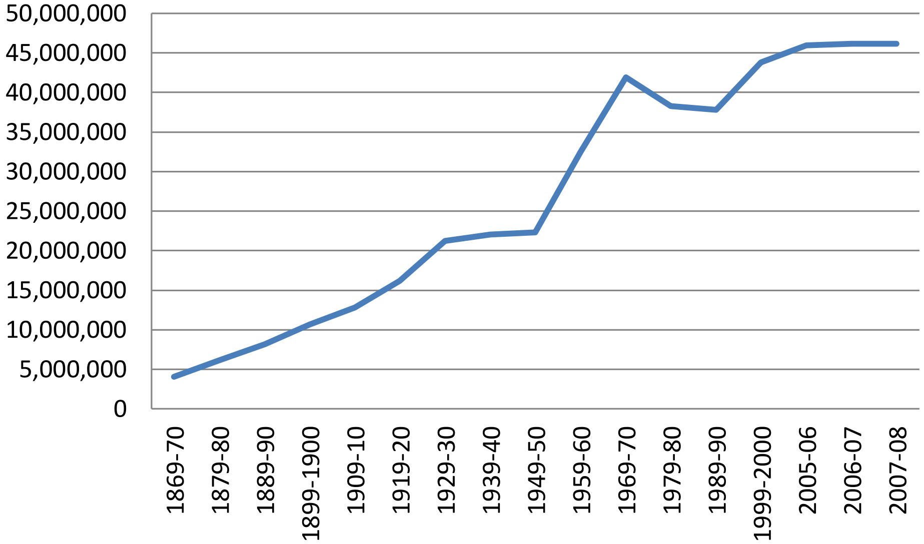
Source: U.S. Department of Education, National Center for Education Statistics, Digest of Education, 2010, Table 90

Figure 3.—Publics Schools with Elementary Grades, One-Teacher, 1909-2010



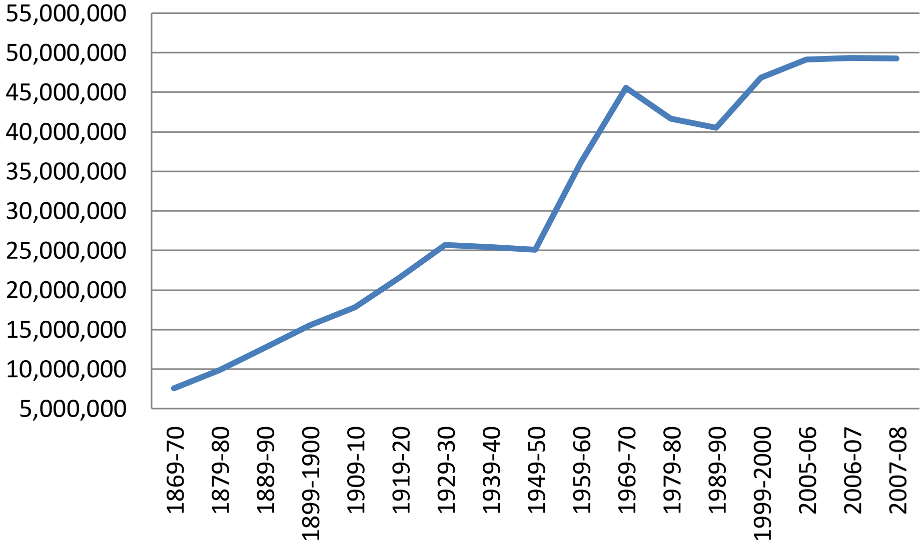
Source: U.S. Department of Education, National Center for Education Statistics, Digest of Education, 2010, Table 90

Figure 4.—Average Daily Attendance, 1869-2008



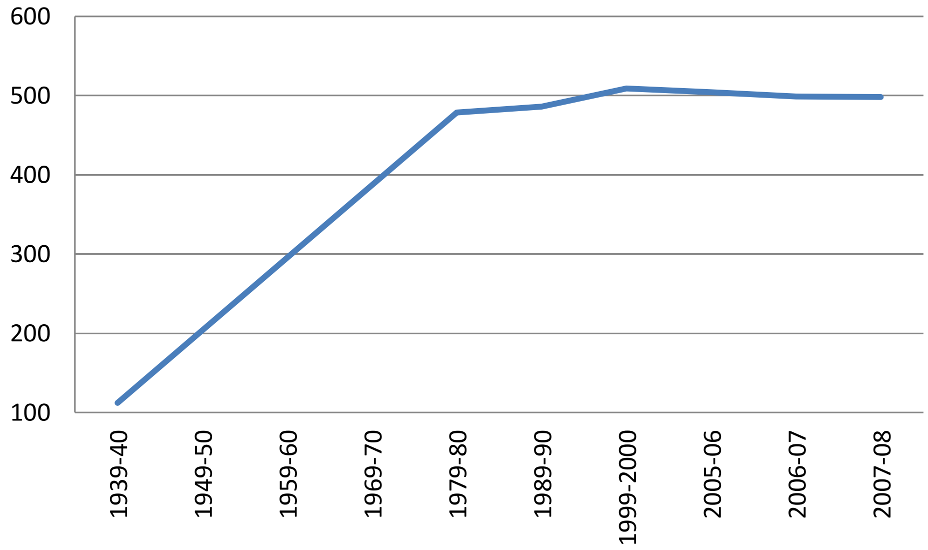
Source: U.S. Department of Education, National Center for Education Statistics, Digest of Education, 2010, Table 90

Figure 5.—Total Enrollment in Elementary and Secondary Schools, 1869-2008



Source: U.S. Department of Education, National Center for Education Statistics, Digest of Education, 2010, Table 90

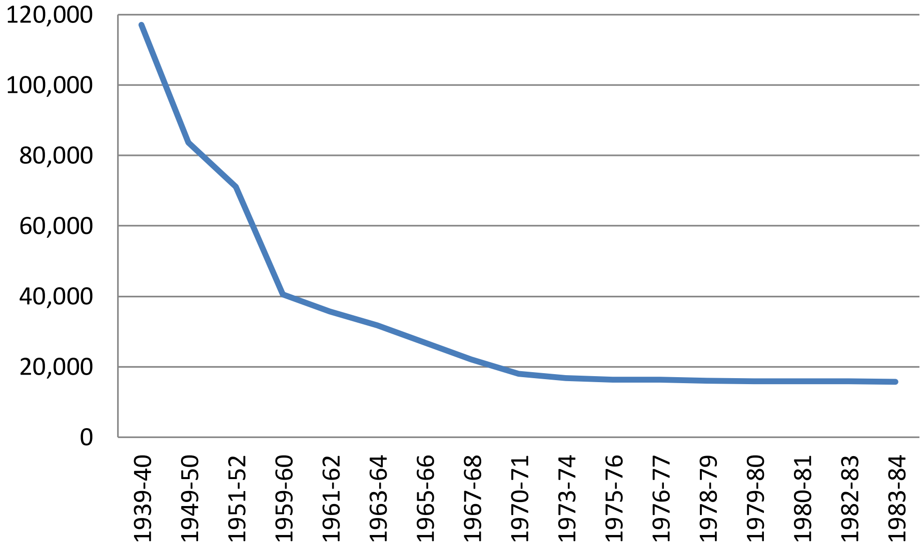
FIGURE 6.—AVERAGE ENROLLMENT PER SCHOOL, 1939-2008



Source: U.S. Department of Education, National Center for Education Statistics, Digest of Education, 2010, Table 90

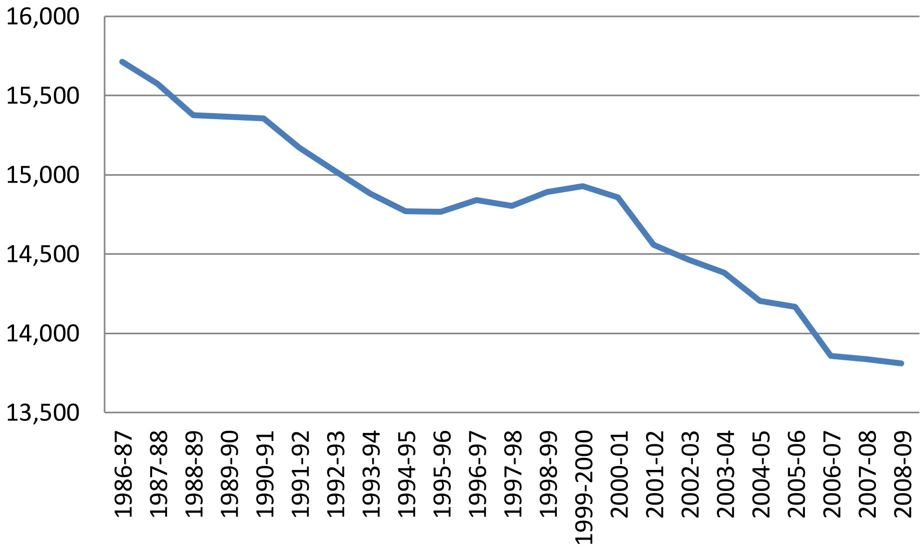
Consolidation of schools was directly associated with the need to consolidate districts. Cubberley and his progressive colleagues suggested that on average, one consolidated school should include five to seven schools present (Cubberley, 1919). Nevertheless, school districts of the period operated two schools on average, and most of the rural districts had only one school. Hence, in order to consolidate five to seven schools, district consolidation was necessary. Because of this reason, the number of districts began to decrease through consolidation movement. As shown in Figure 7, the number of districts in 1939 was about 120,000. In 1984, the number is less than 20,000. After 1980s, however, the speed of the decrease slows down, and Figure 8 indicates that in year 2009, the number of districts is roughly 14,000. These figures report that between 1939 and 2009, more than 100,000 districts have vanished by consolidation. As shown in Figure 9, with the increasing enrollment, average enrollment per district increases from less than 250 to more than 3500—more than fourteen folds—between 1939 and 2009.

FIGURE 7.—NUMBER OF DISTRICTS, 1939-1984



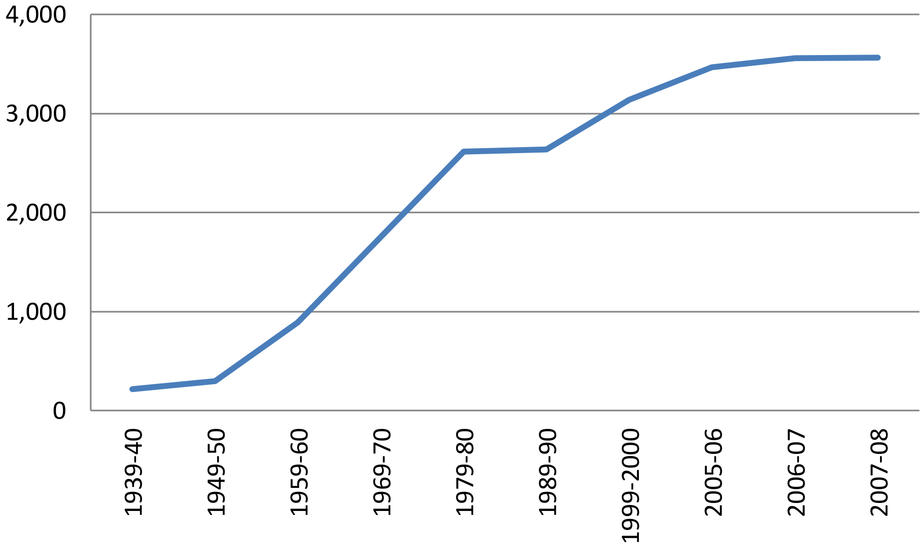
Source: U.S. Department of Education, National Center for Education Statistics, Digest of Education, 2010, Table 90

FIGURE 8.—NUMBER OF DISTRICTS, 1985-2010



Source: U.S. Department of Education, National Center for Education Statistics, Digest of Education, 2010, Table 90

FIGURE 9.—AVERAGE ENROLLMENT PER DISTRICT, 1939-2008

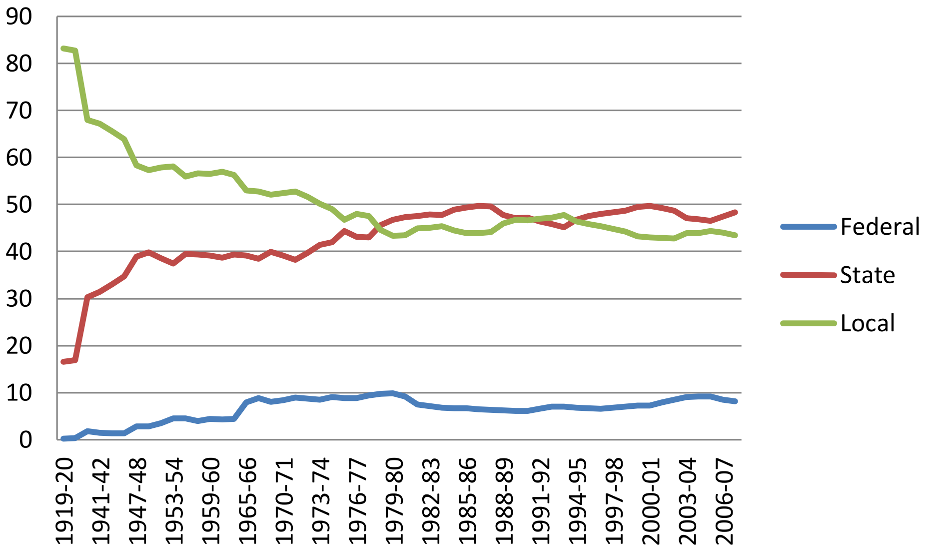


Source: U.S. Department of Education, National Center for Education Statistics, Digest of Education, 2010, Table 35

Throughout the consolidation movement, state governments had an important position. Hooker and Mueller (1970) report that the districts generally confronted consolidation ferociously. However, state governments either encouraged consolidation by offering economic inducements or required consolidation by changing the boundaries of the districts legislatively. Strang (1987) explains that the gradual change in the control mechanism was established by the abolition of school boards which are locally designated, and the power of the boards left behind was worn down as state governments progressively broaden their power over locally dealt problems like curriculum and accreditation. Briefly, while the schools were becoming larger, the school boards were getting less connected to local communities and having less power compared to the state governments or professional officials and managers.

The centralization of the school finance reflects the increasing importance of the state governments in public education. Figure 10 demonstrates the decrease in the percent share of local revenues from 83 in 1920 to 45 in 1978. Over the same period, percent share of state revenues increase from 16 to 45. Since 1978, local governments and states have supplied about the same amount of funding to public education.

FIGURE 10.—PERCENT SHARE OF REVENUE



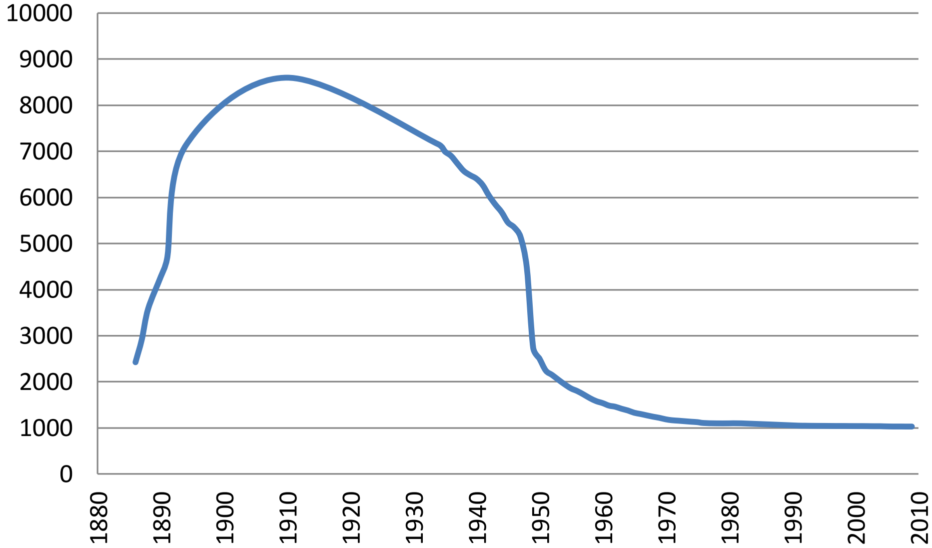
Source: U.S. Department of Education, National Center for Education Statistics, Digest of Education, 2010, Table 180

As Berry (2007) states, this short yet dynamic course of time gave birth to the American public education system of today. Community controlled schools and local school districts changed into complex systems of educational bureaucracies, which are professionally operated and some running hundreds of schools and schooling more than a hundred of thousand pupils (Howell, 2005). Since school district consolidation is generally considered as a method for school districts to reduce costs this movement is still continuing throughout the U.S. In the year 2009, there were only 13,809 regular public school districts, and the total enrollment in elementary and secondary schools was about 50 million (U.S. Department of Education, National Center for Education Statistics, Digest of Education Statistics, 2010). Even though there is a significant slowdown in the speed of school district consolidation since the 1970s, several states offer inducements to consolidate even today. Haller and Monk (1988) state that some states have building or transportation aid plans to encourage school district consolidation. Gold, Smith and Lawton (1995) mention at least eight states, including New York, which promote district reformation, generally in the fashion of consolidation, thorough general aid programs. On the contrary, Huang (2004) point out that approximately one-third of the states in the U.S. offer operating aid programs, which counterbalance the sparseness and smallness of school districts to dissuade school district consolidation. As Duncombe and Yinger (2007) explain, even though researchers do not have a consensus on the cost effects of school district consolidation, we can expect consolidation will be present in the public education policy plans in many states, especially if the beleaguered school districts want to reduce their costs and increase the performance of their pupil.

3.1.2. History of the School District Consolidation in Texas

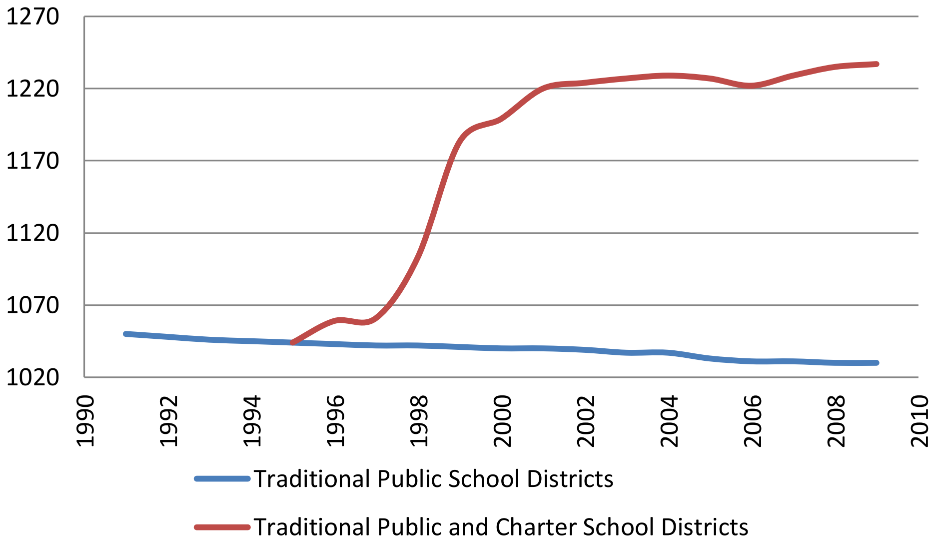
The attempts to have better educational cost efficiency in the state of Texas follow a similar pattern to those all over the U.S. Figure 11 presents the number of traditional public school districts in Texas between 1880 and 2010. In 1880s, there were about 2500 districts. Until 1910s, the number kept increasing and there were more than 8000 public school districts in Texas by 1920. Then the consolidation process began: the number of Texas traditional public school districts decreased sharply from 7,153 in 1938 (29th Biennial Report, State Department of Education 1934-1935 and 1935-1936) to 1,799 in 1956 (Annual Statistical Report, Part 1, 1975-1976; Texas Education Agency, 1976). The consolidation process somehow slowed down after this sharp decrease; the number of traditional public school districts fell to 1050 between 1956 and 1991, and the number decreased further to 1030 between 1991 and 2010. In 1995, however, the amendment of the Texas Education Code started a new type of public school, commonly known as a charter school, which increased the number of public school districts to 1237 at the end of 2009 (Texas Public School Statistics Pocket Edition 1991-2010, Texas Education Agency, 2010). Figure 12 presents this change.

FIGURE 11.—NUMBER OF SCHOOL DISTRICTS IN TEXAS, 1880-2010



Source: Texas Department of Education, Report of the Superintendent of Public Instruction 1886-1988 to 1906-1908; Texas Education Agency, Annual Statistical Report, Part 1, 1975-1976; Texas Education Agency, Biennial Report; Texas Education Agency, Texas Public School Statistics Pocket Edition 1991-1992 to 2007-2008.

FIGURE 12.—NUMBER OF DISTRICTS IN TEXAS, 1990-2010

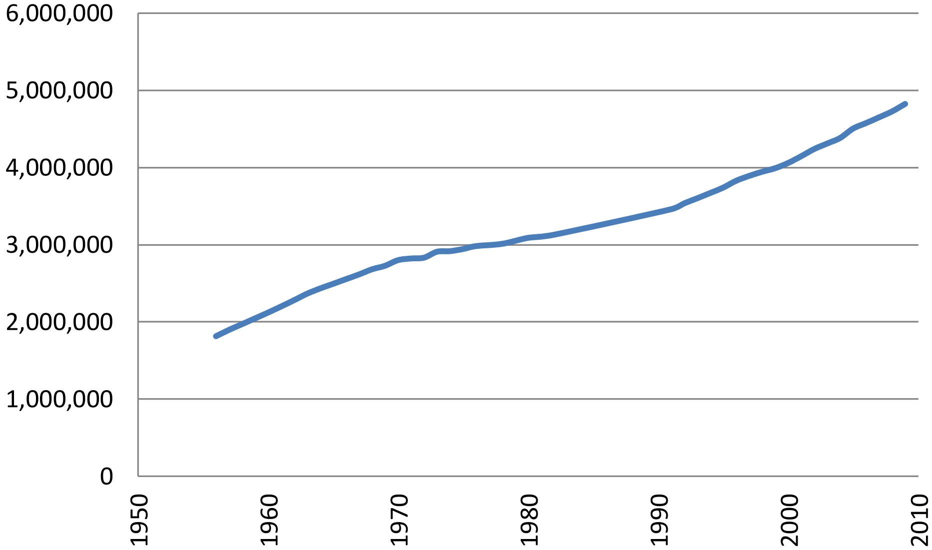


Source: Texas Education Agency, Texas Public School Statistics Pocket Edition 1991-1992 to 2007-2008.

While the consolidation process has been constructing larger school districts in Texas, public school enrollment in general has been increasing too, which adds to the size of the districts. Figure 13 depicts the continuous growth. According to the "Annual Statistical Report" of the Texas Education Agency (TEA) (1975-1976), the Texas statewide public school K-12 enrollment in 1956-57 school year was 1,815,509. The enrollment increased to 3,130,151 by 1984 (Biennial Report, TEA, 1982-1984) and by 1991, there were 3,460,378 public school K-12 students in Texas (Texas Public School Statistics Pocket Edition 1991-1992, Texas Education Agency, 1992). The growth in public school K-12 enrollment has been steady, and the number reached 4,824,778 students by 2010 (Texas Public School Statistics Pocket Edition 2009-2010, Texas Education Agency, 2010). That is, the 55-year change in Texas statewide public school

K-12 enrollment between 1955 and 2010 is 165 percent, and more growth in future is predicted by National Center for Educational Statistics (NCES).

FIGURE 13.—TOTAL ENROLLMENT IN K-12 IN TEXAS, 1956-2010

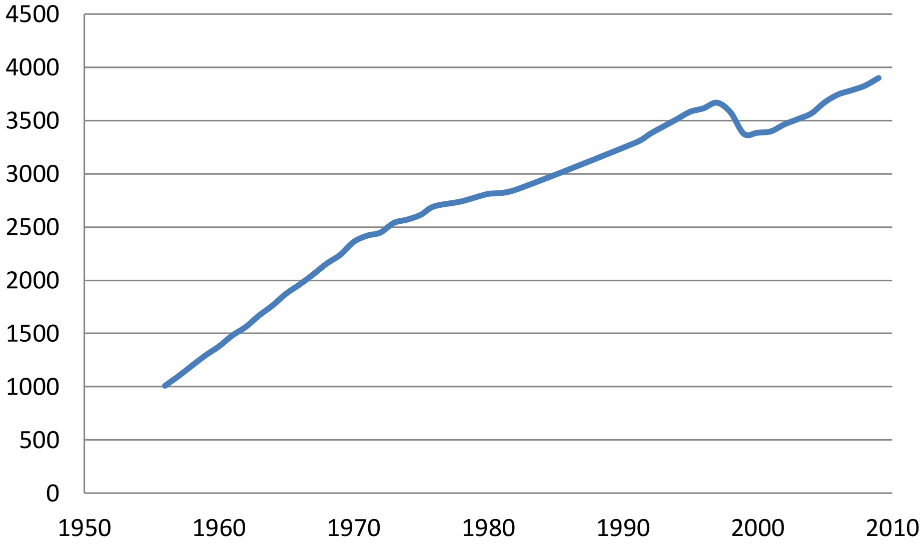


Source: Texas Education Agency, Annual Statistical Report, Part 1, 1975-1976; Texas Education Agency, Biennial Report; Texas Education Agency, Texas Public School Statistics Pocket Edition 1991-1992 to 2007-2008.

As the number of Texas school districts has been decreasing, district size kept increasing. Figure 14 presents that the district size increased from about 1010 to 3900 between 1955 and 2010—a 286% increase. Between 1992 and 2010, the enrollment in districts with a size of 5,000 and over has risen from 71.5% to 77.5% of the total enrollment, whereas the enrollment in districts with a size less than 1,600 has fallen from 11.3% to 9.9% of the total enrollment, and the enrollment in district with a size between 1,600 and 5000 has fallen from 17.2% to 12.6% of the total enrollment (TEA pocket edition 1991-1992, and 2009-2010, TEA) Today, more than 28 percent of enrollment in

Texas is in districts with a size of 50,000 and over and more than 67 percent of enrollment in Texas is in districts with a size more than 10,000 (TEA pocket edition 2009-2010). Moreover, only about 23 percent of the enrollment in Texas is in districts with a size less than 5,000 in the present day. Currently, 169 out of 1,237 public school districts in Texas have an enrollment more than 5,000. In short, Texas education geography is now being surrounded by bigger school districts, as never before.

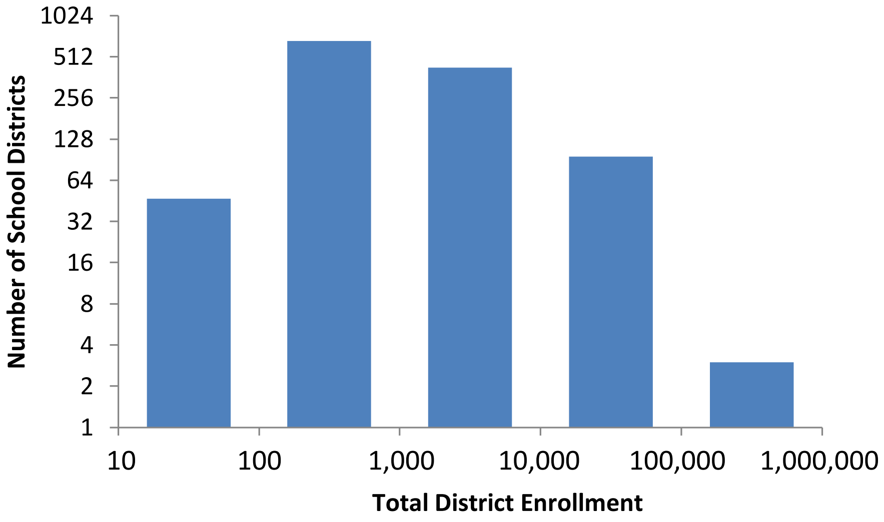
FIGURE 14.—AVERAGE ENROLLMENT IN K-12 PER DISTRICT IN TEXAS, 1956-2010



Source: Texas Education Agency, Annual Statistical Report, Part 1, 1975-1976; Texas Education Agency, Biennial Report; Texas Education Agency, Texas Public School Statistics Pocket Edition 1991-1992 to 2007-2008.

Nevertheless, the growth of the average district size conceals the great variation in the school district size in Texas. In 2010, the smallest district in Texas, Guardian Angel Performance Arts AC in Bexar Country, had only one school with an enrollment of 17 students. Houston Independent School District (ISD) in Harris County, on the other hand, had 294 schools with a total enrollment of 200,944 students, which makes the district the biggest in Texas. Figure 15 reflects this disparity clearly. In 2010, the size of most of the districts in Texas—1,139 out of 1,237 to be exact—was smaller than 10,000. 714 of these districts had a size smaller than 1,000. But 3 districts in Texas — Houston ISD, Dallas ISD, and Cypress-Fairbanks ISD—had an enrollment more than 100,000 students. This huge variation in the school district size is a significant characteristic of Texas.

FIGURE 15.—DISTRICT SIZE DISTRIBUTION IN TEXAS IN 2010



Source: Department of Education, National Center for Education Statistics, Common Core of Data.

According to the design of the education funding system in Texas, smaller districts receive additional funds per student. The formula states that school districts with an average daily attendance (ADA) less than 1,601 qualify for the small district adjustment, and districts with an ADA between 1,601 and 5,000 qualify for the mid-size district adjustment. The adjustments are designed to be a decreasing function of the ADA, so that the smallest district can get the biggest additional fund. Considering the district ADA in 2010, 858 districts in Texas are qualify for small district adjustment and 210 districts qualify for mid-size district adjustment—86% of the districts is Texas are eligible for a funding adjustment. Texas House of Representatives (2004) reports that the adjustment for small districts costs \$330 million per year and adjustment for mid-size districts cost \$91 million per year, which adds up to \$421 million per year. These adjustments add to the already high cost of K-12 education to the state of Texas.

As for many other states in the U.S., school district consolidation keeps being an option on table for Texas to reduce costs. In January 2011, State Representative Fred Brown, R-Bryan, offered a bill (House Bill 106) which reduces the number of public school districts in Texas from 1,235 to 254—one for each county. He suggests that the savings from administrative cost would be in the billions each year, which could be spent to improve the education in Texas. Actual outcomes of such a consolidation scenario, however, may depend on multiple effects of school district consolidation.

3.2. Effects of School District Consolidation

Before beginning to analyze the consequences of consolidation, we must first define clearly what consolidation means. There is a mixture of terms used by the public, policy makers and researchers to explain the consolidation. For example Fitzwater and Reed (1953) describes consolidation as the process of merging two or more attendance areas to produce a larger school. This restructuring implies that consolidated schools will no more be independent schools, but be one large and new education institution. Some states such as Kansas used different terminologies to describe the reorganization. The consolidation movement in Kansas in the 1960s was called as unification. Moreover, the restructured school districts were not identified as consolidated or reorganized districts but as “unified school districts” (House Bill 377). However, as Bard, Gardener and Wieland (2006) points out, regardless of the terminology selected by the public, policy makers or researchers, the majority of the society keep using the term consolidation to identify all kinds of restructuring, reorganization, unification, or merger of schools or school districts.

In spite of the existence of various terms and the nuance between them, what we know for sure is that consolidation refers to a change in the size and the number of the education units available. For instance, a merger of two small school districts would give birth to one large school district. The change in the size of the education units is the first effect to attract attention, and as a matter of fact, the change in the size is the main goal of the consolidation movement as mentioned earlier. That would explain why there is a relatively larger literature on the effects of consolidation through changes in the size of districts and school (see Fox (1981) and Andrews, Duncombe and Yinger (2002)). However another important consequence of consolidation—the change in the number of education units available—had long been ignored in the literature and never been taken into consideration until Hoxby (2000). Hoxby noticed how the number of available education units to choose from is subject to consolidation, and hence, a Tiebout (1956) like mechanism would as well be working in the school district consolidation movement.

After Hoxby (2000) influential study on the relationship between consolidation and competition among schools, relatively a smaller literature formed around this idea. Nevertheless the literature on competition faced many issues about how to measure competition and handle the endogeneity in their models. Eventually, the tendency in the literature to overlook some of the effects of consolidation brought conclusions which cannot be generalized. But in order to understand the general results of consolidation, we must investigate the structure as a whole. In this section, we first go through the branch of literature on the size effects of consolidation. Then we will review the small literature on competition effects in detail.

3.2.1. Economies of Size

Consolidation could increase or decrease per-pupil cost by changing the size of consolidating districts. In this part, we discuss how changes in size are incorporated with the costs of education. First, economies of scale decrease in average unit costs, which can be accredited to increases in the scale of production. Selection of the unit would be very simple in various standard economic productions. Nevertheless, when the production is education, the selection would be problematic because the unit can denote many different components of education such as the enrollment rate, attendance rate, student achievement or the range of education.

The literature uses the term economies of scale mostly for either the economies associated with the scale or production of the firms, or the economies related to the size of the firms. There are several dimensions of scale. Pratten (1991) lists fifteen main dimensions of scale under three categories, which are “dimensions affecting the efficiency of production”, “dimensions affecting selling and distribution costs” and “overall dimensions of scale”.

“Dimensions affecting the efficiency of production” includes eight main dimensions: the total output, the duration of production, the rate of production, the extent of standardization, the capacity of the production units, the total capacity of the plants, the overall size of the production site, and the extent of vertical integration. “Dimensions affecting selling and distribution costs” consists of four main dimensions: sales to each consumer, the total number of consumers, the geographic concentration of the consumers, and the size of delivery to the consumers. “Overall dimensions of scale” contains three main dimensions: the size of the firms, the scale of the industry, and the scale of the national economy.

The education literature generally concentrates on the relationship between the enrollment rate and per pupil expenditure, which can simply be called economies of size. Economies of size can be estimated by regressing the education cost per pupil on student achievement, direct input prices, environmental variables and other related variables. If the estimation gives a result of negative enrollment elasticity of cost, then there said to be economies of size. Conversely, if there is a positive enrollment elasticity of cost then there are diseconomies of size.

Possible sources of economies of size and diseconomies of size are summarized in Pratten (1991) and Tholkes (1991). The sources of economies of size can be discussed under eight categories: Indivisibilities, the economies of specialization, the economies of increased dimensions, the learning effect, the economies of massed resources, superior techniques of organizing production, economies associated with vertical integration, and price gains from size.

Indivisibilities: Over particular ranges of output, some of the costs are at least partially independent of scale, that is, with respect the output, these costs are completely or partially indivisible. In the education sector, as the number of students increases in certain ranges, one teacher’s services supplied to each student do not decrease in quality. Moreover, no matter how many students the district has, there needs to be a school board and the superintendent as the central administration of the district. Within some range of enrollment, no additional administrators would be necessary to have the same degree of control.

The Economies of Specialization: As the production of a firm becomes larger, the opportunities for specialization of the capital equipment and labor force increase. That is to say, increased output may make it possible for the firm to hire a worker with special skills or a worker with better skills compared to the current ones, or to utilize a special device or equipment in the firm. For instance it may be easier for larger schools to employ more specialized teachers. It is mentioned in Haller and Monk (1988) that consolidation can be defended by specialization argument that it enables high schools to offer more specialized classes to students.

The Economies of Increased Dimension: Both initial costs and operating costs of most capital equipment increase less quickly than the capacity of the equipment. Since there are relatively less parts to produce, bigger units are less costly. Operating costs, as well, are not much affected by the size, since the total direct labor cost of operating units of equipment does not increase as much as the size. Moreover, maintenance costs are generally proportional to the capital cost, and hence not get changed much by the size. For example, a larger school may be able to produce the same quality of education with a lower average cost, since they can utilize more efficient classrooms, or they may be able to produce a better quality of education with the same average cost, since they can have a new science laboratory.

The Learning Effect: Learning is a source of economies, which is connected to the changes in the size by the cumulative production and the duration of production. Technically, the learning effects can be generated by the invention during the production process, or by the other cost-reducing outcomes of the continuous production. To give examples, bigger districts can put into practice the improvements in a curriculum with lower costs. Also, teachers can become more prolific in a bigger school, because the available accumulated experience by the teacher body increases with size of the school.

The Economies of Massed Resources: Economies of massed resources can be a generated by the procedure of the law of large numbers. That is, a bigger firm can take greater risks because they can spread the risks better. Economies of massed resources can be achieved for specific types of labor, raw materials, monetary resources and production plants.

Superior Techniques of Organizing Production: It can be easier for larger firms to utilize more efficient techniques of organizing production. For instance, automatic equipment can replace manually operated equipment in larger firms. It can also become possible by the increased size to substitute a better method of flow production to have a higher rate of production. In education, in larger schools, computerized education can be made available to every student, which in turn increases the pace of education.

Economies Associated with Vertical Integration: Integration of some of the production processes can bring some technical economies of scale. Such benefits can arise from transportation costs or transaction costs. Decreased number of production locations may enable economies for transportation costs. Also, less need to control the quality of the production can result in economies for transaction costs.

Price Gains from Size: As the company gets bigger, they may have more control over the price of the production material. For example, a larger district can negotiate better for the prices of education equipment, because they would buy in bulks. Also, as stated by Merrifield (1999), they can have more power in the teacher labor market to decrease the wage rates of the teachers.

While one or more of the economies mentioned above can realize with an increase in the size of the firm, it is also possible for the firm to experience some diseconomies due to the same increase in the size. Possible sources of diseconomies of size can be analyzed in five groups: Technical forces, management, consumer relations, labor relations, and selling and distribution.

Technical Forces: Some technical forces are associated with diseconomies of scale. In fact there are two types of additional costs to deal with the technical difficulties due to the increase in the size. First, more expensive and durable equipment may be required to support the overuse. Secondly, there can be some initial costs to foresee the technical limitation and to take the precautions before the increase in the size. Technically, school equipment can face severer wearing out with as the enrollment increases. Also there are costs of planning and managing the merging of schools and districts, in order to avoid technical complexities.

Management: Since the efficiency of management can worsen as the size increases, the costs of management may increase more than the relative proportional increase in the size. If that is the case, than there would definitely be an optimum size for the firm both in horizontal scale and vertical scale. For example, as the size of the district increases, since the chain of management gets more intricate, decision-making process may slow down and the information network may deteriorate within.

Consumer Relations: Smaller firms may be able to develop improved relations with their customers. Moreover, consumers may involve in the feedback process more efficiently with the smaller firms. In education, teachers can get to know their students better in small schools and help them more effectively. Students may feel more attached to smaller schools, and their sense of connection may improve the motivation and therefore the quality of education. In addition, parents of the students may keep contact with the teachers better and smaller schools may take advantage of a more intense parental involvement.

Labor Relations: As the size of the firm gets bigger, the work produced by the workers in the firm may become less satisfactory. The decrease in the performance of the workers may be due to several factors such as the loss of the family spirit, or the weak connection with the managers. Teachers may simply find it difficult to teach in larger schools, and the quality of the education may decrease. Moreover, it may be easier for the teachers to unionize in a larger district to counteract the monopsony they face. Hence, these types of teacher organizations increase the price of teacher labor, and increase the costs.

Selling and Distribution: One of the potential sources of increased costs at higher scales of output is the selling and distribution. As the size of the firm increases, average length of haul increases as well. Hence, transportation costs would increase for the average unit of production sold. In the education sector, average transportation distance increases as the schools or districts get larger. As mentioned in Kenny (1982), average transportation time for students increases as well.

3.2.2. Research on Size

Most of the research in the literature dealing with the question of consolidation and economies of size focuses on the estimation of education cost functions by utilizing total or operating expenditures data. Almost all of these studies, however, face methodological problems, which are extensively pointed out in Fox (1981), Cotton (1996), and Andrews, Duncombe and Yinger (2002). The relatively more up to date studies somehow try to cope with these concerns in modeling and estimating the cost functions.

The studies in the literature generally use the average test scores to measure the student performance. Most of them use data on math and reading scores; however some of the studies prefer using the graduation rates instead of the average test scores. Prices of factors of production, and mainly the teacher wages are incorporated in several studies, and a few studies including Riew (1986) put teacher quality measures in their equations instead of teacher wages. There are some other studies such as Downes and Pogue (1994), Duncombe, Ruggiero and Yinger (1996), Reschovsky and Imazeki (1997, 2001), Duncombe and Yinger (1997, 1998, 2000), and Imazeki and Reschovsky (2004a), which realize that there can be some endogeneity due to the simultaneous determination of the teacher wages with the school's financial plans and educational goals, and therefore make some quality adjustments and take the teacher wages as endogenous. Ratcliffe, Riddle and Yinger (1990), and Downes and Pogue (1994) approach to the cost modeling engages demand for education to integrate the customers' behavioral background, and they estimate expenditure functions in reduced form. In addition to this attempt to integrate the demand side, Downes and Pogue (1994), Duncombe, Ruggiero and Yinger (1996), Reschovsky and Imazeki (1997, 2001), Duncombe and Yinger (1997, 1998, 2000), and Imazeki and Reschovsky (2004a) take the educational performance and student outcomes as endogenous.

Some of the latest studies in the literature try to control for the unobserved elements in the cost functions, mainly the efficiency. Deller and Rudnicki (1992), and Duncombe, Miner and Ruggiero (1995) utilize stochastic frontier models to incorporate efficiency in the picture. Nevertheless, with respect to the variables of enrollment, they do not report big dissimilarities between the OLS and stochastic frontier estimation results. In order to control for district-specific effects, Downes and Pogue (1994) use panel data methods, and they report statistically significant association between expenditures and enrollment. Instead of a stochastic frontier analysis, Duncombe, Ruggiero and Yinger (1996) employed a technique called data envelopment analysis (DEA), which generates an efficiency index with linear programming. A similar methodology is utilized in many other studies such as Duncombe and Yinger (1997, 1998, 2000), Reschovsky and Imazeki (2001) and Imazeki and Reschovsky (2004a). What is remarkable about the size literature is that even though the studies employed different methodologies and analyzed different geographical locations, nearly all of these studies reach a consensus: Over a certain range of enrollment, there exist economies of size.

Although expenditure regressions with cross sectional data can offer some support for economies of size, using panel data with appropriate methodology would be a better way to reach a conclusion. Nonetheless, there is no study in the literature, which follows such a direction to evaluate the size effects. Benton (1992), Hall (1993), Piercy (1996), and Weast (1997) try to control for the pre and post consolidation, but their data are not adequate enough and they concentrate on no more than one specific district, which means there is no control group. Streifel, Foldesy and Holman (1991) use a data set including 19 school district and they evaluate the finance data in the pre and post consolidation period. Yet, they do not control for many important variables such as teacher wages, variations in the student body, or student performance, and hence, their results are not representative. Howley (1994) states that since there is no study in the literature handling the pre and post consolidation information, our knowledge about the gains from consolidation is not well-backed and thus not reliable. Duncombe and Yinger

(2007) make an effort to fill this gap in the literature by using panel data, which covers periods of pre and post-consolidation. They introduce the first structural method to analyze the association between consolidation and educational cost efficiency. Nevertheless, their findings do not serve as an overall analysis of consolidation because they pay no attention to the changes in the degree of competition due to the changes in the number of available school districts.

3.2.3. Research on Competition

There are many studies in the literature which analyze the relationship between Tiebout competition and student performance. Belfield and Levin (2002) and Taylor (2000) present surveys of the literature on this relationship. For instance, Zanzig (1997) reports that student test scores in California increase as competition among public school districts increases. Borland and Howsen (1992, 1993, 1996) use data from schools in Kentucky and present parallel findings. Hoxby (2000) analyzes the National Longitudinal Survey of Youth and shows that students get higher scores on standardized tests, complete more years of schooling, and earn higher salaries if they attend a high school in a more competitive education market.

Competition from the charter schools is also examined in the literature. For example, Hoxby (2003) presents that traditional public schools' student test scores in math and reading improve when the introduction of charter schools increases competition. Moreover, Sass (2006) and Booker et al. (2008) report similar results for Florida and Texas, relatively. Bettinger (2005) and Bifulco and Ladd (2006), however, cannot find any significant impact of charter school competition on the achievement of traditional public schools, and Ni (2009) presents that charter schools in Michigan had a negative impact on traditional public school students' performance.

The effect of competition from private schools on public schools is analyzed by several researchers. The private school enrollment is possibly endogenous. Couch, Shughart and Williams (1993), Dee (1998) and Hoxby (2000, 2002, 2003) control for the endogeneity of private school enrollment by using instrumental variables and show that when expenditures are held constant, public school performance improves with more competition from private schools, or similarly, when outcomes are held constant, cost of education decreases with more private schools competition.

Some of the studies in the literature examine the relationship between competition and the relative efficiency of public schools. For example, Imazeki and Reschovsky (2004b) use competition as an independent variable in their education cost model in which the relationship between competition and efficiency is with the assumption. Husted and Kenny (1997) follow a different methodology and estimate school efficiency frontiers for different states. They show that states with a number of school districts per capita below a certain threshold have lower levels of education system efficiency. Grosskopf et al. (1999, 2001) present that urban Texas school districts are more inefficient in metropolitan areas with less competition from public and private schools. Millimet and Collier (2008) use Illinois data and find evidence that the efficiency of a school district increases as the efficiency of neighboring school districts increases. They attribute this finding to the relationship between school district competition and efficiency. Furthermore, Kang and Greene (2002) show that New York school districts in more concentrated counties are less efficient. Duncombe, Miner and Ruggiero (1997), however, argue that as private school enrollment increases, their index of cost efficiency for New York public school districts decreases. Nevertheless, they do not control for private school endogeneity which may be the reason why they find an inverse relationship between competition and school district efficiency.

Moreover, several researchers investigate the possibility of a critical level of competition such that increased competition is beneficial for governments in markets on one side of that critical point while more competition is not beneficial for the governments on the other side. Borland and Howsen (1993), Zanzig (1997), Grosskopf et al. (1999, 2001) Hoxby (2003), and Bettinger (2005) present such a switching point. In this study, we explicitly allow for the threshold effects in competition when modeling the trade-off between competition and school district consolidation.

3.3. A Model of Cost and Consolidation

In order to analyze the direct and indirect effects of school district consolidation on school district costs, we use a stochastic cost frontier methodology. Especially for the examination of public and other non-profit supplier behavior, the stochastic cost frontier methodology is very suitable. The possibility of cost inefficiency increases drastically when the suppliers do not have any incentive to maximize the profits of the institution. Furthermore, the cost efficiency incentives may get even weaker if there is no competition in the market or competition from other similar suppliers is not strong. With the stochastic cost frontier methodology, it is possible to evaluate the degree of cost inefficiency while determining the features of the true cost function. Gronberg, Jansen and Taylor (2011a) presents the benefits of employing a stochastic cost frontier methodology to estimate the school cost function. They also explain possible challenges associated with using the methodology.

In a standard stochastic frontier model, expenditure can be specified as

$$E = C(Z \mid \beta) \cdot \exp(v + u), \tag{16}$$

where E is actual or observed spending, $C(Z \mid \beta)$ is the cost frontier, $Z = \{w_1, \dots, w_k;\ z_1, \dots, z_m; y\}$ is a vector of variables affecting the frontier level of cost, w_l are input prices, z_j are quasi-fixed inputs, y is outcome(s), β is the cost parameter vector to be estimated, v is a two-sided exogenous random shock component such as bad weather conditions during the testing day, and u is a one-sided error term that captures cost inefficiency. The cost frontier here is the true neo-classical cost function. The frontier analysis finds what this deterministic cost frontier is along with the cost inefficiency, which increases the cost above minimum cost. So $u_i \geq 0$, and cost efficiency is defined as $CE_i = \exp(-u_i) \leq 1$.

Educational outcomes have a quantity dimension and a quality dimension. The number of students served represents a quantity dimension, and the human capital produced represents a quality dimension. We follow Andrews, Duncombe and Yinger (2002), and let N denote school district enrollment and S denote student achievement. In the education literature, it is a common practice to estimate an average or per pupil expenditure. Taking N as quantity we incorporate these features into equation (16) as

$$E^* \equiv \frac{E}{N} = \frac{C(\, w_1, \dots, w_k;\; z_1, \dots, z_m;\; S, N \mid \beta) \cdot \exp(v + u)}{N} \qquad (17)$$

Taking the natural logarithms of both sides of the equation (17) gives

$$\ln E^* = \ln C(\cdot) - \ln N + v + u \qquad (18)$$

Duncombe and Yinger (1993) explain that economies of scale can be measured with respect to quantity, N, or with respect to quality, S.[9] In the education literature enrollment measure is more common which is probably due to the direct relationship between enrollment and school district consolidation. Andrews, Duncombe and Yinger (2002) refer to the enrollment measure as economies of size. We follow them and define economies of size as the enrollment elasticity of per pupil expenditures ($\eta = \partial \ln E^* / \partial \ln N$), holding student achievement S, input prices w, quasi-fixed inputs z, and cost inefficiency constant. Using (18), we get

$$\eta = \theta - 1 \qquad (19)$$

where $\theta = \partial \ln C / \partial \ln N$ is the enrollment elasticity of total cost. Economies of size exist if $\eta < 0$, or correspondingly if $\theta < 1$.

The level of competition in the education market in which the district operates may be an essential characteristic of the decision-making environment faced by the public school district officials. That is, since public officials do not have a direct incentive to maximize the profits of the public institution they work for, they may be more prone to involve in excessive spending. Competition, on the other hand, may be an

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[9] They actually present three different measures of economies of scale: along with N and S, they also explain that there are economies of scale in the production of the public facility (or school activities), G, which is not an output but an intermediate input into the final output of student achievement. We don't have the data for G, and for that reason, we model the cost frontier as a reduced form of their model.

important force that disciplines this wasteful behavior through various mechanisms. Hence, the prediction of our competition hypothesis is that increased competition in a district's education market would result in a decrease in that district's cost inefficiency.

The stochastic cost frontier methodology lets us model the one-sided error term, u, and hence test our competition efficiency hypothesis. That is, we can specify that

$$u = u(x, \delta)\ with\ u \geq 0 \tag{20}$$

where x is a vector of environmental cost efficiency factors, including a measure of competition, and δ is a parameter vector. We can substitute expression (20) into the per pupil expenditure equation in (18) to yield

$$\ln E^{*} = \ln C(\cdot) - \ln N + v + u(x, \delta)\ with\ u \geq 0 \tag{21}$$

We analyze school district consolidation as changes in N. Then the model in (21) yields two potential effects of a school district consolidation on per pupil expenditures: changes in N due to consolidation causes direct economies of scale effect on per pupil expenditures, and that consolidation may also change the school district cost efficiency through changing the degree of concentration of the school district's market. Let x_1 be the competition measure of the district that a greater value of x_1 means a more competitive environment. Differentiating (21) with respect to ln$N$ gives

$$\eta = (\theta - 1) + \left(\frac{\partial u}{\partial x_1}\right) \cdot \left(\frac{\partial x_1}{\partial N}\right) \cdot N \tag{22}$$

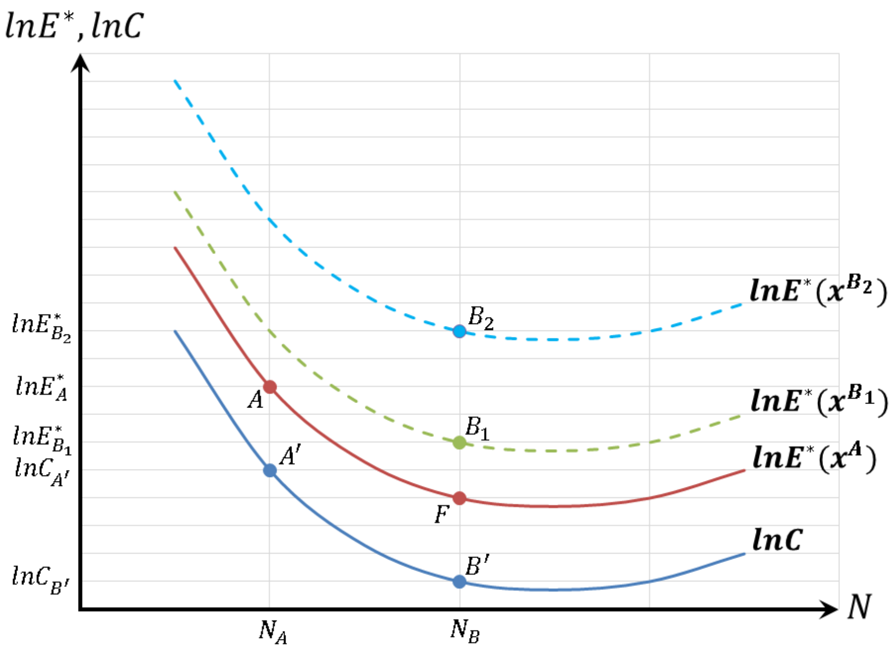
We can decompose the observed reaction of per pupil spending to a change in N by a consolidation into two effects: a scale effect $(\theta - 1)$ and a competitive efficiency effect $(\partial u/\partial x_1) \cdot (\partial x_1/\partial N) \cdot N$. Our competitive efficiency hypothesis infers that

$(\partial u/\partial x_1) < 0$ and $(\partial x_1/\partial N) < 0$, so assuming that $(\theta - 1) < 0$, consolidation's expected cost savings due to the economies of scale would be reduced, if not completely offset and outweighed, by the increases in the expenditures due to increased cost inefficiency.

We illustrate the mathematical derivation above in a cost and expenditure curves figure below. In Figure 16 , there is a hypothetical set of cost and expenditure curves which are U-shaped in enrollment by assumption. In the figure, we portray a consolidation scenario between district A of size N_A and a second district of size $(N_B - N_A)$. Consolidation of these two districts would create a new district (district B), which would have a total enrollment of N_B. Before consolidation, district A's frontier log cost per pupil is $\ln C_{A'}$, log expenditure per pupil is $\ln E_A^*$, and the distance from the frontier, u_A , $is\ AA'$. Point A on the log expenditure per pupil curve show district A's position before consolidation which is associated with the competitive environment x^A. If the two districts consolidate, after consolidation, district B's frontier log cost per pupil would be equal to $\ln C_{B'}$ which is at a lower level than $\ln C_{A'}$. If the change in the competitive environment due to the consolidation had no effect on the inefficiency, point F would be presenting the level of log expenditure per pupil after consolidation as the distance FB' is equal to u_A, and the cost savings would be equal to $\ln C_{A'} - \ln C_{B'}$, or in other words the vertical distance between points A and F. Our competitive efficiency hypothesis, however, implies that inefficiency after consolidation, u_B , is greater than

u_A. Hence log expenditure per pupil curve associated with the new competitive environment after consolidation should be on a higher level relative to $\ln E^*(x^A)$. If the economies of scale effect on cost dominates the competitive effect on inefficiency, there would still be some positive realized cost savings but the savings would be smaller than the true savings of economies of scale. That is, if the competitive environment after consolidation is x^{B_1} then point B_1 on the associated log expenditure per pupil curve would be representing the level of the new district's per pupil expenditure ($\ln E_{B_1}^*$), and the realized savings due to consolidation would be $\ln E_A^* - \ln E_{B_1}^* > 0$. If the competitive effect dominates the scale effect, however, all of the savings due to the economies of scale would be wiped out by the increased inefficiency resulting in realized losses. That is, if the competitive environment after consolidation is x^{B_2} then point B_2 on the associated log expenditure per pupil curve would be representing the level of the new district's per pupil expenditure ($\ln E_{B_2}^*$), and the realized losses due to consolidation would be $\ln E_{B_2}^* - \ln E_A^* > 0$.

FIGURE 16.—COST AND EXPENDITURE CURVES



3.3.1. Specification of the Econometric Model

The econometric specification of our model is a version of the cost frontier model presented in (21) which captures the effects of key variables relevant to the expenditure setting of Texas public school districts. Gronberg, Jansen and Taylor (2011a) use a similar model. Since other restricted functional forms such as Cobb-Douglas can be nested in a translog specification by setting the interaction terms equal to zero, and since classical linear models can be nested in a frontier model by setting the one-sided error term equal to zero, we decide to model $C(\cdot)$ as a modified translog cost frontier.[10]

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[10] Modification of the standard translog cost frontier is in two ways: First, since the variables in percentages can take on values of zero, we do not take the natural logarithm of those variables and assume that these percentage variables are the natural logarithm of the absolute values of the variables. Second,

The natural logarithm of the expenditures per pupil (E^*) is the dependent variable in (23). The right-hand-side variables are n_1 output variables including enrollment, $N \equiv q_1$, and the quality measures q_i, n_2 input prices denoted by w_l, and n_3 environmental factors denoted by z_j. All of the right-hand-side variables except those that are already percentages are in natural logarithms. As discussed in the data section below, there is a big variation in school district size in Texas. Because of this variation, some researchers such as Imazeki and Reschovsky (2004a) exclude the largest districts in Texas from their analysis. In this study, however, instead of dropping some districts, we decide to keep all of the districts with complete data, and include a cubic term for log enrollment in the model to control for multiple inflection points in the cost frontier.

Hence the model for district expenditures per pupil is:

$$\begin{aligned}\ln E^* = \alpha_0 &+ \sum_{i=1}^{n_1} \alpha_{1i} q_i + \sum_{i=1}^{n_2} \alpha_{2i} w_i + \sum_{i=1}^{n_3} \alpha_{3i} z_i + 0.5 \sum_{i=1}^{n_1} \sum_{j=1}^{n_1} \alpha_{4ij} q_i q_j \\ &+ 0.5 \sum_{i=1}^{n_2} \sum_{j=1}^{n_2} \alpha_{5ij} w_i w_j + 0.5 \sum_{i=1}^{n_3} \sum_{j=1}^{n_3} \alpha_{6ij} z_i z_j \\ &+ \sum_{i=1}^{n_1} \sum_{j=1}^{n_2} \alpha_{7ij} q_i w_j + \sum_{i=1}^{n_1} \sum_{j=1}^{n_3} \alpha_{8ij} q_i z_j + \sum_{i=1}^{n_2} \sum_{j=1}^{n_3} \alpha_{9ij} w_i z_j \\ &+ \alpha_{10} \cdot q_1^3 + v + u \end{aligned} \tag{23}$$

where we impose the usual symmetry restrictions, $\alpha_{aij} = \alpha_{aji}$, for $a = 4, 5 \; and \; 6$.

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cubic term of enrollment is added to the model as an extension for further investigation of multiple inflection points in the cost frontier.

3.3.2. The Scaling Property and Further Specifications

Our analysis is predicated on the assumption that competition affects school district efficiency, but not the educational production technology itself. Therefore, in order to avoid the biases associated with the traditional estimation methods of stochastic cost frontiers, we think that it is essential to incorporate a systematic element called the scaling property into our models. The integration of the scaling property allows us to take advantage of several powerful features, which are consistent with our public school data, and are not provided within conventional models.

Simar, Lovell and Eeckaut (1994) suggest the semi-parametric method, which is later named as the "scaling property" by Wang and Schmidt (2002), and Alvarez et al. (2006), to accounting for exogenous effects in the stochastic frontier models. The scaling property defines u as,

$$u = u(x_i, \delta) = h(x_i, \delta) \cdot u^* \tag{24}$$

where u^* is a nonnegative variable, which is random and not a function of the environmental cost efficiency factors x_i such as size or competition, and $h(x_i, \delta)$ is a nonnegative function of x_i.[11]

The fundamental characteristic of the scaling property is the fact that the variation in x_i redefines the scale but it does not alter any other aspect of the shape of the

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[11] Since the scaling property results in $\mathrm{E}[u] = h(x_i, \delta) \cdot \mathrm{E}[u^*]$, the method implies more than just introducing heteroskedasticity to the model. In order to avoid biases, Simar, Lovell and Eeckaut (1994) uses this property to build a nonlinear least squares estimator free of a pre-specified distribution. Later, with their Monte Carlo analysis, Wang and Schmidt (2002) present strong evidence of critical biases with the traditional estimators of the parameters of a stochastic frontier which pay no attention to the scaling property, and the estimates of u of Jondrow et al. (1982). Wang and Schmidt's line of reasoning and findings are also valid for the traditional estimates of cost factors and cost efficiency.

distribution of u. This happens because the scaling function $h(x_i, \delta)$ only determines the scale, and the shape is defined by the basic distribution of u^*, which does not depend on x_i. In other words, the scaling property lets the school heterogeneity to show up by stretching or contracting the horizontal axis through changing the horizontal scale without altering the underlying shape.[12] This captures the intuitively sensible and attractive idea that for all schools, the shape of the distribution of u, that is the random part of the residual, is the same.

This fundamental characteristic of the scaling property is not only statistical: The economic interpretation of this characteristic is important, and it is desirable in our stochastic cost frontier model. The scaling property decomposes $u(x_i, \delta)$ into two logically and economically independent terms: The basic random term u^* can be viewed as the school's initial cost efficiency level which captures the random elements in the model such as administrator's innate talents. Nevertheless, when these innate talents are employed to run the school, the degree of their contribution to the cost efficiency depends heavily on other factors such as the education level or experience of the administrator, or other environmental variables like the location of the school. Hence, the final level of cost efficiency depends also on this second term $h(x_i, \delta)$, which is a function of x_i.

A second appealing characteristic of the scaling property is that it allows clear explanations of how x_i affects school's cost inefficiency since the property does not

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[12] To be more specific, assume that $f(u^*)$ is the density function of u^*, and u is equal to $h \cdot u^*$, where h is a constant. Therefore, the density of u is $(1/h) \cdot f(u/h)$ which practically has the same shape as $f(u^*)$ because appropriate adjustment of the axes would portray two identical graphs of densities.

necessitates any assumption for the basic distribution. As such, the property makes it possible to acquire consistent estimates of β and δ. So the expenditure equation in (21) becomes

$$\ln E^* = \ln C(\cdot \mid \beta) - \ln N + v + h(x, \delta) \cdot u^* \tag{25}$$

As discussed by Fried, Lovell and Schmidt (2008), there are several candidates for the scaling function $h(x, \delta)$.[13] The basic distribution of u^* has some candidates as well.[14] We followed Wang and Schmidt (2002) and define u as

$$u \equiv \mathcal{N}^+[\, 0 \,, \exp(\delta_0 + \delta \cdot x_i') \,] \tag{26}$$

Our u can be rewritten as $u = h(\cdot) \cdot u^*$ and thus has the scaling property.[15] u^* here has a half-normal distribution and the variance of u, σ_u^2 , is defined as $\exp(\delta_0 + \delta \cdot x_i')$. In our final model, the mean and standard deviation of u change as the x_i changes, but the shape of the distribution does not change.

Measurement error is generally a function of school district size. To account for the effect of district size heterogeneity on the two-sided error, we model the variance of v as

$$\sigma_v^2 = \exp\left(\gamma_0 + \gamma_1 \cdot \frac{1}{N}\right) \tag{27}$$

where $v_i \sim iid\ \mathcal{N}(0, \sigma_v^2)$. With our specification above, the log-likelihood function can be written as

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[13] Suitable scaling function candidates include the linear, $\delta^T \cdot x_i$, or the exponential, $\exp(\delta \cdot x_i')$.

[14] Suitable basic distribution specifications include half normal, exponential or truncated normal distributions.

[15] An example of such a specification is presented in Caudill, Ford and Gropper (1995).

$$\ln L = \sum_{i=1}^{N} \left\{ \frac{1}{2} \ln\left(\frac{2}{\pi}\right) - \ln\sigma_S + \ln\Phi\left(\frac{\varepsilon_i \lambda}{\sigma_S}\right) - \frac{\varepsilon_i^2}{2\sigma_S^2} \right\} \tag{28}$$

where $\sigma_S = \sqrt{\sigma_u^2 + \sigma_v^2}$, $\lambda = \sigma_u/\sigma_v$, $\varepsilon_i = u_i + v_i$, and $\Phi(\cdot)$ is the cumulative distribution function of the standard normal distribution. In our paper the maximization of the likelihood function with respect to the parameters is accomplished by using a looping algorithm of 10 Newton-Raphson iterations followed by 100 Berhdt-Hall-Hall-Hausman iterations to get the maximum likelihood estimates of all parameters. Once we have the estimates of all parameters, we have estimates of ε_i , which carry information about u_i . Jondrow et al. (1982) offer two different estimates of cost efficiency, both of which are based on the conditional distribution of u given ε. The estimates can be obtained using either the expected value or the mode of the conditional distribution $f(u \mid \varepsilon)$. That is

$$\hat{u}_{je} = \mathrm{E}(u_i \mid \varepsilon_i) = \mu_{*i} + \sigma_* \left\{ \frac{\phi(-\mu_{*i}/\sigma_*)}{1 - \Phi(-\mu_{*i}/\sigma_*)} \right\}, \text{and} \tag{29}$$

$$\hat{u}_{jm} = \mathrm{M}(u_i \mid \varepsilon_i) = \begin{cases} \mu_{*i} \; if \; \mu_{*i} \geq 0 \\ 0 \; otherwise \end{cases} \tag{30}$$

where $\mu_{*i} = (\varepsilon_i \sigma_u^2)/(\sigma_u^2 + \sigma_v^2)$, $\sigma_* = \sigma_u \sigma_v / \sqrt{\sigma_u^2 + \sigma_v^2}$, and $\phi(\cdot)$ is the standard normal density function. Using one of the point estimates of u offered by Jondrow et al. we can predict the log expenditure per pupil of a district as

$$\widehat{\ln E_i^*} = \mathrm{E}(\ln E_i^* \mid q_i, w_i, z_i, x_i) = \hat{\alpha}_0 + Z_{ij}^* \hat{\alpha}_j' + \hat{u}_{je} \tag{31}$$

where Z_j^* is a vector of variables in the translog specification, and $\hat{\alpha}_0$ and $\hat{\alpha}_j$ are the maximum likelihood estimates of α_0 and α_j , respectively. In order to analyze the marginal effect of each variable that explains the variance of cost inefficiency on the cost inefficiency, we take the derivative of $\hat{u}_{je}$ with respect to that x_j variable. Appendix A presents how we calculate $\partial\hat{u}_{je}/\partial x_j$. Jondrow et al. estimate the cost efficiency by substituting one of these two point estimates of u_i into $\exp\{-u_i\}$. The cost efficiency can also be estimated a la Battese and Coelli (1988) using equation (32)

$$CE_i \equiv \mathrm{E}\{\exp(-u_i)\,|\varepsilon_i\} = \left\{\frac{1-\Phi(\sigma_* - \mu_{*i}/\sigma_*)}{1-\Phi(-\mu_{*i}/\sigma_*)}\right\}\cdot \exp\left(-\mu_{*i} + \frac{1}{2}\sigma_*^2\right) \tag{32}$$

Since $\exp\{\mathrm{E}(u_i \mid \varepsilon_i)\}$ is not equal to and is just a first order approximation to $\mathrm{E}\{\exp(-u_i)\,|\varepsilon_i\}$, we prefer presenting the cost efficiency findings a la Battese and Coelli in our paper. The cost frontier is the standard against which the CE_i above is estimated. Hence $CE_i = 1$ would mean perfect cost efficiency, whereas $CE_i = 0$ would mean perfect cost inefficiency.

3.4. Data

For our analysis, we get the data from the Texas Education Agency (TEA) and the National Center for Education Statistics (NCES). The unit of analysis is the public school districts. Our analysis incorporates all 952 traditional public school districts, which provide K-12 education in 2006-07 school year, and have compete data for that school year. We excluded charter school districts from this study because they may not have the same education production technology public school districts have. Table 16 presents the summary statistics of the variables we used.

We use the natural logarithm of actual current operating expenditures as the dependent variable. We do not include the transportation expenditures with an argument similar to that of Gronberg et al. (2005) that the transportation expenditures would cause additional noise because they are not likely to be identified by the factors that identify the student performance. Also, we do not include food expenditures in order to avoid similar kind of unwanted noise, and due to the fact that the value of the food and other in-kind transfers that public school lunch programs get cannot be measured well. Moreover, as in Gronberg, Jansen and Taylor (2011b), we do not include intergovernmental payments, facility acquisition and construction, community service, and debt service. When we exclude these costs, we find that the mean of Texas public school district operational expenditure per pupil is $8,444 in our sample, with a minimum of $4,745 and a maximum of $25,232.

We include both quantity and quality dimensions of output as independent variables. The quantity dimension we use in this study is measures as the total number of students in a public school district in fall enrollment. This quantity measure varies between 50 and 202,449, with a mean of 4,690 and a median of 1,015.

TABLE 16.—DESCRIPTIVE STATISTICS, TEXAS PUBLIC SCHOOL DISTRICTS

Variable	Mean	Standard Deviation	Minimum	Maximum
Operational expenditure per pupil	8,444	2,225	4,745	25,232
Enrollment	4,690	13,016	50	202,449
Change in TAKS passing rate	0.013	0.042	-0.12	0.25
Percent taking advanced courses	0.183	0.088	0	0.853
Lagged passing rate	0.701	0.105	0.407	0.977
Percent low income students	0.532	0.183	0	0.999
Percent limited English proficiency	0.077	0.092	0	0.687
Percent Special Education students	0.124	0.033	0.04	0.305
Percent high school students	0.301	0.04	0.088	0.557
Distance from major metropolitan areas	107.2	81.2	3.4	365.3
Hedonic predicted salary	1.209	0.092	1	1.463
High school comparable wage index	3.067	0.454	2.493	3.995
Chapter 41 district	0.173	0.379	0	1
HHI-CBSA-ALL (all public and private schools)	0.318	0.233	0.059	1

Number of observations = 952

We use two indicators of quality dimension of output. Our first quality indicator is the annual change in passing rates on the Texas Assessment of Knowledge and Skills (TAKS). This test is given to students in grades 3 to 11 once a year to assess their mathematics and reading/language arts knowledge. We compute the percentage of students in each public school district who passed the exam in 2006-07 school year by analyzing the administrative data on individual student scores, and then we calculate the difference in passing rates by comparing this percentage to the passing rate among the same student body in 2005-06 school year. This difference in the passing rates for a perfectly matched student cohort is our value-added measure. In our sample, the range of this measure is [-0.12, 0.25] and the mean is 0.013, which shows that on average, there is almost no change in the percent passing rates,

With our second quality indicator, we deal with the general critic of how standardized examination like TAKS can intentionally be made easier to pass. It is a common argument that the states have lowered their performance standards to increase the passing rates. Hence, in order to measure the cost effects of higher levels of performance, we introduce an additional public school district performance indicator, which is the percentage of students who completed and advanced course. In our sample, this measure has a mean of 0.183 with a high standard deviation of 0.088. Along with that, the minimum of the measure is zero, while the maximum of it is 0.853, implying that there is a great variation in this quality measure in Texas.

In addition to the quality and quantity measures of output, we employ price indicators for three major educational inputs, teachers, non-teachers and classroom materials, as independent variables. For the teacher price, we use the hedonic wage index of beginning teacher salaries from Gronberg, Jansen and Taylor (2011a). For the salaries of other personnel, we use the comparable wage index (CWI) for high school graduates used by the Texas Comptroller of Public Accounts.[16] We do not add the wage rates of other professionals and administrators as independent variables since they are very highly correlated with the teacher salaries.

To measure the cost of the classroom material and instructional equipment, it would the best to add direct indicators of local prices of these materials. Nevertheless, local price data for these materials do not exist. Actually, the local variation in prices of these materials is mainly due to the transportation costs because the prices for educational material such as notebooks or pencils are mostly determined in the national market. Hence, a sensible approach to measure the non-personnel input prices is to add a measure of geographic isolation as a proxy for the differences in local prices of classroom material. We employ the Haversine formula to calculate the great-circle distance from the location to the closest major metropolitan area and use it as a measure of geographic isolation.

Other than the output and purchased input indicators, our model also includes numerous environmental factors, which are not purchased but affect the district cost. In order to measure the changes in costs due to the differences in needs of the students, we use the percentages of students in each public school district who are classified as economically disadvantaged, high school, special education or limited English proficient

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[16] More information about the comparable wage index for high school graduates without a college degree is available at http://fastexas.org/

(LEP) students. Moreover, since the previous years' achievement level can make it easier or more difficult to increase the passing rates in the current school year, we include the two year lagged (2004-05) TAKS passing rates for grades 3 to 11.

One of the variables that we use to explain the cost efficiency is the Chapter 41 of the Texas Education Code. For the Texas school finance system, school districts are categorized as either property-poor or property-wealthy. The wealth category of a district is determined by calculating the wealth per student of that district, which is equal to the district's prior year tax base divided by Chapter 41 weighted average daily attendance (WADA), and comparing this ratio to a predetermined per student wealth level. In 2006, a district is considered to be property-wealthy (or Chapter 41 district) if the wealth per student of that district is greater than or equal to $319,500. Chapter 41's goal is to redistribute the wealth from property-wealthy school districts to property-poor districts to help the public education in property-poor districts. Accumulation of wealth in districts would result in unproductive, wasteful spending. To analyze this possible effect of capital accumulation on cost inefficiency, we include a dummy variable which takes the value 1 if the district is property-wealthy sometime between 1994 and 2007.

An important contribution of our study is that the model incorporates the competitive effect in school cost inefficiency. For that reason, a competition measure is required for the analysis. Many researcher such as Hoxby (2000), Grosskopf et al. (2001), Holmes, Desimone and Rupp (2006), and Booker et al. (2008) employ Herfindahl-Hirschman indices (HHI) of market concentration to measure the competition in the education market. We follow the literature and use a Herfindahl-

Hirschman index (HHI) of education market concentration based on total district enrollments.

We use all public schools including the charter schools and all private schools—both accredited and nonaccredited—as market participants when calculating the concentration index (ALL). Data on the enrollment and location of the schools come from the Texas Education Agency, National Center for Education’s Common Core of Data (CCD) and Private School Universe Survey (PSS). PSS is carried out every 2 years with the initial collection during the 1989-1990 school year, and last collection during the 2007-2008 school year. The unit of the survey is private elementary and secondary schools, excluding institutions or organizations that offer base for home schooling without providing in-class education for the students. According to the PSS data, there are 2851 private schools in Texas. We assumed private school systems with no administrative connection with other schools to be individual private school districts including the entire grade level that private school system offers. Within each county, all of the Catholic Diocesan schools are controlled by a private central authority, and hence, we found it very sensible to gather these schools as a private school district. We also aggregated Seventh-Day Adventist schools within each county as a private school district. Moreover, we considered some other private schools, which are reported by

TEA to be directed by one central authority, to be in one private school district. Following these guidelines, we determined 2413 private school districts.

We assume that the education markets are the CBSAs identified by the OMB.[17] Therefore, we treat each CBSA as a separate education market. In case a school district is not in any of these CBSAs, we assume that their school district's county is a distinct education market. So the concentration index of a public school district (HHI-CBSA-ALL) is the sum of squared enrollment shares of all of the public school districts and private districts in that district's CBSA, or county if that district is not in a CBSA.[18]

Figure 17 plots the distribution of our school competition measure across the 952 school districts in our sample. As the figure illustrates, the delivery of education services is highly concentrated in many markets in Texas. According to the standards of the Antitrust Division of the U.S. Department of Justice these education markets would have been considered as either moderately concentrated (HHI = [0.10, 0.18]) or concentrated (HHI > 0.18), if these markets were private sector markets.

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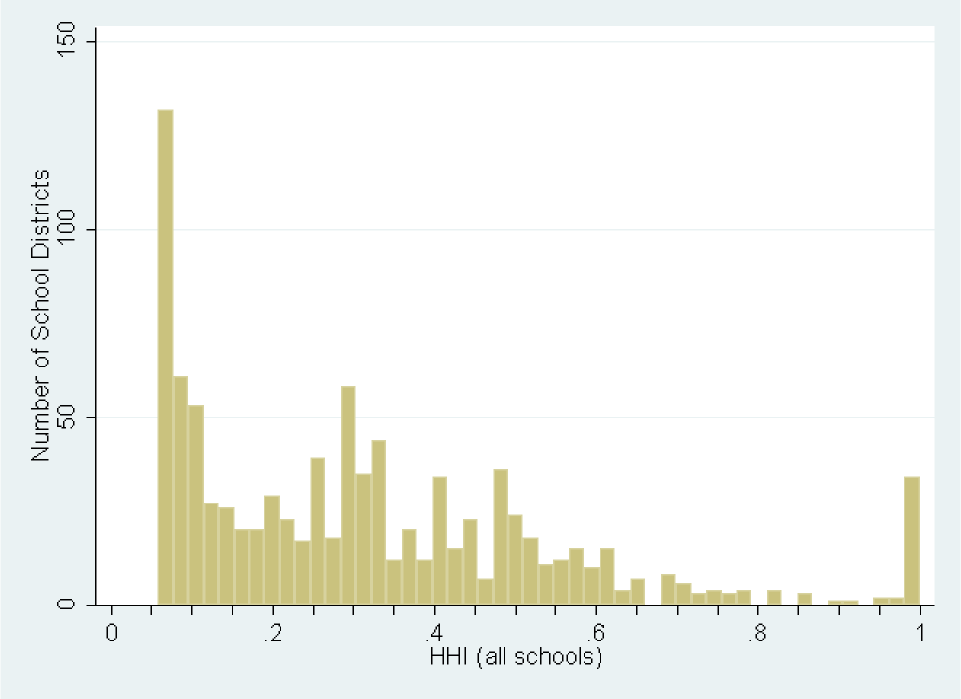
[17] According to the Office of Management and Budget, a metropolitan area contains a core urban population of 50,000 or more, and a micropolitan area contains an urban core population of more than 10,000 but less than 50,000. Each metropolitan or micropolitan area contains counties with the core urban areas and any neighboring counties with a high degree of social and economic integration with the urban core.

[18] There are many Texas school districts which are in multiple counties geographically. The TEA, however, officially associates each public school district with only a single county. If a school district is not in a CBSA, we use the county designated to that district by the TEA as its education market.

FIGURE 17.—DISTRIBUTION OF THE HHI-CBSA-ALL



3.5. Regression Results

Maximization of the likelihood function presented in equation (28) is accomplished by using a looping algorithm of 10 Newton-Raphson iterations followed by 100 Berhdt-Hall-Hall-Hausman iterations. Table 17 presents modified marginal effects from our estimates of the model in equation (23). The parameter estimates from the modified translog model are used to calculate the implied marginal effects on log expenditures per pupil from a change in one of the explanatory variables. Because of the interaction terms in equation (23), these marginal effects depend not only on the estimated model parameters but also on the values of the explanatory variables themselves. One implication is that these marginal effects will, in general, differ for each district. In Table 17, we report the marginal effects of each linear variable evaluated at the mean of all other explanatory variables, and the estimated marginal effects of the quadratic or cubic terms. In the same table, we also present the marginal effects at the means of the values of all of the explanatory variables including the squared and cubic terms. To give an example, the modified marginal effect of enrollment (q_1) presented in the table as "log(Enrollment), linear" is:

$$\omega_{q1} = \alpha_{11} + \sum_{j=1}^{n_2} \alpha_{71j}\overline{w}_j + \sum_{j=1}^{n_3} \alpha_{81j}\overline{z}_j \tag{33}$$

where $\overline{w}_j$ and $\overline{z}_j$ are the means of w_j and z_j respectively. The estimate of squared enrollment $(q_1 q_1)$ presented in the table as "log(Enrollment), squared" is equal to α_{411}, and the estimate of cubic enrollment (q_1^3) presented in the table as "log(Enrollment), cubed" is equal to α_{10}. The marginal effect of enrollment at the means of the values of all of the explanatory variables including the squared and cubed terms is presented in the table as "log(Enrollment), joint" and is equal to:

$$\psi_{q1} = \alpha_{11} + \sum_{j=1}^{n_2} \alpha_{71j}\overline{w}_j + \sum_{j=1}^{n_3} \alpha_{81j}\overline{z}_j + 2\alpha_{411}\overline{q}_1 + 3\alpha_{10}\overline{q}_1^2 \tag{34}$$

TABLE 17.—MODIFIED MARGINAL EFFECTS, MAIN SPECIFICATIONS (MULTIPLE PAGES)

	No HHI	HHI-CBSA-ALL Linear	HHI-CBSA-ALL Quadratic
log(Enrollment), linear	-0.768 *** (0.132)	-0.771 *** (0.131)	-0.773 *** (0.131)
log(Enrollment), squared	0.068 *** (0.016)	0.069 *** (0.016)	0.070 *** (0.016)
log(Enrollment), cubed	-0.002 *** (0.001)	-0.002 *** (0.001)	-0.002 *** (0.001)
log(Enrollment), joint	-0.095 *** (0.005)	-0.094 *** (0.005)	-0.094 *** (0.005)
log(Change in TAKS passing rate), linear	0.219 ** (0.109)	0.254 ** (0.108)	0.254 ** (0.108)
log(Change in TAKS passing rate), squared	-0.967 (1.469)	-1.034 (1.455)	-1.004 (1.457)
log(Change in TAKS passing rate), joint	0.195 * (0.102)	0.228 ** (0.102)	0.229 ** (0.102)
Percent taking advanced courses, linear	0.374 ** (0.148)	0.367 ** (0.147)	0.366 ** (0.147)
Percent taking advanced courses, squared	-0.531 (0.324)	-0.521 (0.322)	-0.515 (0.321)
Percent taking advanced courses, joint	0.180 *** (0.053)	0.176 *** (0.053)	0.177 *** (0.053)
Lagged passing rate, linear	-0.181 (0.602)	-0.074 (0.605)	-0.066 (0.606)
Lagged passing rate, squared	0.111 (0.431)	0.039 (0.432)	0.035 (0.433)
Lagged passing rate, joint	-0.025 (0.049)	-0.019 (0.049)	-0.017 (0.049)
Percent low income students, linear	0.151 (0.241)	0.137 (0.239)	0.131 (0.239)
Percent low income students, squared	0.120 (0.221)	0.135 (0.219)	0.140 (0.219)
Percent low income students, joint	0.279 *** (0.035)	0.281 *** (0.034)	0.280 *** (0.034)
Percent limited English proficiency, linear	-0.054 (0.119)	-0.077 (0.120)	-0.073 (0.120)
Percent limited English proficiency, squared	0.196 (0.480)	0.238 (0.480)	0.229 (0.481)

TABLE 17.—MODIFIED MARGINAL EFFECTS, MAIN SPECIFICATIONS (MULTIPLE PAGES)

	No HHI	HHI-CBSA-ALL Linear	HHI-CBSA-ALL Quadratic
Percent limited English proficiency, joint	-0.024	-0.040	-0.038
	(0.086)	(0.086)	(0.086)
Percent Special Education Students, linear	-1.006	-1.043	-1.026
	(0.749)	(0.744)	(0.745)
Percent Special Education Students, squared	6.828 **	7.018 **	6.951 **
	(2.794)	(2.774)	(2.779)
Percent Special Education Students, joint	0.688 ***	0.699 ***	0.699 ***
	(0.138)	(0.137)	(0.137)
Percent High school Students, linear	-2.991 ***	-3.228 ***	-3.235 ***
	(0.901)	(0.895)	(0.898)
Percent High school Students, squared	5.184 ***	5.536 ***	5.548 ***
	(1.438)	(1.427)	(1.431)
Percent High school Students, joint	0.130	0.105	0.105
	(0.121)	(0.121)	(0.121)
log(Distance), linear	-0.100 **	-0.101 **	-0.100 **
	(0.050)	(0.050)	(0.050)
log(Distance), squared	0.015 ***	0.015 ***	0.015 ***
	(0.006)	(0.006)	(0.006)
log(Distance), joint	0.034 ***	0.029 ***	0.029 ***
	(0.007)	(0.007)	(0.007)
log(Hedonic predicted salary), linear	-0.408	-0.349	-0.380
	(0.625)	(0.653)	(0.654)
log(Hedonic predicted salary), squared	2.503	2.253	2.346
	(1.629)	(1.713)	(1.716)
log(Hedonic predicted salary), joint	0.527 ***	0.493 ***	0.497 ***
	(0.102)	(0.102)	(0.102)
log(High school comparable wage), linear	-2.834 ***	-2.344 **	-2.319 **
	(1.090)	(1.109)	(1.113)
log(High school comparable wage), squared	1.190 **	0.997 **	0.987 **
	(0.491)	(0.498)	(0.499)
log(High school comparable wage), joint	-0.192 ***	-0.131 **	-0.127 **
	(0.052)	(0.054)	(0.054)
Observations	952	952	952
Log Likelihood	864.7	870.9	871.2

TABLE 17.—MODIFIED MARGINAL EFFECTS, MAIN SPECIFICATIONS (MULTIPLE PAGES)

	No HHI	HHI-CBSA-ALL Linear	HHI-CBSA-ALL Quadratic
Explanatory Variables for Cost Inefficiency Variance Function, $\log(\sigma_u^2)$			
Chapter 41	1.829 *** (0.303)	1.655 *** (0.288)	1.666 *** (0.307)
HHI-CBSA-ALL		1.411 *** (0.412)	2.274 * (1.307)
HHI-CBSA-ALL Squared			-0.825 (1.181)
Constant	-5.187 *** (0.388)	-5.526 *** (0.442)	-5.696 *** (0.543)
Explanatory Variables for Idiosyncratic Error Variance Function, $\log(\sigma_v^2)$			
1 / log(Enrollment)	28.244 *** (2.562)	27.310 *** (2.580)	26.979 *** (2.607)
Constant	-9.250 *** (0.456)	-9.154 *** (0.466)	-9.092 *** (0.479)

Note: The dependent variable is log(Expenditure per pupil). Standard errors are in parentheses. Triple asterisk (***) means significance at the 1% level. Double asterisk (**) means significance at the 5% level. Single asterisk (*) means significance at the 10% level.

The estimated properties of the core cost function are generally consistent with theoretical expectations. It costs significantly more to produce higher levels of output quality. This is true for both quality measures—changes in passing rates and percent of students taking advanced courses. Districts that must offer higher teacher wages have higher per pupil costs. Districts that operate in environments that require the adoption of more resource intensive instructional technologies also have higher costs. Relevant environmental factors here include the percentage of economically disadvantaged students, percentage of special education students and remoteness from large metropolitan areas. For an example, when evaluated at the sample mean values for all explanatory variables (including the squared term), the cost of educating an economically disadvantaged student is 28 percent higher than is the cost for educating a student who is not eligible for free or reduced lunch.

One focus of our analysis is upon evidence of the existence and extent of economies to student population size. Figure 18 and Figure 19 plot predicted cost per pupil against enrollment.[19] The predicted cost in these figures are generated for a hypothetical representative district with all cost factors except for scale held constant at sample mean values. We find that the impact of scale is not the traditional U-shape. We do find a region of increasing average cost per pupil from $6,477 to $6,608 over the enrollment range from 20,518 to 303,028 students, but the increase in average cost per pupil is with a decreasing speed after 78,850 students at $6,542 per pupil, and average cost starts declining as the district size exceeds 303,028 students. Thus there may be continual economies of scale associated with extremely large enrollments but since there is only two data points over that range, this finding cannot be strongly suggested. Yet, this second region of declining average costs is, to the best of our knowledge, unique to our study of school costs.[20] This finding is fundamentally due to the inclusion of the cubic enrollment in our model specification. If we drop the cubic term and estimate the

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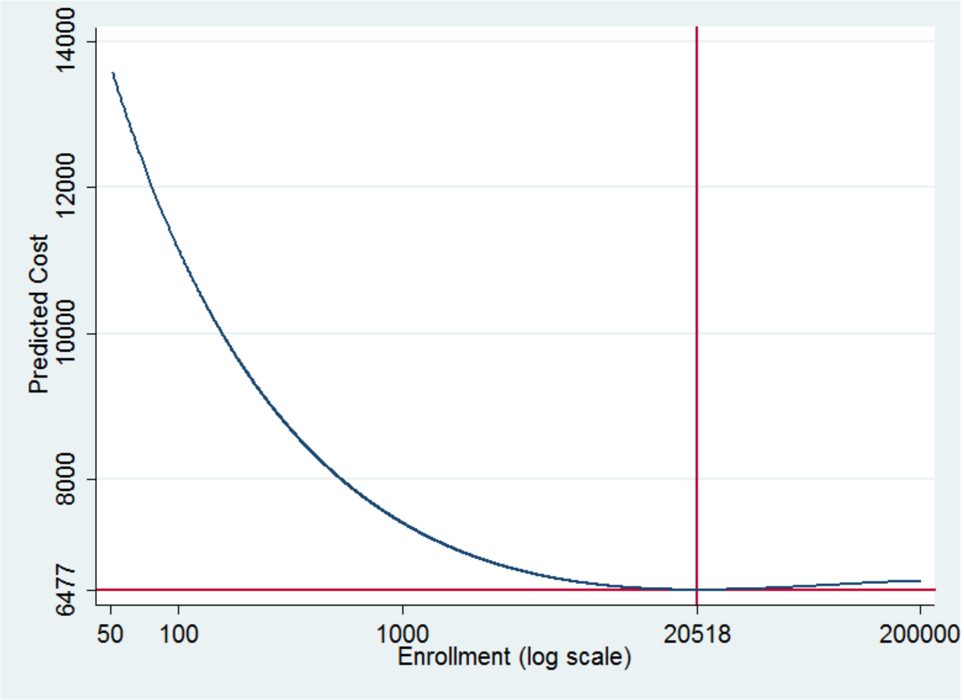
[19] The figures are over a scale from 50 to 736,972 because 50 is the minimum enrollment in our sample and 736,972 is the total enrollment in Harris, the biggest county in Texas in terms of enrollment. A district size of 736,972 can realize in Texas if a consolidation scenario to convert each county to a single district were to put into practice. This consolidation scenario is actually proposed, and consequences of such a scenario are examined thoroughly in our simulation section.

[20] The biggest district in Texas in terms of enrollment is Houston ISD with 202,449 students in 2006-07 school year. A consolidation of districts at county level would result in a district, "Harris ISD," which would have 736,972 students. Hence, some cost savings due to being in the second region of declining average costs can actually realize in Texas if the competitive effect does not dominate the scale effect.

standard quadratic- in-enrollment type of model, we estimate a traditional U-shaped average per pupil cost curve, with increasing average costs to enrollments greater than 18,137. A likelihood-ratio test, however, rejects the restricted quadratic model in favor of the cubic model specification.[21]

FIGURE 18.—PREDICTED COST PER PUPIL, ENROLLMENT < 200,000



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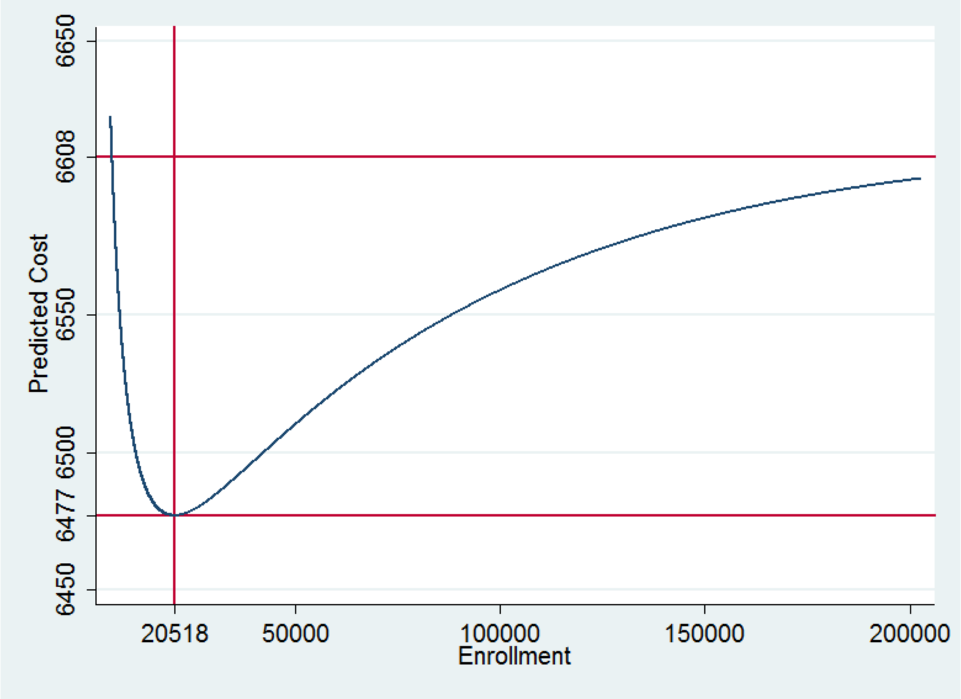
[21] Likelihood-ratio test is LR $= 10.5$ and probability of a larger value of $\chi^2(1) = 0.0012$. Therefore, the cubic term results in a statistically significant improvement in the model fit.

FIGURE 19.—PREDICTED COST PER PUPIL, ENROLLMENT > 20,518



Gronberg, Jansen and Taylor (2011a) argue that the stochastic frontier approach is a theoretically sound response to the faux-cost-function criticisms. If school districts were largely efficient, then no response would be necessary, and there would be no advantage to using stochastic frontier analysis. The one-sided error term would be negligible, and frontier analysis would yield the same coefficient estimates as would classical linear regression. However, our analysis finds evidence of significant one-sided error in the regression, implying substantial cost inefficiency. As presented in the baseline column of Table 17, Chapter 41 has a positive and significant effect on the variance of cost inefficiency implying that capital accumulation contributes to the cost inefficiency. In the second column, we present that HHI-CBSA-ALL also has a positive and significant effect on the variance of cost inefficiency. We find that the marginal effect of HHI-CBSA-ALL on cost inefficiency is 0.030. Furthermore, we test if the variance of cost inefficiency is a quadratic function of HHI. As presented in the third columns, however, the likelihood ratio test rejects the inclusion of the squared HHI term.

In Figure 20, we show the distribution of estimated efficiency values for each school district in our sample. The distribution is heavily skewed, with observations piling up between 90 and 98 percent efficiency and a long left tail of observations extending to a minimum value of 53 percent efficiency. The average level of efficiency among the traditional public school districts in our sample is 92 percent. By way of comparison, Gronberg, Jansen and Naufal (2006) reported estimates centered around 90 percent for a variety of efficiency estimates for Texas schools.

FIGURE 20.—DISTRIBUTION OF COST EFFICIENCY

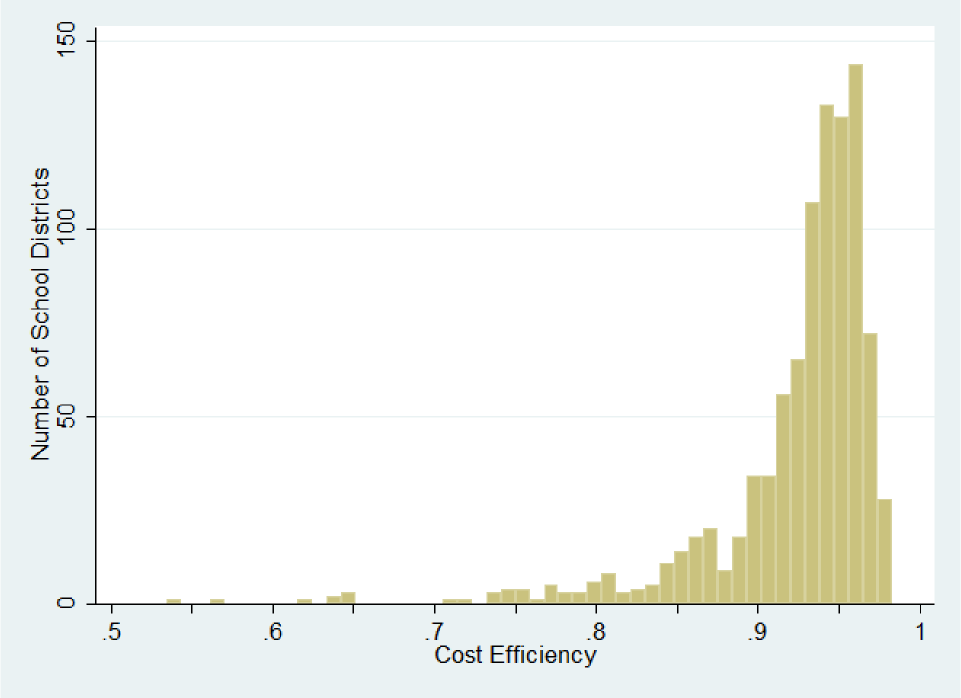
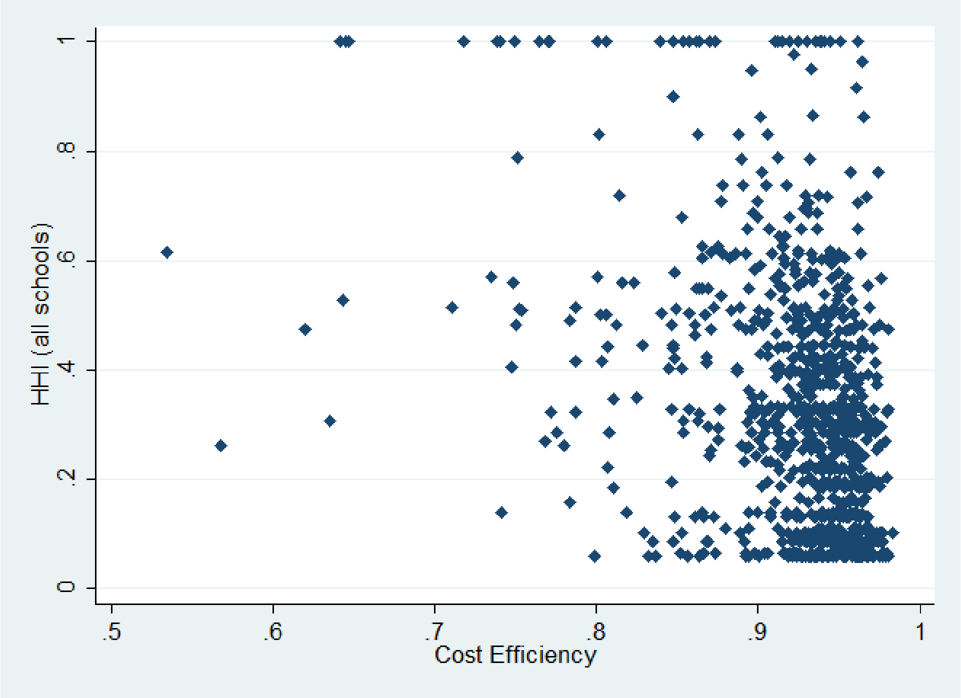


Figure 21 provides information on the relationship between estimated inefficiency and measured competition for our Texas sample of districts. The graph shows the scatterplot of HHI against our estimated cost efficiency. We see that the plots are concentrated in the HHI range of 0 to 0.6 and cost efficiency index values in the rage of 0.8 to 1. That is, most districts are between 80% and 100% efficiency, and have concentration measures between 0 and 0.6. However, there are many values for smaller values of the cost efficiency index and many values with HHI values above 0.6.

FIGURE 21.—SCATTERPLOT OF THE HHI-CBSA-ALL VERSUS COST EFFICIENCY



In Figure 22 and Figure 23, we present a map of our concentration measure and a map of Texas school district cost efficiency. In Figure 22, darker shades indicate more concentration, and in Figure 23, darker shades indicate more cost efficiency. When we compare the maps, we see that the relatively more cost efficient districts are concentrated around the metropolitan areas where HHI values are relatively lower. The cost efficiencies of the districts in western Texas, however, are generally between 50% and 90%, where HHI values are more than 0.50.

FIGURE 22.—TEXAS MAP OF THE HHI-CBSA-ALL

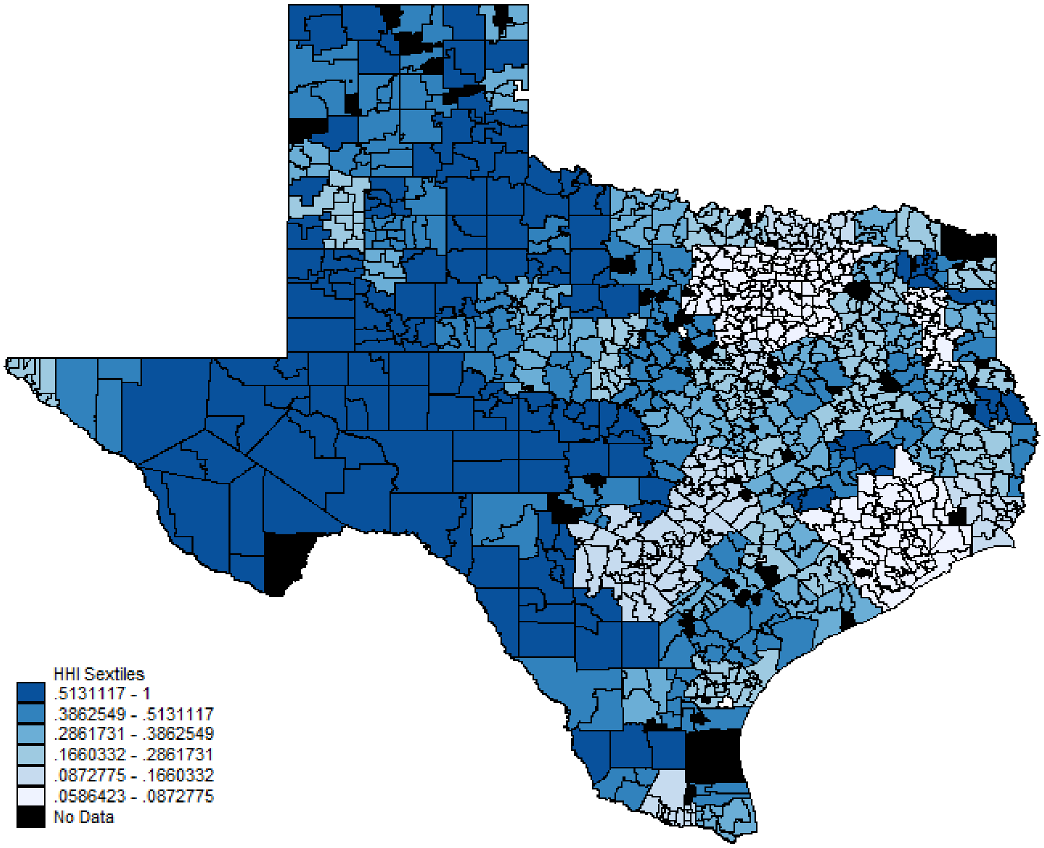
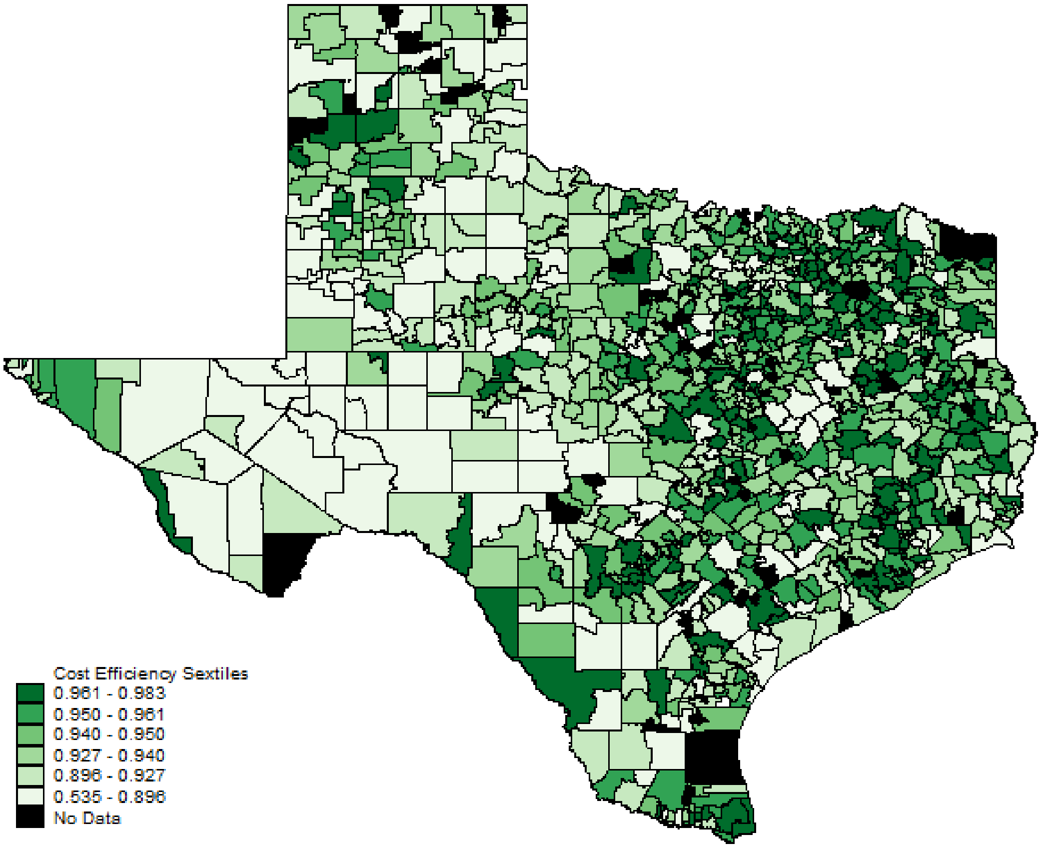


Figure 23.—Texas Map of Cost Efficiency



As noted earlier, the one-step scaling approach to stochastic frontier analysis allows us to model the one-sided inefficiency error term. In our case, the two critical theoretical determinants of inefficiency are Chapter 41 status and competition. The principal point of departure in our study is the assessment of the competition-efficiency relationship. As reported in Table 17, the estimated relationship between inefficiency and the Herfindahl concentration index is positive and significant. Since higher values for the Herfindahl index are associated with a less competitive market structure, our results support the hypothesis that a decrease in competitive market structure is associated with an increase in cost inefficiency. Quantitatively, the estimated marginal effects suggest that an increase of 0.1 in the HHI-CBSA-ALL results in an increased inefficiency of less than 1% (0.3%). Thus a fairly large increase in market concentration has a small but positive impact on school district inefficiency.

3.5.1. Alternative Specifications

In order to examine the sensitivity of our results presented in Table 18, we ran several alternative specification of our model in equation (23). Table 18 shows modified marginal effects from our alternative specifications. In the first column, we exclude Houston ISD and Dallas ISD from our sample and estimate our model. Houston ISD and Dallas ISD are the two biggest public districts in Texas and can be considered as two outliers in terms of enrollment. For that reason, the results presented in the second column of Table 17 may be sensitive to including these districts in our sample. The first column of Table 18, however, presents that the estimation results do not change in sign or significance, and their magnitudes do not change much either, implying that the results in the second column of Table 17 are not sensitive to inclusion of Houston ISD and Dallas ISD.

TABLE 18.—MODIFIED MARGINAL EFFECTS, ALTERNATIVE SPECIFICATIONS (MULTIPLE PAGES)

	Houston & Dallas Excluded	Low Density Excluded	High Density Excluded	Spline
log(Enrollment), linear	-0.775 ***	-0.605 ***	-0.699 ***	-0.776 ***
	(0.149)	(0.141)	(0.176)	(0.131)
log(Enrollment), squared	0.070 ***	0.050 ***	0.059 ***	0.070 ***
	(0.018)	(0.017)	(0.022)	(0.016)
log(Enrollment), cubed	-0.002 ***	-0.001 *	-0.002 *	-0.002 ***
	(0.001)	(0.001)	(0.001)	(0.001)
log(Enrollment), joint	-0.094 ***	-0.088 ***	-0.103 ***	-0.094 ***
	(0.005)	(0.005)	(0.006)	(0.005)
log(Change in TAKS passing rate), linear	0.254 **	0.269 **	0.270 **	0.258 **
	(0.108)	(0.111)	(0.110)	(0.109)
log(Change in TAKS passing rate), squared	-1.035	-1.845	-0.985	-0.977
	(1.452)	(1.527)	(1.433)	(1.460)
log(Change in TAKS passing rate), joint	0.228 **	0.223 **	0.245 **	0.234 **
	(0.102)	(0.105)	(0.103)	(0.103)
Percent taking advanced courses, linear	0.369 **	0.312 *	0.422 ***	0.368 **
	(0.147)	(0.177)	(0.153)	(0.146)
Percent taking advanced courses, squared	-0.525	-0.391	-0.679 **	-0.508
	(0.322)	(0.410)	(0.342)	(0.318)
Percent taking advanced courses, joint	0.177 ***	0.170 ***	0.178 ***	0.182 ***
	(0.053)	(0.054)	(0.055)	(0.053)
Lagged passing rate, linear	-0.078	0.068	-0.419	-0.056
	(0.605)	(0.628)	(0.626)	(0.606)
Lagged passing rate, squared	0.042	-0.059	0.269	0.028
	(0.433)	(0.449)	(0.448)	(0.433)
Lagged passing rate, joint	-0.019	-0.014	-0.042	-0.016
	(0.049)	(0.050)	(0.051)	(0.049)
Percent low income students, linear	0.137	0.207	-0.003	0.118
	(0.239)	(0.249)	(0.259)	(0.239)
Percent low income students, squared	0.135	0.070	0.271	0.150
	(0.219)	(0.230)	(0.240)	(0.219)
Percent low income students, joint	0.281 ***	0.281 ***	0.284 ***	0.278 ***
	(0.034)	(0.035)	(0.036)	(0.035)
Percent limited English proficiency, linear	-0.075	-0.104	-0.110	-0.069
	(0.120)	(0.121)	(0.130)	(0.120)
Percent limited English proficiency, squared	0.243	0.389	0.370	0.244
	(0.485)	(0.507)	(0.545)	(0.481)

Table 18.—Modified Marginal Effects, Alternative Specifications (Multiple Pages)

	Houston & Dallas Excluded	Low Density Excluded	High Density Excluded	Spline
Percent limited English proficiency, joint	-0.038	-0.044	-0.058	-0.031
	(0.086)	(0.086)	(0.093)	(0.086)
Percent Special Education Students, linear	-1.051	-0.653	-1.392 *	-0.977
	(0.743)	(0.774)	(0.765)	(0.749)
Percent Special Education Students, squared	7.051 **	5.670 *	8.214 ***	6.790 **
	(2.771)	(2.915)	(2.818)	(2.794)
Percent Special Education Students, joint	0.699 ***	0.757 ***	0.667 ***	0.708 ***
	(0.137)	(0.136)	(0.142)	(0.138)
Percent High school Students, linear	-3.221 ***	-3.205 ***	-3.383 ***	-3.241 ***
	(0.898)	(0.926)	(0.941)	(0.900)
Percent High school Students, squared	5.522 ***	5.517 ***	5.784 ***	5.564 ***
	(1.431)	(1.485)	(1.496)	(1.435)
Percent High school Students, joint	0.105	0.097	0.114	0.109
	(0.121)	(0.123)	(0.126)	(0.121)
log(Distance), linear	-0.102 **	-0.121 **	-0.087	-0.100 **
	(0.051)	(0.050)	(0.062)	(0.050)
log(Distance), squared	0.015 ***	0.017 ***	0.014 **	0.015 ***
	(0.006)	(0.006)	(0.007)	(0.006)
log(Distance), joint	0.030 ***	0.026 ***	0.033 ***	0.028 ***
	(0.007)	(0.007)	(0.008)	(0.007)
log(Hedonic predicted salary), linear	-0.347	0.022	-0.214	-0.409
	(0.652)	(0.723)	(0.645)	(0.657)
log(Hedonic predicted salary), squared	2.258	1.077	2.009	2.464
	(1.712)	(1.898)	(1.743)	(1.725)
log(Hedonic predicted salary), joint	0.496 ***	0.428 ***	0.513 ***	0.512 ***
	(0.102)	(0.104)	(0.108)	(0.104)
log(High school comparable wage), linear	-2.353 **	-2.420 **	-2.004 *	-2.327 **
	(1.110)	(1.139)	(1.149)	(1.125)
log(High school comparable wage), squared	1.000 **	1.033 **	0.841	0.991 **
	(0.498)	(0.509)	(0.519)	(0.504)
log(High school comparable wage), joint	-0.133 **	-0.112 **	-0.152 ***	-0.125 **
	(0.054)	(0.053)	(0.057)	(0.055)
Observations	950	904	904	952
Log Likelihood	867.3	871.7	800.2	872.4

TABLE 18.—MODIFIED MARGINAL EFFECTS, ALTERNATIVE SPECIFICATIONS (MULTIPLE PAGES)

	Houston & Dallas Excluded	Low Density Excluded	High Density Excluded	Spline
Explanatory Variables for Cost Inefficiency Variance Function, $\log(\sigma_u^2)$				
Chapter 41	1.643 *** (0.275)	1.524 *** (0.355)	1.609 *** (0.242)	1.769 *** (0.492)
HHI-CBSA-ALL	1.373 *** (0.402)	1.124 ** (0.469)	1.118 *** (0.389)	3.870 ** (1.835)
(HHI – 0.303) × D(HHI > 0.303) (CBSA-ALL)				-3.010 (1.938)
Constant	-5.477 *** (0.413)	-5.560 *** (0.572)	-5.214 *** (0.337)	-6.192 *** (1.036)
Explanatory Variables for Idiosyncratic Error Variance Function, $\log(\sigma_v^2)$				
1 / log(Enrollment)	27.316 *** (2.600)	25.695 *** (2.844)	26.022 *** (2.743)	25.794 *** (2.827)
Constant	-9.169 *** (0.467)	-8.884 *** (0.514)	-9.042 *** (0.486)	-8.861 *** (0.584)

Note: The dependent variable is log(Expenditure per pupil). Standard errors are in parentheses. Triple asterisk (***) means significance at the 1% level. Double asterisk (**) means significance at the 5% level. Single asterisk (*) means significance at the 10% level.

District density may be suggested to play an important role in getting the results in Table 17. We define density of a district as the enrollment in that district over the geographical size of the district. Hence, districts with low density are those with greater land area but lower levels of enrollment relatively, and districts with high density are those with smaller land area but higher levels of enrollment relatively. Extremely low density districts may be expected to be consistently low performers in terms of efficiency for the reason that these districts are generally located in remote urban areas with lower levels of competition. Extremely high density districts may be expected to be consistently high cost efficiency districts for the reason that high density districts are commonly found in highly competitive locations. Therefore, extremely low density and high density districts in our sample may be the driving force in our findings. In order to test these possibilities, we first exclude the districts with a density lower than the 5th percentile from our sample. The results from that estimation are presented in the second column of Table 18. We find that excluding the low density districts does not change our findings much in magnitude, sign or significance. Secondly, we exclude the districts with a density higher than the 95th percentile from our sample. The results from that estimation are shown in the third column in Table 18. Again, our findings present that our main results in Table 17 are not sensitive to including the extremely high density districts to the sample.

For the last column of Table 18, we search for a possible break point on the cost inefficiency variance function with respect to the HHI-CBSA-ALL. To search for such a point, along with the HHI variable, we include $(\mathrm{HHI} - \mathrm{HHI}_{br}) \times \mathrm{D}(\mathrm{HHI} > \mathrm{HHI}_{br})$ as an explanatory variable of the variance of cost inefficiency. Here, HHI_{br} stands for the point where the variance of cost inefficiency is continuous but not differentiable, and $\mathrm{D}(\mathrm{HHI} > \mathrm{HHI}_{br})$ is equal to 1 if $\mathrm{HHI} > \mathrm{HHI}_{br}$, and 0 otherwise. We try all the available HHI values in our sample as HHI_{br} and find that the log likelihood of the estimation maximizes when HHI_{br} is equal to 0.303. The statistical significance, signs and magnitudes of the coefficients other than that of HHI presented in the Spline column in Table 18 are similar to those in Table 17. Nevertheless, according to the likelihood ratio test, the inclusion of $(\mathrm{HHI} - \mathrm{HHI}_{br}) \times \mathrm{D}(\mathrm{HHI} > \mathrm{HHI}_{br})$ does not result in a statistically significant improvement in the model fit at 5% level. Hence we do not include the variable as an explanatory variable of the variance of cost inefficiency.

3.5.2. Sensitivity to Different Competition Measures

The results presented so far may be sensitive to how competition in the education market is measured. The common approach in the literature is to use Herfindahl-Hirschman indices to measure the market concentration. However, different sets of potential competitors and the geographic definition of the market would change these indices, which, in turn, may change the coefficient estimates, signs and significance of the HHI variables in the regression.

First, the HHI used to generate the results in Table 17 assumes that public school districts and all of the private schools (ALL) belong to the set of potential competitors. This, however, may not be true if private schools are not direct competitors with the public school districts. Hence, we measured the HHI with only public schools (PUB) as one of the alternative approaches. Alternatively, the concentration measure may include accredited private schools along with the public school districts (ACC) since accreditation status of private schools can be used to determine their degree of substitutability. In the state of Texas, the Texas Private School Accreditation Commission (TEPSAC) accredits non-public primary and secondary educational organization by controlling and endorsing those institutions and ensuring their quality. Going to an accredited non-public school has the advantage of transferability of student credits earned in the accredited non-public schools to Texas public schools. So, one would expect accredited private schools to be good substitutes for public schools. Hence, potential market participants may include the accredited private schools along with the public schools districts.[22]

Furthermore, the assumption that the education markets are the CBSAs determined by the OMB may not be suitable. The OMB has certain guidelines based on urban core populations to determine the CBSAs. However, these guidelines do not necessarily delineate the education markets. Several alternative assumptions about the borders of the education markets can be made which would result in a completely different set of education markets. For instance, one equally plausible assumption can be that counties, instead of the CBSAs, are the separate education markets. This assumption would increase the number of education markets in a state, and would generate different concentration ratios for the counties within a CBSA.

It is also possible to define the district-specific markets by the spatial distribution of the competitors. Simple geometrical shapes such as circles around schools in a district can be used to delineate the relevant education markets for that district. In order to calculate the HHI with such a market definition, we assume that the relevant geographic market for each school district includes all of the districts with at least one school within a 15-mile radius circle (R15) around each of the district's own schools. Figure 1 illustrates this method. In the figure, rectangles represent school districts, and black spots represent schools. There are three schools in the district with the star. When circles of

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[22] Out of 1,116 private schools in 2006-07 school year, 577 are accredited by TEPSAC. In that school year, total private enrollment in Texas is 193,393 and enrollment in approved private schools is 151,952, which corresponds to %79 of the total private enrollment.

the specified radius are drawn around those schools, we see that four other districts surrounding the star district have schools in those circles. Those districts along with the star district are shaded in gray which represents the education market for the star district. Of course, 15-mile radius is arbitrarily chosen. In order to check the sensitivity on the measure with respect to the size of the radius, we generate two other indices with 25-mile radius (R25), and 50-mile radius (R50) criteria.

Finally, we explore the possibility of the rings in education markets, in which the schools at the outer rings contribute to the competition in the education market less than the schools at the core. This would somehow incorporate the distance between the competitors to the concentration measure. In a sense, rings measure is similar to the radial measure of competition that we assume that the relevant core for each school district includes all of the districts with at least one school within a 15-mile radius circle around each of the district's own schools. In addition to that, however, we also assume that the relevant periphery for each school district includes all of the districts with at least one school within a ring formed by a 15-mile radius and a 50-mile radius circle around each of the district's own schools. We assume that the contribution of the districts in the periphery to the concentration index is by half of what would normally be counted in a Herfindahl index. Because of the peripheral contribution, the ring HHI of concentration for a district would always be smaller than (or in some cases equal to) the 15-mile radius HHI of concentration. Table 19 displays the pairwise correlations between the different HHIs presented in this section, and Table 20 reports their summary statistics.

Table 19.—Pairwise Correlations Between the HHIs, Texas Data

		a	b	c	d	e	f	g	h
HHI-CBSA-ALL	a	1.00							
HHI-R15-ALL	b	0.72	1.00						
HHI-R25-ALL	c	0.66	0.73	1.00					
HHI-R50-ALL	d	0.53	0.55	0.62	1.00				
HHI-County-ALL	e	0.87	0.67	0.63	0.48	1.00			
HHI-CBSA-PUB	f	0.99	0.72	0.66	0.53	0.87	1.00		
HHI-R15-PUB	g	0.71	0.98	0.73	0.56	0.68	0.72	1.00	
HHI-R25-PUB	h	0.65	0.71	0.97	0.62	0.64	0.65	0.72	1.00
HHI-R50-PUB	i	0.52	0.54	0.62	0.98	0.48	0.52	0.55	0.61
HHI-County-PUB	j	0.87	0.67	0.63	0.48	0.99	0.87	0.68	0.64
HHI-CBSA-ACC	k	0.99	0.72	0.66	0.53	0.87	0.99	0.71	0.65
HHI-R15-ACC	l	0.71	0.99	0.73	0.55	0.67	0.72	0.98	0.71
HHI-R25-ACC	m	0.66	0.73	0.99	0.62	0.63	0.66	0.73	0.97
HHI-R50-ACC	n	0.52	0.55	0.62	0.99	0.48	0.53	0.56	0.62
HHI-County-ACC	o	0.87	0.67	0.63	0.48	0.99	0.87	0.68	0.64
HHI-Rings-ALL	p	0.73	0.96	0.77	0.76	0.68	0.74	0.95	0.76

		i	j	k	l	m	n	o	p
HHI-R50-PUB	i	1.00							
HHI-County-PUB	j	0.48	1.00						
HHI-CBSA-ACC	k	0.52	0.87	1.00					
HHI-R15-ACC	l	0.54	0.67	0.71	1.00				
HHI-R25-ACC	m	0.62	0.63	0.66	0.73	1.00			
HHI-R50-ACC	n	0.98	0.48	0.52	0.55	0.62	1.00		
HHI-County-ACC	o	0.48	0.99	0.87	0.67	0.63	0.48	1.00	
HHI-Rings-ALL	p	0.74	0.68	0.73	0.96	0.78	0.76	0.68	1.00

Note: The tags following the HHI names denote the market definition and the set of competitors.

TABLE 20.—DESCRIPTIVE STATISTICS OF THE HHIS, TEXAS DATA

Variable	Mean	Standard Deviation	Minimum	Maximum
HHI-CBSA-ALL	0.318	0.233	0.059	1
HHI-R15-ALL	0.4	0.258	0.014	1
HHI-R25-ALL	0.241	0.18	0.014	1
HHI-R50-ALL	0.131	0.111	0.027	0.812
HHI-County-ALL	0.391	0.222	0.116	1
HHI-CBSA-PUB	0.331	0.237	0.065	1
HHI-R15-PUB	0.414	0.263	0.014	1
HHI-R25-PUB	0.249	0.185	0.014	1
HHI-R50-PUB	0.136	0.118	0.027	1
HHI-County-PUB	0.391	0.222	0.116	1
HHI-CBSA-ACC	0.33	0.238	0.067	1
HHI-R15-ACC	0.401	0.26	0.014	1
HHI-R25-ACC	0.241	0.181	0.014	1
HHI-R50-ACC	0.131	0.112	0.027	1
HHI-County-ACC	0.391	0.222	0.116	1
HHI-Rings-ALL	0.266	0.166	0.024	0.906
Number of observations = 952				

Note: The tags following the HHI names denote the market definition and the set of competitors.

Table 21, Table 22, Table 23, and Table 24 present the estimation results of the model in (23) with different measures of competition. First, the results show that holding everything else constant, measuring the HHI with three different sets of competitors does not change the signs or significance of the results. That is, the sign and significance of the marginal effect of concentration on cost inefficiency is not sensitive to using different measures of concentration. Moreover, actual value of the marginal effect of concentration does not seem to change much as the sets of competitors used to measure the HHI change. For example, if HHI-R15-ALL is the concentration measure, the marginal effect of concentration is 0.0225, but if the concentration measure is HHI-R15-PUB or HHI-R15-ACC, then the marginal effect of concentration is 0.021 or 0.022, respectively.

Secondly, using different market definitions seem to change the degree of marginal effect of concentration in a positive and relatively small range. The marginal effect of concentration with the HHIs measured with the market defined as counties are somewhat smaller than that of HHI-CBSAs. For instance, the marginal effect of concentration is 0.03 when HHI-CBSA-ALL is used, but it is 0.0198 if HHI-County-ALL is used. Furthermore, as the radius of the radial measures of concentration increases the marginal effect of concentration increases. To give an example, the marginal effect of HHI-R15-ALL on cost inefficiency is 0.0225, while the marginal effect of HHI-R25-ALL on cost inefficiency is 0.0355 and the marginal effect of HHI-R50-ALL on cost

TABLE 21.—MODIFIED MARGINAL EFFECTS WITH DIFFERENT HHIS – 1 (MULTIPLE PAGES)

	HHI-CBSA-ALL	HHI-R15-ALL	HHI-R25-ALL	HHI-R50-ALL
log(Enrollment), linear	-0.771 *** (0.131)	-0.750 *** (0.130)	-0.740 *** (0.130)	-0.725 *** (0.131)
log(Enrollment), squared	0.069 *** (0.016)	0.067 *** (0.016)	0.066 *** (0.016)	0.063 *** (0.016)
log(Enrollment), cubed	-0.002 *** (0.001)	-0.002 *** (0.001)	-0.002 *** (0.001)	-0.002 *** (0.001)
log(Enrollment), joint	-0.094 *** (0.005)	-0.093 *** (0.005)	-0.093 *** (0.005)	-0.095 *** (0.005)
log(Change in TAKS passing rate), linear	0.254 ** (0.108)	0.235 ** (0.105)	0.241 ** (0.105)	0.236 ** (0.105)
log(Change in TAKS passing rate), squared	-1.034 (1.455)	-0.672 (1.420)	-0.696 (1.414)	-0.725 (1.428)
log(Change in TAKS passing rate), joint	0.228 ** (0.102)	0.218 ** (0.100)	0.224 ** (0.099)	0.218 ** (0.099)
Percent taking advanced courses, linear	0.367 ** (0.147)	0.364 ** (0.147)	0.343 ** (0.146)	0.336 ** (0.147)
Percent taking advanced courses, squared	-0.521 (0.322)	-0.516 (0.322)	-0.460 (0.321)	-0.459 (0.322)
Percent taking advanced courses, joint	0.176 *** (0.053)	0.175 *** (0.053)	0.175 *** (0.052)	0.168 *** (0.052)
Lagged passing rate, linear	-0.074 (0.605)	0.129 (0.602)	0.137 (0.600)	0.123 (0.601)
Lagged passing rate, squared	0.039 (0.432)	-0.104 (0.430)	-0.110 (0.429)	-0.095 (0.430)
Lagged passing rate, joint	-0.019 (0.049)	-0.016 (0.049)	-0.018 (0.049)	-0.010 (0.049)
Percent low income students, linear	0.137 (0.239)	0.178 (0.241)	0.202 (0.240)	0.210 (0.242)
Percent low income students, squared	0.135 (0.219)	0.097 (0.221)	0.078 (0.220)	0.068 (0.222)
Percent low income students, joint	0.281 *** (0.034)	0.282 *** (0.034)	0.285 *** (0.034)	0.282 *** (0.034)
Percent limited English proficiency, linear	-0.077 (0.120)	-0.070 (0.119)	-0.068 (0.118)	-0.056 (0.119)
Percent limited English proficiency, squared	0.238 (0.480)	0.299 (0.479)	0.265 (0.479)	0.266 (0.485)

TABLE 21.—MODIFIED MARGINAL EFFECTS WITH DIFFERENT HHIS – 1 (MULTIPLE PAGES)

	HHI-CBSA-ALL	HHI-R15-ALL	HHI-R25-ALL	HHI-R50-ALL
Percent limited English proficiency, joint	-0.040	-0.024	-0.027	-0.015
	(0.086)	(0.086)	(0.085)	(0.086)
Percent Special Education Students, linear	-1.043	-0.947	-1.015	-0.909
	(0.744)	(0.749)	(0.741)	(0.748)
Percent Special Education Students, squared	7.018 **	6.604 **	6.832 **	6.475 **
	(2.774)	(2.790)	(2.762)	(2.787)
Percent Special Education Students, joint	0.699 ***	0.692 ***	0.681 ***	0.699 ***
	(0.137)	(0.138)	(0.137)	(0.137)
Percent High school Students, linear	-3.228 ***	-3.075 ***	-3.171 ***	-3.285 ***
	(0.895)	(0.886)	(0.882)	(0.897)
Percent High school Students, squared	5.536 ***	5.306 ***	5.439 ***	5.613 ***
	(1.427)	(1.411)	(1.406)	(1.430)
Percent High school Students, joint	0.105	0.120	0.105	0.095
	(0.121)	(0.121)	(0.120)	(0.121)
log(Distance), linear	-0.101 **	-0.115 **	-0.113 **	-0.110 **
	(0.050)	(0.049)	(0.050)	(0.051)
log(Distance), squared	0.015 ***	0.017 ***	0.016 ***	0.016 ***
	(0.006)	(0.006)	(0.006)	(0.006)
log(Distance), joint	0.029 ***	0.030 ***	0.029 ***	0.030 ***
	(0.007)	(0.007)	(0.007)	(0.007)
log(Hedonic predicted salary), linear	-0.349	-0.403	-0.314	-0.611
	(0.653)	(0.639)	(0.645)	(0.626)
log(Hedonic predicted salary), squared	2.253	2.373	2.128	2.902 *
	(1.713)	(1.672)	(1.692)	(1.630)
log(Hedonic predicted salary), joint	0.493 ***	0.484 ***	0.481 ***	0.473 ***
	(0.102)	(0.102)	(0.101)	(0.101)
log(High school comparable wage), linear	-2.344 **	-2.790 **	-2.789 **	-3.005 ***
	(1.109)	(1.105)	(1.095)	(1.088)
log(High school comparable wage), squared	0.997 **	1.186 **	1.181 **	1.281 ***
	(0.498)	(0.496)	(0.492)	(0.489)
log(High school comparable wage), joint	-0.131 **	-0.156 ***	-0.166 ***	-0.159 ***
	(0.054)	(0.053)	(0.052)	(0.052)
Observations	952	952	952	952
Log Likelihood	870.9	869.5	872.3	872.3

TABLE 21.—MODIFIED MARGINAL EFFECTS WITH DIFFERENT HHIS – 1 (MULTIPLE PAGES)

	HHI-CBSA-ALL	HHI-R15-ALL	HHI-R25-ALL	HHI-R50-ALL
Explanatory Variables for Cost Inefficiency Variance Function, $\log(\sigma_u^2)$				
Chapter 41	1.655 *** (0.288)	1.660 *** (0.299)	1.649 *** (0.255)	1.698 *** (0.322)
HHI	1.411 *** (0.412)	1.051 *** (0.378)	1.681 *** (0.451)	2.638 *** (0.787)
Constant	-5.526 *** (0.442)	-5.465 *** (0.486)	-5.422 *** (0.364)	-5.520 *** (0.498)
Explanatory Variables for Idiosyncratic Error Variance Function, $\log(\sigma_v^2)$				
1 / log(Enrollment)	27.310 *** (2.580)	27.098 *** (2.653)	27.820 *** (2.616)	27.258 *** (2.617)
Constant	-9.154 *** (0.466)	-9.129 *** (0.494)	-9.269 *** (0.462)	-9.114 *** (0.484)

Note: The dependent variable is log(Expenditure per pupil). Standard errors are in parentheses. Triple asterisk (***) means significance at the 1% level. Double asterisk (**) means significance at the 5% level. Single asterisk (*) means significance at the 10% level.

TABLE 22.—MODIFIED MARGINAL EFFECTS WITH DIFFERENT HHIS – 2
(MULTIPLE PAGES)

	HHI-County-ALL	HHI-CBSA-PUB	HHI-R15-PUB	HHI-R25-PUB
log(Enrollment), linear	-0.743 *** (0.131)	-0.771 *** (0.132)	-0.749 *** (0.130)	-0.742 *** (0.130)
log(Enrollment), squared	0.066 *** (0.016)	0.069 *** (0.016)	0.066 *** (0.016)	0.066 *** (0.016)
log(Enrollment), cubed	-0.002 *** (0.001)	-0.002 *** (0.001)	-0.002 *** (0.001)	-0.002 *** (0.001)
log(Enrollment), joint	-0.095 *** (0.005)	-0.094 *** (0.005)	-0.093 *** (0.005)	-0.094 *** (0.005)
log(Change in TAKS passing rate), linear	0.238 ** (0.105)	0.250 ** (0.108)	0.231 ** (0.105)	0.240 ** (0.105)
log(Change in TAKS passing rate), squared	-0.747 (1.424)	-1.020 (1.456)	-0.634 (1.419)	-0.693 (1.414)
log(Change in TAKS passing rate), joint	0.219 ** (0.099)	0.225 ** (0.102)	0.215 ** (0.100)	0.222 ** (0.099)
Percent taking advanced courses, linear	0.365 ** (0.147)	0.368 ** (0.147)	0.366 ** (0.147)	0.346 ** (0.146)
Percent taking advanced courses, squared	-0.524 (0.323)	-0.522 (0.322)	-0.518 (0.322)	-0.466 (0.321)
Percent taking advanced courses, joint	0.173 *** (0.053)	0.177 *** (0.053)	0.177 *** (0.053)	0.175 *** (0.052)
Lagged passing rate, linear	0.016 (0.598)	-0.083 (0.605)	0.121 (0.602)	0.147 (0.600)
Lagged passing rate, squared	-0.023 (0.428)	0.046 (0.432)	-0.098 (0.430)	-0.117 (0.429)
Lagged passing rate, joint	-0.016 (0.049)	-0.019 (0.049)	-0.016 (0.049)	-0.018 (0.049)
Percent low income students, linear	0.197 (0.241)	0.137 (0.240)	0.179 (0.241)	0.198 (0.240)
Percent low income students, squared	0.081 (0.221)	0.136 (0.219)	0.096 (0.221)	0.081 (0.220)
Percent low income students, joint	0.283 *** (0.034)	0.281 *** (0.034)	0.281 *** (0.034)	0.284 *** (0.034)
Percent limited English proficiency, linear	-0.065 (0.119)	-0.075 (0.120)	-0.067 (0.119)	-0.065 (0.118)
Percent limited English proficiency, squared	0.224 (0.481)	0.232 (0.480)	0.293 (0.479)	0.262 (0.479)

TABLE 22.—MODIFIED MARGINAL EFFECTS WITH DIFFERENT HHIS – 2 (MULTIPLE PAGES)

	HHI-County-ALL	HHI-CBSA-PUB	HHI-R15-PUB	HHI-R25-PUB
Percent limited English proficiency, joint	-0.031	-0.039	-0.022	-0.025
	(0.086)	(0.086)	(0.086)	(0.085)
Percent Special Education Students, linear	-0.921	-1.037	-0.911	-1.015
	(0.744)	(0.744)	(0.751)	(0.741)
Percent Special Education Students, squared	6.472 **	6.996 **	6.475 **	6.834 **
	(2.774)	(2.776)	(2.798)	(2.761)
Percent Special Education Students, joint	0.686 ***	0.699 ***	0.697 ***	0.681 ***
	(0.137)	(0.137)	(0.138)	(0.137)
Percent High school Students, linear	-3.116 ***	-3.195 ***	-3.034 ***	-3.144 ***
	(0.895)	(0.899)	(0.890)	(0.884)
Percent High school Students, squared	5.367 ***	5.483 ***	5.236 ***	5.398 ***
	(1.428)	(1.434)	(1.419)	(1.408)
Percent High school Students, joint	0.116	0.106	0.120	0.107
	(0.121)	(0.121)	(0.121)	(0.120)
log(Distance), linear	-0.108 **	-0.100 **	-0.115 **	-0.114 **
	(0.051)	(0.050)	(0.050)	(0.050)
log(Distance), squared	0.016 ***	0.015 ***	0.017 ***	0.016 ***
	(0.006)	(0.006)	(0.006)	(0.006)
log(Distance), joint	0.031 ***	0.030 ***	0.030 ***	0.028 ***
	(0.007)	(0.007)	(0.007)	(0.007)
log(Hedonic predicted salary), linear	-0.402	-0.371	-0.408	-0.318
	(0.638)	(0.648)	(0.637)	(0.644)
log(Hedonic predicted salary), squared	2.388	2.321	2.387	2.136
	(1.670)	(1.698)	(1.668)	(1.690)
log(Hedonic predicted salary), joint	0.490 ***	0.496 ***	0.484 ***	0.480 ***
	(0.102)	(0.102)	(0.102)	(0.102)
log(High school comparable wage), linear	-2.738 **	-2.411 **	-2.820 **	-2.822 **
	(1.110)	(1.108)	(1.104)	(1.095)
log(High school comparable wage), squared	1.160 **	1.024 **	1.198 **	1.194 **
	(0.498)	(0.497)	(0.496)	(0.492)
log(High school comparable wage), joint	-0.161 ***	-0.138 **	-0.159 ***	-0.170 ***
	(0.053)	(0.054)	(0.053)	(0.052)
Observations	952	952	952	952
Log Likelihood	868.1	869.9	869	872.2

TABLE 22.—MODIFIED MARGINAL EFFECTS WITH DIFFERENT HHIS – 2 (MULTIPLE PAGES)

	HHI-County-ALL	HHI-CBSA-PUB	HHI-R15-PUB	HHI-R25-PUB
Explanatory Variables for Cost Inefficiency Variance Function, $\log(\sigma_u^2)$				
Chapter 41	1.648 *** (0.259)	1.666 *** (0.284)	1.666 *** (0.299)	1.649 *** (0.254)
HHI	0.935 ** (0.388)	1.269 *** (0.400)	0.982 *** (0.370)	1.614 *** (0.437)
Constant	-5.398 *** (0.384)	-5.494 *** (0.429)	-5.462 *** (0.483)	-5.425 *** (0.360)
Explanatory Variables for Idiosyncratic Error Variance Function, $\log(\sigma_v^2)$				
1 / log(Enrollment)	28.216 *** (2.592)	27.462 *** (2.580)	27.076 *** (2.647)	27.823 *** (2.611)
Constant	-9.314 *** (0.457)	-9.177 *** (0.464)	-9.122 *** (0.491)	-9.267 *** (0.460)

Note: The dependent variable is log(Expenditure per pupil). Standard errors are in parentheses. Triple asterisk (***) means significance at the 1% level. Double asterisk (**) means significance at the 5% level. Single asterisk (*) means significance at the 10% level.

TABLE 23.—MODIFIED MARGINAL EFFECTS WITH DIFFERENT HHIS – 3 (MULTIPLE PAGES)

	HHI-R50-PUB	HHI-County-PUB	HHI-CBSA-ACC	HHI-R15-ACC
log(Enrollment), linear	-0.726 *** (0.131)	-0.743 *** (0.131)	-0.751 *** (0.131)	-0.750 *** (0.130)
log(Enrollment), squared	0.064 *** (0.016)	0.066 *** (0.016)	0.067 *** (0.016)	0.067 *** (0.016)
log(Enrollment), cubed	-0.002 *** (0.001)	-0.002 *** (0.001)	-0.002 *** (0.001)	-0.002 *** (0.001)
log(Enrollment), joint	-0.095 *** (0.005)	-0.095 *** (0.005)	-0.094 *** (0.005)	-0.093 *** (0.005)
log(Change in TAKS passing rate), linear	0.233 ** (0.105)	0.238 ** (0.105)	0.243 ** (0.105)	0.236 ** (0.105)
log(Change in TAKS passing rate), squared	-0.719 (1.429)	-0.747 (1.424)	-0.758 (1.420)	-0.671 (1.421)
log(Change in TAKS passing rate), joint	0.215 ** (0.100)	0.219 ** (0.099)	0.223 ** (0.099)	0.219 ** (0.100)
Percent taking advanced courses, linear	0.341 ** (0.147)	0.365 ** (0.147)	0.366 ** (0.147)	0.364 ** (0.147)
Percent taking advanced courses, squared	-0.469 (0.324)	-0.524 (0.323)	-0.522 (0.323)	-0.517 (0.322)
Percent taking advanced courses, joint	0.170 *** (0.052)	0.173 *** (0.053)	0.175 *** (0.053)	0.175 *** (0.053)
Lagged passing rate, linear	0.119 (0.601)	0.016 (0.598)	0.062 (0.598)	0.128 (0.602)
Lagged passing rate, squared	-0.092 (0.430)	-0.023 (0.428)	-0.054 (0.428)	-0.103 (0.430)
Lagged passing rate, joint	-0.011 (0.049)	-0.016 (0.049)	-0.014 (0.049)	-0.017 (0.049)
Percent low income students, linear	0.214 (0.242)	0.197 (0.241)	0.182 (0.241)	0.179 (0.241)
Percent low income students, squared	0.064 (0.222)	0.081 (0.221)	0.096 (0.221)	0.097 (0.221)
Percent low income students, joint	0.282 *** (0.034)	0.283 *** (0.034)	0.284 *** (0.034)	0.282 *** (0.034)
Percent limited English proficiency, linear	-0.051 (0.119)	-0.065 (0.119)	-0.075 (0.119)	-0.069 (0.119)
Percent limited English proficiency, squared	0.251 (0.484)	0.224 (0.481)	0.257 (0.484)	0.294 (0.479)

Table 23.—Modified Marginal Effects with Different HHIs – 3
(Multiple Pages)

	HHI-R50-PUB	HHI-County-PUB	HHI-CBSA-ACC	HHI-R15-ACC
Percent limited English proficiency, joint	-0.013	-0.031	-0.036	-0.024
	(0.086)	(0.086)	(0.086)	(0.086)
Percent Special Education Students, linear	-0.889	-0.921	-0.989	-0.947
	(0.750)	(0.744)	(0.741)	(0.749)
Percent Special Education Students, squared	6.404 **	6.472 **	6.765 **	6.602 **
	(2.793)	(2.774)	(2.762)	(2.791)
Percent Special Education Students, joint	0.701 ***	0.686 ***	0.691 ***	0.692 ***
	(0.138)	(0.137)	(0.137)	(0.138)
Percent High school Students, linear	-3.237 ***	-3.116 ***	-3.207 ***	-3.070 ***
	(0.897)	(0.895)	(0.893)	(0.887)
Percent High school Students, squared	5.545 ***	5.367 ***	5.499 ***	5.299 ***
	(1.432)	(1.428)	(1.424)	(1.412)
Percent High school Students, joint	0.102	0.116	0.105	0.121
	(0.121)	(0.121)	(0.121)	(0.121)
log(Distance), linear	-0.111 **	-0.108 **	-0.108 **	-0.115 **
	(0.051)	(0.051)	(0.050)	(0.049)
log(Distance), squared	0.016 ***	0.016 ***	0.016 ***	0.017 ***
	(0.006)	(0.006)	(0.006)	(0.006)
log(Distance), joint	0.030 ***	0.031 ***	0.030 ***	0.030 ***
	(0.007)	(0.007)	(0.007)	(0.007)
log(Hedonic predicted salary), linear	-0.601	-0.402	-0.391	-0.404
	(0.626)	(0.638)	(0.645)	(0.638)
log(Hedonic predicted salary), squared	2.877 *	2.388	2.375	2.379
	(1.631)	(1.670)	(1.691)	(1.671)
log(Hedonic predicted salary), joint	0.474 ***	0.490 ***	0.496 ***	0.485 ***
	(0.102)	(0.102)	(0.101)	(0.102)
log(High school comparable wage), linear	-2.995 ***	-2.738 **	-2.590 **	-2.785 **
	(1.090)	(1.110)	(1.113)	(1.105)
log(High school comparable wage), squared	1.276 ***	1.160 **	1.104 **	1.183 **
	(0.490)	(0.498)	(0.499)	(0.497)
log(High school comparable wage), joint	-0.161 ***	-0.161 ***	-0.138 **	-0.157 ***
	(0.052)	(0.053)	(0.054)	(0.053)
Observations	952	952	952	952
Log Likelihood	871.5	868.1	870.1	869.3

TABLE 23.—MODIFIED MARGINAL EFFECTS WITH DIFFERENT HHIS – 3 (MULTIPLE PAGES)

	HHI-R50-PUB	HHI-County-PUB	HHI-CBSA-ACC	HHI-R15-ACC
Explanatory Variables for Cost Inefficiency Variance Function, $\log(\sigma_u^2)$				
Chapter 41	1.726 *** (0.335)	1.648 *** (0.259)	1.601 *** (0.250)	1.664 *** (0.301)
HHI	2.371 *** (0.751)	0.935 ** (0.388)	1.210 *** (0.377)	1.027 *** (0.377)
Constant	-5.516 *** (0.519)	-5.398 *** (0.384)	-5.382 *** (0.355)	-5.460 *** (0.488)
Explanatory Variables for Idiosyncratic Error Variance Function, $\log(\sigma_v^2)$				
1 / log(Enrollment)	27.280 *** (2.629)	28.216 *** (2.592)	27.794 *** (2.595)	27.116 *** (2.654)
Constant	-9.110 *** (0.491)	-9.314 *** (0.457)	-9.272 *** (0.457)	-9.130 *** (0.494)

Note: The dependent variable is log(Expenditure per pupil). Standard errors are in parentheses. Triple asterisk (***) means significance at the 1% level. Double asterisk (**) means significance at the 5% level. Single asterisk (*) means significance at the 10% level.

TABLE 24.—MODIFIED MARGINAL EFFECTS WITH DIFFERENT HHIS – 4 (MULTIPLE PAGES)

	HHI-R25-ACC	HHI-R50-ACC	HHI-County-ACC	HHI-Rings-ALL
log(Enrollment), linear	-0.740 *** (0.130)	-0.724 *** (0.131)	-0.743 *** (0.131)	-0.736 *** (0.130)
log(Enrollment), squared	0.066 *** (0.016)	0.063 *** (0.016)	0.066 *** (0.016)	0.065 *** (0.016)
log(Enrollment), cubed	-0.002 *** (0.001)	-0.002 *** (0.001)	-0.002 *** (0.001)	-0.002 *** (0.001)
log(Enrollment), joint	-0.093 *** (0.005)	-0.095 *** (0.005)	-0.095 *** (0.005)	-0.093 *** (0.005)
log(Change in TAKS passing rate), linear	0.241 ** (0.105)	0.236 ** (0.105)	0.238 ** (0.105)	0.248 ** (0.107)
log(Change in TAKS passing rate), squared	-0.698 (1.415)	-0.716 (1.428)	-0.747 (1.424)	-0.680 (1.423)
log(Change in TAKS passing rate), joint	0.224 ** (0.099)	0.218 ** (0.099)	0.219 ** (0.099)	0.230 ** (0.102)
Percent taking advanced courses, linear	0.343 ** (0.146)	0.337 ** (0.147)	0.365 ** (0.147)	0.348 ** (0.148)
Percent taking advanced courses, squared	-0.460 (0.321)	-0.459 (0.322)	-0.524 (0.323)	-0.483 (0.323)
Percent taking advanced courses, joint	0.175 *** (0.052)	0.169 *** (0.052)	0.173 *** (0.053)	0.171 *** (0.053)
Lagged passing rate, linear	0.138 (0.600)	0.119 (0.601)	0.016 (0.598)	0.177 (0.602)
Lagged passing rate, squared	-0.111 (0.429)	-0.092 (0.430)	-0.023 (0.428)	-0.134 (0.430)
Lagged passing rate, joint	-0.017 (0.049)	-0.010 (0.049)	-0.016 (0.049)	-0.012 (0.049)
Percent low income students, linear	0.202 (0.240)	0.209 (0.242)	0.197 (0.241)	0.182 (0.241)
Percent low income students, squared	0.078 (0.220)	0.069 (0.222)	0.081 (0.221)	0.094 (0.220)
Percent low income students, joint	0.285 *** (0.034)	0.282 *** (0.034)	0.283 *** (0.034)	0.282 *** (0.034)
Percent limited English proficiency, linear	-0.068 (0.118)	-0.056 (0.119)	-0.066 (0.119)	-0.072 (0.119)
Percent limited English proficiency, squared	0.265 (0.479)	0.269 (0.485)	0.224 (0.481)	0.328 (0.480)

TABLE 24.—MODIFIED MARGINAL EFFECTS WITH DIFFERENT HHIS – 4 (MULTIPLE PAGES)

	HHI-R25-ACC	HHI-R50-ACC	HHI-County-ACC	HHI-Rings-ALL
Percent limited English proficiency, joint	-0.027 (0.085)	-0.015 (0.086)	-0.031 (0.086)	-0.022 (0.086)
Percent Special Education Students, linear	-1.015 (0.741)	-0.902 (0.748)	-0.921 (0.745)	-0.907 (0.757)
Percent Special Education Students, squared	6.831 ** (2.762)	6.452 ** (2.788)	6.473 ** (2.774)	6.481 ** (2.819)
Percent Special Education Students, joint	0.681 *** (0.137)	0.700 *** (0.138)	0.686 *** (0.137)	0.702 *** (0.138)
Percent High school Students, linear	-3.171 *** (0.882)	-3.279 *** (0.897)	-3.117 *** (0.895)	-3.213 *** (0.887)
Percent High school Students, squared	5.440 *** (1.406)	5.605 *** (1.431)	5.369 *** (1.428)	5.509 *** (1.413)
Percent High school Students, joint	0.105 (0.120)	0.096 (0.121)	0.116 (0.121)	0.104 (0.120)
log(Distance), linear	-0.113 ** (0.050)	-0.110 ** (0.051)	-0.108 ** (0.051)	-0.117 ** (0.050)
log(Distance), squared	0.016 *** (0.006)	0.016 *** (0.006)	0.016 *** (0.006)	0.017 *** (0.006)
log(Distance), joint	0.029 *** (0.007)	0.030 *** (0.007)	0.031 *** (0.007)	0.028 *** (0.007)
log(Hedonic predicted salary), linear	-0.314 (0.645)	-0.607 (0.626)	-0.402 (0.638)	-0.475 (0.641)
log(Hedonic predicted salary), squared	2.127 (1.692)	2.893 * (1.630)	2.388 (1.671)	2.507 (1.680)
log(Hedonic predicted salary), joint	0.481 *** (0.102)	0.474 *** (0.101)	0.490 *** (0.102)	0.462 *** (0.103)
log(High school comparable wage), linear	-2.780 ** (1.096)	-3.000 *** (1.088)	-2.740 ** (1.110)	-2.748 ** (1.109)
log(High school comparable wage), squared	1.177 ** (0.493)	1.279 *** (0.489)	1.161 ** (0.498)	1.174 ** (0.498)
log(High school comparable wage), joint	-0.166 *** (0.052)	-0.159 *** (0.052)	-0.161 *** (0.053)	-0.141 *** (0.053)
Observations	952	952	952	952
Log Likelihood	872.4	872.2	868.1	872.4

TABLE 24.—MODIFIED MARGINAL EFFECTS WITH DIFFERENT HHIS – 4
(MULTIPLE PAGES)

	HHI-R25-ACC	HHI-R50-ACC	HHI-County-ACC	HHI-Rings-ALL
Explanatory Variables for Cost Inefficiency Variance Function, $\log(\sigma_u^2)$				
Chapter 41	1.648 *** (0.255)	1.702 *** (0.324)	1.648 *** (0.259)	1.677 *** (0.447)
HHI	1.686 *** (0.451)	2.592 *** (0.774)	0.935 ** (0.388)	2.161 *** (0.811)
Constant	-5.424 *** (0.365)	-5.515 *** (0.500)	-5.398 *** (0.384)	-5.721 *** (0.839)
Explanatory Variables for Idiosyncratic Error Variance Function, $\log(\sigma_v^2)$				
1 / log(Enrollment)	27.818 *** (2.616)	27.255 *** (2.618)	28.216 *** (2.591)	26.198 *** (2.882)
Constant	-9.268 *** (0.462)	-9.113 *** (0.485)	-9.313 *** (0.457)	-8.956 *** (0.608)

Note: The dependent variable is log(Expenditure per pupil). Standard errors are in parentheses. Triple asterisk (***) means significance at the 1% level. Double asterisk (**) means significance at the 5% level. Single asterisk (*) means significance at the 10% level.

inefficiency is 0.0559. In addition, when the markets are defined as rings, the marginal effect of HHI-Rings-ALL on cost inefficiency is 0.0464. That is, while all of the measures of concentration we explore indicate a positive and significant relationship between the cost inefficiency and the HHI, different market definitions result in different levels of marginal effects of HHIs on inefficiency. According to the results presented above, the marginal effect of concentration lies somewhere in the [0.019, 0.056] range.

In conclusion, the findings presented in this section indicate that the sign and significance of the relationship between concentration and cost inefficiency are not too sensitive to adding or dropping the private schools. Changing the definition of education markets, on the other hand, changes the degree of the relationship significantly over a small range. Yet, all of the measures of concentration we employ validate the relationship.

3.6. Endogeneity in the Stochastic Cost Frontier Model

In general, stochastic cost frontier models potentially have endogeneity problem because of several reasons. When specifying a stochastic cost function in education context, cost is expressed as a function of outputs and inputs. If cost is jointly determined with some of the output variables, then the specification creates an endogeneity problem. For example, educational quality indicators such as changes in passing rates are outputs that are possibly endogenous.[23] Moreover, some of the input

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[23] Output quantity indicators can also be argued to be endogenous. However, since it is commonly assumed in the literature that enrollment as exogenous, we follow the literature and make that exogeneity assumption.

prices can be endogenous especially if they are calculated with weights based on features that are subject to choice. To give an example, any average wage is weighted with respect to some specific teacher characteristics which are to be chosen by the school district through hiring process. This selection makes any average wage indicator endogenous. Furthermore, if a translog specification is used to model the cost frontier, endogeneity of some of the explanatory variables in the cost function would swell the overall endogeneity of the model due to the interaction terms of the endogenous variables. Finally, the endogeneity problem gets even more complicated if some of the variables explaining the cost inefficiency are simultaneously determined with cost. The presence of endogeneity results in a parameter inconsistency problem for the maximum likelihood estimation of the stochastic cost frontier model. For instance, if the cost inefficiency is explained with a measure of competition in the education market, that measure of competition would be simultaneously determined with the district cost, which would results in endogeneity.

In minimum distance estimations, instrumental variable (IV) methodology is generally applied to deal with the endogeneity problem. In maximum likelihood estimations, however, the general IV methodology cannot be directly employed. Estimation of inefficiency in a stochastic cost frontier, on the other hand, requires maximum likelihood estimation. To the best of our knowledge, the econometric methodology to address the endogeneity problems in stochastic frontier models appropriately is yet to develop, and as a reflection, econometric software packages supporting stochastic frontier analysis cannot account for endogenous regressors. Guan et al. (2009) present an early attempt to handle the endogenous frontier regressors by following a two-step estimation method. In the first step, they estimate the frontier parameters with GMM on a differenced model, and after solving the endogeneity problem, they use the residuals from the GMM to estimate the efficiency using a maximum likelihood method in the second step. It is important to emphasize that their second-step is not an estimation of predicted inefficiency on a set of covariates, which is disapproved in the literature due to severe biases (see Battese and Coelli (1995) and Wang and Schmidt (2002)). Even though their methodology would be somehow applicable to cost frontier models with cross-sectional data, they do not offer a solution for endogenous determinants of cost inefficiency.

The degree of cost inefficiency can be partially a response to the outcomes of the cost ineffieciency which would cause endogeneity. Assume that because of idiosyncratic factors, a district has a highly cost efficient administration. That would mean that the spending of that administration is relatively not wasteful, and hence, is more productive. Other districts in the same education market may be consolidated to the cost efficient district just to take advantage of the wise spending character of its administration. Moreover, the cost efficient district’s being relatively more productive because of their being relatively more cost efficient is another attractive factor why other districts would want to consolidate the cost efficient district. However, if districts get consolidated, the competition in that education market would decline, which would, in turn, cause more wasteful expenditures and increase the cost inefficiency of the administration. The endogeneity here negatively biases the estimated effect of competition on cost efficiency. In other words, the effect of competition on cost efficiency is underestimated in our stochastic cost frontier estimation results presented in Table 2. Unfortunately, the current econometric literature offers no guidance about the suitable methods to deal with the endogenous cost inefficiency components. Even though decomposing cost inefficiency into an exogenous and an endogenous part to address its endogeneity problem would be an interesting dimension of stochastic frontier models to be explored, this kind of a methodological search is out of the scope of this paper.

3.6.1. Potential Instrumental Variables

Even if there was a complete and well-defined econometric methodology developed in the literature which was to require following an IV technique to cope with the endogeneity problem in stochastic cost frontier models (including the endogeneity in cost inefficiency), the very first step in that methodology would be to diagnose the instruments for their exogeneity and relevance in order to verify their validity. Hence, our first objective is to find valid instruments—if there is any—to handle the endogeneity in our model. However, as stated by Angrist and Pischke (2009) finding an instrument with relevance, exogeneity, and strength is very difficult. Bound, Jaeger and Baker (1995) explain that if the selected instruments are poor, then there are inconsistency and finite-sample bias due to these instruments, which are worse than the biases due to endogeneity. In addition, Murray (2006) further explains that the invalidity and weakness of instruments undermines the credibility of the estimates severely because of the smaller estimated standard errors and incorrect confidence intervals.

Therefore, if the instrumental variables are detected to be weak, then considering all the variables as exogenous is better.

Turning back to our stochastic cost frontier model, since the benefits of having the flexible form of specification offset the costs (Gronberg, Jansen and Taylor, 2011a), we chose the translog specification. Nevertheless, this decision induces a greater possibility of identification problems because of the increased number of potentially endogenous variables. That is, in a translog specification, all of the interaction terms of the endogenous variables would also need an instrument each as well as the endogenous variables themselves. To give an example, two potentially endogenous variables and nine exogenous variables in a Cobb-Douglas specification would mean a total of 23 potentially endogenous variables in a translog specification including the potentially endogenous interaction terms. However, the order condition for identification requires that the number of excluded instruments should be at least equal to the number of endogenous regressors. Moreover, the rank condition for identification requires that the excluded instruments are correlated with the endogenous regressors. Since both order and rank conditions must be satisfied for identification, the translog specification may increase the likelihood of an identification problem. Also, if the correlations between the excluded instruments and the endogenous regressors are not zero but small, weak identification problem arises. Again, an endogenous translog specification may be more prone to weak identification because of the increased number of required instruments. Furthermore, the exogeneity of the instruments in a stochastic frontier environment cannot be tested in general, but if the number of instruments we use exceeds what is necessary, our model would suffer the overidentification problem. Tests such as Sargan’s statistic or Hansen’s J-test for different estimator can be used to get some inference about the exogeneity of the instruments. However, since the number of instruments required for our translog specification is already large, we avoid—where possible—increasing the number much more to prevent an undetected overidentification problem in our stochastic frontier setting.

In order to avoid the potential endogeneity due to input prices, as explained in the data section, we use hedonic wage indices that are independent of the choices of the school districts. Instead of following an IV methodology, however, we follow the approach followed by Imazeki and Reschovsky (2006) and Gronberg, Jansen and Taylor (2011b) and put these indices in the model directly in place of average measures of wage to prevent further complications due to instrumenting. Unfortunately, a similar strategy is not available for endogenous output and cost inefficiency variables. Therefore, we explore various sets of potential instruments for these variables to evaluate applicability of these instruments in a yet-to-come complete IV methodology for stochastic frontier models.

In our model, the two educational quality indicators, change in TAKS passing rate and percentage of students taking advanced courses, are the outputs that are possibly endogenous. Possible determinants of the local demand for education and the interaction terms of these determinants with the exogenous determinants of cost can be considered as prospective instruments for our educational quality indicators and all of their interaction terms. The set of determinants of the local demand for education we consider using includes four variables: the share of households in the district with school age children, the share of district population over age 65, the share of adult district population with at least a bachelor's degree, and the share of owner-occupied housing stock.[24]

Furthermore, some measures of benchmark competition in the surrounding education markets and their interaction terms with the exogenous determinants of cost can also be taken as potential set of instruments for the endogenous educational quality terms including their interaction terms.[25] The benchmark measures of competition we explore using are the lagged values of percentage of students taking advance courses in the surrounding campuses and the lagged values of percentage of students who passed the TAKS in the surrounding campuses. The number of lags of these two measures is limited by the data availability. Our model already includes the TAKS passing rate from two years previously (2004-05). Moreover, the TAKS replaced the Texas Assessment of Academic Skills (TAAS) in Texas in the 2002-03 school year so TAKS data is unavailable before 2003-04 school year. Hence, the only available lagged value of percentage of students who passed the TAKS is three years previously (2003-04). The lagged values of percentages of students taking advance courses are available from the 1993-94 school year. However, we explore using only the three years lagged (2003-04) value of the percentages of students taking advance courses in order not to increase the number of instruments unnecessarily. For each district, we determine two different sets

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[24] The data come from Census 2000 voter demographics. The determinants of demand for education we use are similar to those used by Imazeki and Reschovsky (2006).

[25] The idea is similar to the copycat behavior model formalized by Case, Rosen and Hines (1993) that demand for education outcomes in a district is affected by the outcomes in the neighboring education markets.

of surrounding campuses: the first set of campuses includes the campuses which are out of the boundaries of that district, but the closest to one of the campuses in that district, compared to the other campuses outside of that district.[26] The second set of campuses includes the campuses, which are out of the boundaries of that district, but the second closest to one of the campuses in that district, compared to the other campuses outside of that district. Then, using the data of the campuses in the first set, we calculate the enrollment weighted average of the three years lagged values of percentage of students who passed the TAKS. This variable constitutes one of our benchmark measures of competition. By following the same procedure, we create other three benchmark measures using one of the two sets of campuses and one of lagged values of the variables we decide to use.

Moreover, the concentration indices we use to measure competition in the education market explain the cost inefficiency in our model. However, our indices of concentration are simultaneously determined with the district cost, which results in endogeneity. In order to alleviate the endogeneity problem, instruments such as those presented in Hoxby (2000) can be used. Hoxby explains that streams played an important role in the delineation of the school district boundaries in the eighteen and nineteen centuries and hence these natural boundaries are key determinants of supply of school districts even though they are not limiting the student transportation today. In a comment, Rothstein (2007) offers alternative categories of streams grouped into two

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[26] The distance from a campus to another campus is calculated by using the haversine formula. The haversine formula calculates the shortest, great-circle (or as the crow flies) distance between two points over the surface of the earth. The coordinates of the campuses are available from NCES Common Core of Data.

different size categories as instruments. We follow Hoxby and Rothstein and use the U.S. Geological Survey (USGS) Geographic Names Information System (GNIS) data to create two categories of streams based on the length of the streams defining streams longer than 3.5 miles as large, and others as small.[27] We consider using the counts of the two different types of streams in a district's county as two separate instruments for our endogenous concentration measure. Summary statistics of all of the instrumental variables we explore using are presented in Table 25.

3.6.2. Addressing the Endogeneity

Since there is no well-established econometric methodology in the literature about how to address the endogeneity in the cost inefficiency, we first examine a model similar to the baseline model presented in Table 17 but exclude all of the variables explaining the variances of one-sided and two-sided errors. In order to instrument the endogenous education quality variables and all their interaction terms, we use eight aforementioned education quality instruments, their squared terms, their interaction terms with each other, and their interaction terms with the exogenous cost frontier determinants.

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[27] The data we use is the one Rothstein mentions in his comment as the "alternative version of GNIS data" which includes coordinates of two points for each stream in each county: one of the points is the origin where that stream starts traversing that county, and the other point is the destination where that stream ends traversing that county. The length between these two points is calculated by using the haversine formula.

TABLE 25.—DESCRIPTIVE STATISTICS OF THE INSTRUMENTAL VARIABLES

Variable	Mean	Standard Deviation	Minimum	Maximum
Percent households with school aged children	0.360	0.079	0.139	0.909
Percent population over age 65	0.252	0.081	0	0.525
Percent adults with at least bachelor’s degree	0.154	0.085	0.021	0.787
Percent owner-occupied housing stock	0.762	0.102	0	0.966
3 years lagged percent taking advance courses in the closest neighborhood	0.073	0.068	0	0.512
3 years lagged passing rate in the closest neighborhood	0.677	0.116	0.198	0.970
3 years lagged percent taking advance courses in the second closest neighborhood	0.071	0.070	0	0.742
3 years lagged passing rate in the second closest neighborhood	0.688	0.109	0.230	0.970
Count of small streams in the district’s county	21.6	22.2	0	117
Count of large streams in the district’s county	33.2	18.4	0	69

Number of observations = 951

Heteroskedasticity-robust identification and instrument relevance statistics from the first stage regression of the IV estimation are presented in Table 26. As presented in the table, the Hansen’s J test does not reject the joint null hypothesis that the instruments are valid. The underidentification tests of Kleibergen and Paap (2006), on the other hand, cannot reject the null hypothesis that our equation is underidentified, that is, the matrix of reduced-form coefficients on the excluded instruments is not full column rank. Furthermore, the robust Kleibergen-Paap Wald rk F statistic is equal to 0.75. Critical values of the statistic is not available in the literature but since the statistic is the generalization of the Cragg and Donald (1993) Wald F statistic, the critical values presented in Stock and Yogo (2005) can be used for inference. Looking at their Table 1, if thirty excluded instrumental variables are used for one endogenous variable, the critical value of the statistic is 21.42 if the bias of the IV estimator is set to 5% of the bias of the OLS. The table is restricted to three endogenous variables and thirty instruments at most. However, the critical value appears to be decreasing as the number of endogenous variables increases, or the number of excluded instruments increase above a certain level. Even so, we infer from the values in their table that we cannot reject the null hypothesis with a statistic as small as 0.75, that there is a weak instrumental variables problem. Finally, we test the relevance of potentially endogenous regressors with Anderson and Rubin (1949) and Stock and Wright (2000) tests which are robust in the presence of weak instruments. The tests reject the null hypothesis suggesting that endogenous regressors are not irrelevant. However, these tests are jointly testing the validity of overidentifying restrictions, and for that reason, the suggestion of relevant endogenous regressors is not too strong.

TABLE 26.—FIRST STAGE STATISTICS OF THE IV ESTIMATION (MULTIPLE PAGES)

Variable	Shea's Partial R^2	Partial R^2	F Statistic (116, 779)	p-value of F Statistic
Change in TAKS passing rate	0.1314	0.1723	1.98	0.000
× Enrollment	0.1246	0.1444	2.03	0.000
× Change in TAKS passing rate	0.1977	0.3262	1.07	0.300
× Percent taking advanced courses	0.1657	0.1869	1.52	0.001
× Lagged passing rate	0.1379	0.1586	1.91	0.000
× Percent low income students	0.1282	0.2118	1.82	0.000
× Percent limited English proficiency	0.2108	0.2683	1.64	0.000
× Percent Special Education students	0.1728	0.2041	1.73	0.000
× Percent high school students	0.1721	0.1846	1.98	0.000
× Distance from major metropolitan areas	0.1091	0.1783	1.91	0.000
× Hedonic predicted salary	0.1259	0.1549	1.98	0.000
× High school comparable wage index	0.1015	0.1649	2.01	0.000
Percent taking advanced courses	0.2126	0.2182	2.53	0.000
× Enrollment	0.2388	0.2193	2.64	0.000
× Percent taking advanced courses	0.1790	0.2615	2.27	0.000
× Lagged passing rate	0.2099	0.2320	2.58	0.000
× Percent low income students	0.1933	0.2197	2.36	0.000
× Percent limited English proficiency	0.2227	0.2440	2.10	0.000
× Percent Special Education students	0.1980	0.2006	2.58	0.000

TABLE 26.—FIRST STAGE STATISTICS OF THE IV ESTIMATION (MULTIPLE PAGES)

Variable	Shea's Partial R^2	Partial R^2	F Statistic (116, 779)	p-value of F Statistic
× Percent high school students	0.2695	0.2047	2.52	0.000
× Distance from major metropolitan areas	0.2413	0.2180	2.16	0.000
× Hedonic predicted salary	0.2392	0.2503	2.92	0.000
× High school comparable wage index	0.1990	0.2275	2.65	0.000
Underidentification Tests				
Kleibergen-Paap rk LM statistic	$\chi^2(94) = 79.10$		p-value = 0.8646	
Kleibergen-Paap rk Wald statistic	$\chi^2(94) = 105.86$		p-value = 0.1896	
Weak Identification Test				
Kleibergen-Paap Wald rk F statistic	0.748			
Weak-Instrument-Robust Inference				
Anderson-Rubin Wald test	F(116, 779) = 3.21		p-value = 0.0000	
Anderson-Rubin Wald test	$\chi^2(116) = 455.28$		p-value = 0.0000	
Stock-Wright LM S statistic	$\chi^2(116) = 163.10$		p-value = 0.0000	
Overidentification Test of All Instruments				
Hansen's J Statistic	$\chi^2(93) = 94.818$		p-value = 0.4281	
Number of Observations = 951				
Number of Regressors = 79				
Number of Instruments = 172				
Number of Excluded Instruments = 116				

Note: First stage F, underidentification, weak identification, and weak-identification-robust test statistics are heteroskedasticity robust.

Our second analysis in this section is based on further assumptions. First, since we suspect that the weak instruments problem presented in Table 26 may essentially be attributed to the large number of excluded instruments, we restrict our translog specification to a Cobb-Douglas specification. That way, we decrease the number of endogenous variables in the cost equation and hence the number of instruments required to handle the endogeneity, so that we can examine if the weak instrument problem is completely due to our translog specification. Table 27 presents the heteroskedasticity-robust statistics for identification and instrument relevance from the first stage of IV regression of the Cobb-Douglas model. The robust Kleibergen-Paap Wald rk F statistic for the weak identification test is 0.39. The corresponding Stock and Yogo critical value for eight excluded instrumental variables and two endogenous variable at 5% relative maximal IV bias is 17.70. Hence, weak instrumental variables problem is still present in a restricted Cobb-Douglas specification. It can also be inferred from the Partial R^2 of Shea (1997) presented in the table that even though both of the endogenous regressors are weakly identified, identification of the change in TAKS passing rate is weaker. We conclude that the instruments commonly suggested in the literature for educational quality weakly identify the educational quality, and hence, treating the educational quality measures as exogenous would provide better estimates.

Our final inspection in this section is about the endogeneity of our concentration measure. Since we suspect that the HHI we employ in the variance of cost inefficiency is endogenous, and the literature does not offer a well-established procedure to handle the endogeneity in the one-sided error, in order to at least have an inference about the degree of HHI's possible endogeneity, we include the HHI-CBSA-ALL as a determinant of cost in a Cobb-Douglas specification, which resembles the model of Imazeki and Reschovsky (2006). Additionally, we model the variance of u with the Chapter 41 variable and the variance of v with the inverse of log enrollment. The first column of Table 28 presents

TABLE 27.—FIRST STAGE STATISTICS OF THE IV ESTIMATION, COBB-DOUGLAS MODEL

Variable	Shea's Partial R^2	Partial R^2	F Statistic (8, 933)	p-value of F Statistic
Change in TAKS passing rate	0.0038	0.0038	0.40	0.920
Percent taking advanced courses	0.0697	0.0693	9.92	0.000
Underidentification Tests				
Kleibergen-Paap rk LM statistic	$\chi^2(7) = 3.16$		p-value = 0.8696	
Kleibergen-Paap rk Wald statistic	$\chi^2(7) = 3.20$		p-value = 0.8656	
Weak Identification Test				
Kleibergen-Paap Wald rk F statistic	0.393			
Weak-Instrument-Robust Inference				
Anderson-Rubin Wald test	F(8, 933) = 21.68		p-value = 0.0000	
Anderson-Rubin Wald test	$\chi^2(8) = 176.82$		p-value = 0.0000	
Stock-Wright LM S statistic	$\chi^2(8) = 73.39$		p-value = 0.0000	
Overidentification Test of All Instruments				
Hansen's J Statistic	$\chi^2(6) = 11.231$		p-value = 0.0815	
Number of Observations = 951				
Number of Regressors = 12				
Number of Instruments = 18				
Number of Excluded Instruments = 8				

Note: First stage F, underidentification, weak identification, and weak-identification-robust test statistics are heteroskedasticity robust.

the stochastic frontier estimation results of this specification with HHI in the frontier function. Since there is not a direct equivalent of IV regressions with stochastic frontier models, in order to have another, maybe a more appropriate, reference for the IV regression, in the second column of Table 28, we also present the OLS estimation results of the Cobb-Douglas cost function with the same explanatory variables but excluding the Chapter 41 variable and the inverse of log enrollment.

TABLE 28.—ESTIMATION RESULTS WITH COBB-DOUGLAS COST FUNCTION (MULTIPLE PAGES)

	Cost Frontier with HHI	OLS	GMM
log(Enrollment)	-0.763 *** (0.126)	-1.029 *** (0.134)	-1.060 *** (0.145)
log(Enrollment), squared	0.067 *** (0.016)	0.098 *** (0.018)	0.102 *** (0.018)
log(Enrollment), cubed	-0.002 *** (0.001)	-0.003 *** (0.001)	-0.003 *** (0.001)
log(Change in TAKS passing rate)	0.194 ** (0.093)	0.250 ** (0.099)	0.263 ** (0.117)
Percent taking advanced courses	0.162 *** (0.048)	0.244 *** (0.053)	0.210 *** (0.081)
Lagged passing rate	-0.016 (0.048)	0.048 (0.054)	0.054 (0.067)
Percent low income students	0.304 *** (0.032)	0.251 *** (0.038)	0.247 *** (0.047)
Percent limited English proficiency	-0.099 ** (0.050)	-0.094 (0.067)	-0.071 (0.067)
Percent Special Education Students	0.544 *** (0.130)	0.441 *** (0.147)	0.633 *** (0.165)
Percent High school Students	0.203 * (0.122)	0.328 *** (0.118)	0.222 (0.178)
log(Distance)	0.013 ** (0.005)	0.025 *** (0.007)	0.011 (0.012)
log(Hedonic predicted salary)	0.485 *** (0.098)	0.890 *** (0.112)	0.830 *** (0.162)
log(High school comparable wage)	-0.069 (0.049)	-0.135 ** (0.062)	0.042 (0.133)
HHI-CBSA-ALL	0.074 *** (0.020)	0.152 *** (0.026)	0.345 *** (0.117)
Constant	11.194 *** (0.343)	11.892 *** (0.348)	11.780 *** (0.133)
Chapter 41 (in log(σ_u^2))	1.843 *** (0.206)		
Constant (in log(σ_u^2))	-4.732 *** (0.226)		
1 / log(Enrollment) (in log(σ_v^2))	24.668 *** (2.491)		
Constant (in log(σ_v^2))	-8.642 *** (0.416)		

TABLE 28.—ESTIMATION RESULTS WITH COBB-DOUGLAS COST FUNCTION (MULTIPLE PAGES)

	Cost Frontier with HHI	OLS	GMM
Observations	951	951	951
Log Likelihood	766.1		

Note: The dependent variable is log(Expenditure per pupil). Standard errors are in parentheses. Triple asterisk (***) means significance at the 1% level. Double asterisk (**) means significance at the 5% level. Single asterisk (*) means significance at the 10% level.

The heteroskedasticity-robust statistics for identification and instrument relevance from the first stage of IV regression of the Cobb-Douglas model with HHI is presented in Table 29. We treat the educational quality measures as exogenous and instrument the endogenous HHI with two different counts of streams in a district's county. As illustrated in the table, the Hansen's J test does not reject the joint null hypothesis, so the instruments for HHI are valid. Moreover, the Kleibergen and Paap underidentification tests reject the null hypothesis, so the matrix of reduced-form coefficients on the excluded instruments is of full column rank, and the model is not underidentified. In addition, the robust Kleibergen-Paap Wald rk F statistic is equal to 27.08. The Stock and Yogo critical value corresponding to two excluded instrumental variables and one endogenous variable at 10% relative maximal IV size is 19.93, suggesting that null hypothesis of weak identification is rejected as well. Finally, the tests for the relevance of potentially endogenous regressors reject the null hypothesis of irrelevant endogenous regressors.

TABLE 29.—FIRST STAGE STATISTICS OF THE IV ESTIMATION,
COBB-DOUGLAS WITH HHI

Variable	Shea's Partial R^2	Partial R^2	F Statistic (2, 935)	p-value of F Statistic
HHI-CBSA-ALL	0.0514	0.0514	27.08	0.000
Underidentification Tests				
Kleibergen-Paap rk LM statistic	$\chi^2(2) = 37.45$		p-value = 0.0000	
Kleibergen-Paap rk Wald statistic	$\chi^2(2) = 55.08$		p-value = 0.0000	
Weak Identification Test				
Kleibergen-Paap Wald rk F statistic	27.079			
Weak-Instrument-Robust Inference				
Anderson-Rubin Wald test	F(2, 935) = 11.44		p-value = 0.0000	
Anderson-Rubin Wald test	$\chi^2(2) = 23.28$		p-value = 0.0000	
Stock-Wright LM S statistic	$\chi^2(2) = 23.34$		p-value = 0.0000	
Overidentification Test of All Instruments				
Hansen's J Statistic	$\chi^2(1) = 14.451$		p-value = 0.0001	
Number of Observations = 951				
Number of Regressors = 15				
Number of Instruments = 16				
Number of Excluded Instruments = 2				

Note: First stage F, underidentification, weak identification, and weak-identification-robust test statistics are heteroskedasticity robust.

Baum, Schaffer and Stillman (2003) explain that in the presence of arbitrary heteroskedasticity, the GMM estimator is more efficient than the standard IV estimator. We find that Pagan and Hall (1983) general test statistic is 59.8, and at $\chi^2(15)$, the statistic rejects the null hypothesis of homoscedasticity. Therefore, we estimate the second stage of our IV regression with GMM. The results from the second stage GMM regression is presented in the third column of Table 28. As can be seen, the coefficient of HHI in the GMM column is more than the double of the coefficient of HHI in the OLS column verifying that the effects of HHI on cost would be underestimated if its endogeneity is not controlled. The coefficient of HHI in the cost frontier estimation is even smaller compared to 0.345 in the GMM column. Even though the results in the GMM column are not acquired by a direct IV estimation of the model in the cost frontier column, this finding gives us an idea about the degree of underestimation of the coefficient of HHI. In order to have a more accurate impression of the underestimation of the effects of HHI on cost inefficiency, however, a different methodology should be developed to properly address the endogeneity of the inefficiency variables.

3.7. Simulations

Log expenditure per pupil of an existing district can be predicted by adding an estimate of u to the estimate of log cost per pupil of that district. It can be said that the point estimates of u offered by Jondrow et al. are suitable to predict the log expenditure per pupil of an existing district, as presented in equation (31), which is rewritten below

$$\widehat{\ln E_i^*} = \mathrm{E}(\ln E_i^* \mid q_i,\ w_i,\ z_i,\ x_i) = \hat{\alpha}_0 + Z_{ij}^* \hat{\alpha}_j' + \hat{u}_{je} \tag{35}$$

where Z_j^* is a vector of variables in the translog specification, $\hat{\alpha}_0$ and $\hat{\alpha}_j$ are the maximum likelihood estimates of α_0 and α_j , respectively, and $\hat{u}_{je} = \mathrm{E}(u_i \mid \varepsilon_i)$. In case of a hypothetical district, however, since we do not have that hypothetical district's actual log expenditure per pupil, we cannot estimate the district's ε. Hence, a point estimate of u conditional on ε, such as those a la Jondrow et al., cannot be acquired for a hypothetical district. In this paper, we propose an original methodology to simulate the log expenditures per pupil of hypothetical districts.

In simulation, what we are really interested in is to predict the log expenditure of a hypothetical district, and therefore, our aim is to find an estimate of u conditional on x. For instance, if the matter of investigation is the trade-off between a cost variable, say enrollment, and a cost inefficiency variable, say competition in the education market, while holding other variables constant at a specified level, we can evaluate the changes in the predicted log expenditure per pupil as size and competition change, by using an estimate of u conditional on x. This would allow us to draw a figure with iso-expenditure curves at different levels of the predicted log expenditure per pupil and assess the trade-off between two variables determining the predicted log expenditure per pupil. We illustrate such an example in Section 3.7.1 below.

Alternatively, in a consolidation scenario, in order to evaluate if there are cost savings after consolidation, we need to estimate log expenditure per pupil of the consolidated district. Certain assumptions about how the variables explaining cost and cost inefficiency change after consolidation would be necessary. Once those assumptions are made, however, log expenditure per pupil of the consolidated district can easily be estimated using our methodology. We further illustrate the use of our methodology by simulating a consolidation scenario in Section 3.7.2 below. Since any evaluation of the conditional effects of x on the log expenditure per pupil of a hypothetical district and any simulation of a consolidation scenario requires a point estimate of u conditional on x, our proposal constitutes a useful methodological contribution. Our proposed methodology can also be used to examine hypothetical firms and simulate merger scenarios in a stochastic production frontier analysis.

In the methodology section we assume that $u \equiv \mathcal{N}^{+}[\,0\,, \sigma_u^2\,]$ and define $\sigma_u^2 = \exp(\delta_0 + \delta \cdot x_i')$. Our u has a half-normal distribution and the scaling property, that is, basic half-normal distribution of u is not a function of x, and therefore, would not change as x changes. Since the mean of any variable with half-normal distribution can be written as $\sqrt{2\sigma^2}/\sqrt{\pi}$ where σ^2 is the variance of the normal distribution determining the half-normal distribution of the variable, we define $\hat{u}$ as[28]

$$\hat{u} = \mathrm{E}(u \mid x) = \frac{\sqrt{2\sigma_u^2}}{\sqrt{\pi}} = \frac{\sqrt{2}}{\sqrt{\pi}} \cdot \sqrt{\exp(\delta_0 + \delta \cdot x')} \tag{36}$$

Table 30 and Table 31 present summary statistics of $\hat{u}$, $\hat{u}_{je}$ and $\hat{u}_{jm}$, and the correlations between each other.

TABLE 30.—DESCRIPTIVE STATISTICS OF THE ESTIMATES OF COST INEFFICIENCY

Variable	Mean	Standard Deviation	Minimum	Maximum
$\hat{u}$	0.08	0.04	0.05	0.23
$\hat{u}_{je}$	0.08	0.06	0.02	0.62
$\hat{u}_{jm}$	0.06	0.07	0.00	0.62

Number of observations = 952

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[28] If u is assumed to have the scaling property with a different distribution, say truncated normal, $\hat{u}$ can be defined as $\exp(\delta \cdot x') \cdot \mu^*$ where μ^* is the mean of the truncated normal distribution, which is equal to $\mu + \frac{\phi\left(\frac{a-\mu}{\sigma}\right)-\phi\left(\frac{b-\mu}{\sigma}\right)}{\Phi\left(\frac{b-\mu}{\sigma}\right)-\Phi\left(\frac{a-\mu}{\sigma}\right)}\sigma$ where μ and σ are the mean and standard deviation of the normal distribution determining the truncated normal distribution, and a and b are the truncation minimum and maximum boundaries.

TABLE 31.—PAIRWISE CORRELATION COEFFICIENTS OF THE ESTIMATES OF COST INEFFICIENCY

	$\hat{u}$	$\hat{u}_{je}$
$\hat{u}_{je}$	0.643 (0.000)	
$\hat{u}_{jm}$	0.573 (0.000)	0.974 (0.000)

Note: Significance levels are in parentheses.

Figure 24 and Figure 25 present a scatterplot of $\hat{u}$ against $\hat{u}_{je}$, and their histograms. As can be seen in those tables and figures, the correlation between $\hat{u}$ and $\hat{u}_{je}$ is positive and higher than 0.6, and they are over a similar range with almost identical means and comparable standard deviations. Hence, for the existing districts, our $\hat{u}$ is relevant to the point estimates of u offered by Jondrow et al.

FIGURE 24.—SCATTERPLOT OF THE ESTIMATES OF COST INEFFICIENCY

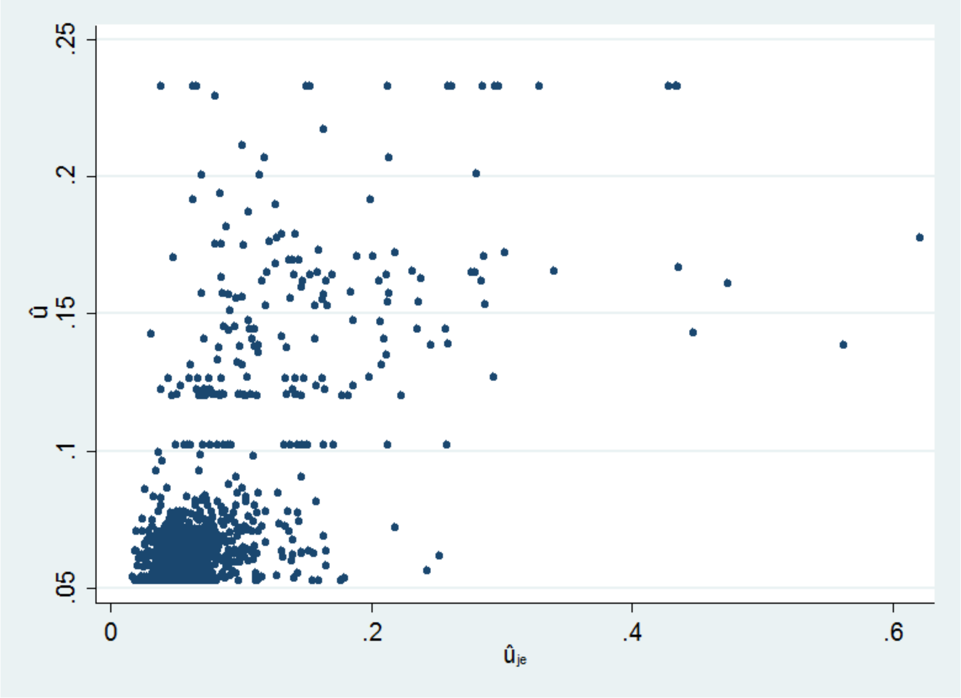
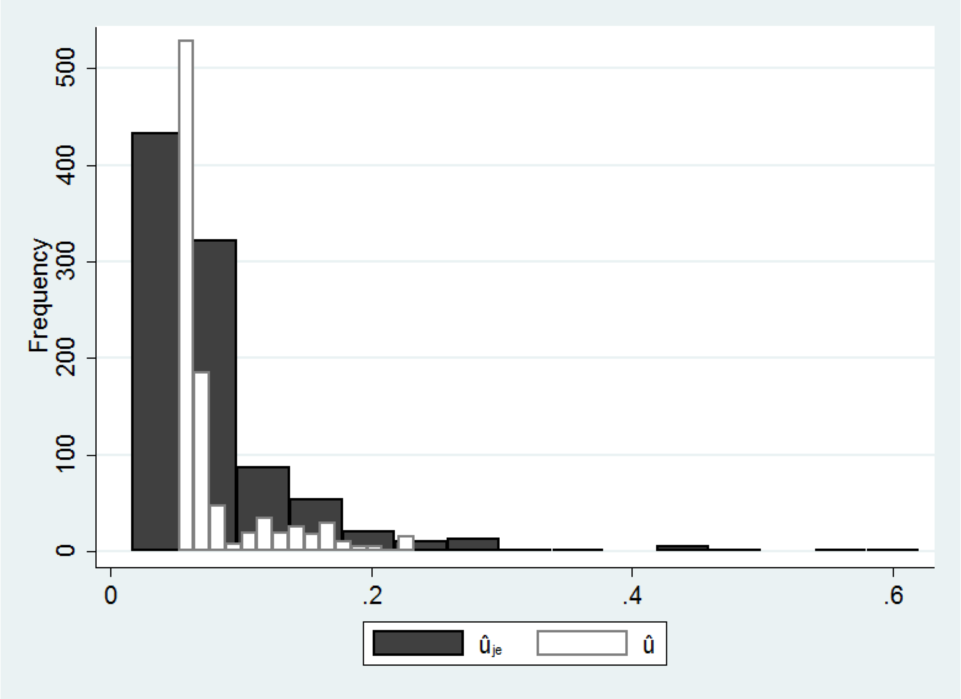


FIGURE 25.—HISTOGRAMS OF THE ESTIMATES OF COST INEFFICIENCY



Moreover, since we assume that $v \sim iid\ \mathcal{N}(0, \sigma_v^2)$, expected value of v would be equal to 0. Thus, we write the expected expenditure per pupil of a hypothetical district as

$$\widehat{\ln E_i^*} = \mathrm{E}(\ln E_i^* \mid q_i,\ w_i,\ z_i,\ x_i\ ) = \hat{\alpha}_0 + Z_{ij}^* \hat{\alpha}_j' + \hat{u}_i \tag{37}$$

For different hypothetical districts, the variables $q, w, z,$ or x would be different. Hence, certain assumptions about these variables are necessary for simulation purposes. In the following two sections on simulation exercises, we explain our assumptions in detail about these variables.

Finally, if we take the derivative of equation (36) with respect to one of the x variables as follows, we get the marginal effects of the variables that explain the variance of cost inefficiency on the cost inefficiency of the hypothetical district.

$$\frac{\partial \hat{u}}{\partial x_j} = \frac{\sqrt{\exp(\delta_0 + \delta \cdot x')} \cdot \sqrt{2}}{\sqrt{\pi}} \cdot \frac{\delta_j}{2} \tag{38}$$

3.7.1. Iso-Expenditure Curves

In Figure 26, we present iso-expenditure curves which summarize the trade-off between the competitive effect and scale effect. We generated the iso-expenditure curves for six different levels of expenditure per pupil holding all cost factors except for enrollment constant at sample mean values and setting the Chapter 41 dummy variable equal to 1,[29] while allowing HHI-CBSA-ALL to be flexible. These assumptions allow us to hold all variables other than the two under immediate attention (enrollment and HHI) constant and focus at the trade-off between the two variables. That is, each iso-expenditure curve presents all possible pairs of N and HHI that would result in the same level of expenditure when other variables affecting the expenditure are fixed. In the figure, $competition = 1 - \text{HHI}$, so $competition = 1$ is perfect competition and $competition = 0$ is monopoly. Just like the cost curve in Figure 3b, the shapes of iso-expenditure curves are not the traditional U-shape, again, due to the inclusion of the cubic enrollment in cost function. There are three different regions in the figure: the first region is from 50 to 20,518 students, the second region is from 20,518 to 303,028 students, and the third region is from 303,028 to 736,972 students.

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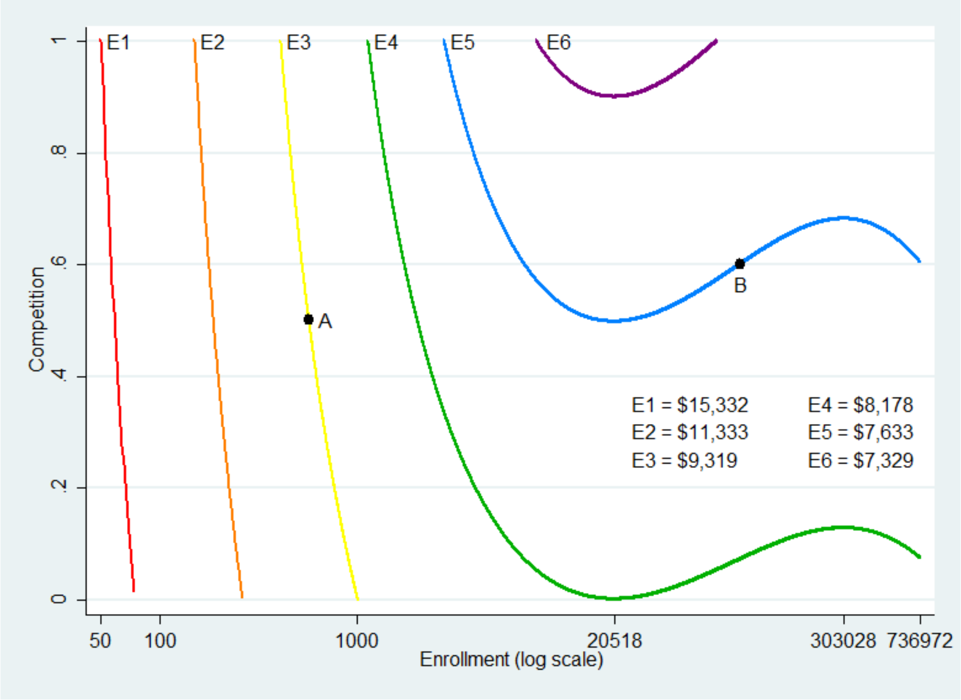
[29] If the Chapter 41 dummy variable was set to be equal to 0, all of the iso-expenditure curves would shift downwards by $\hat{\delta}_{\text{C41}}/\hat{\delta}_{\text{HHI}} = 1.17$. In other words, the six iso-expenditure curves presented in the figure would represent a lower level of expenditure per-pupil than that shown in the legend. Since the shapes of the iso-expenditure curves and local maximums and minimums would not change with the assumption to set Chapter 41 dummy to either 0 or 1, the results presented in this subchapter are not dependent on this assumption.

FIGURE 26.—ISO-EXPENDITURE CURVES



It can be seen in the figure that in the first region, expenditure per pupil decreases as enrollment or competition increases. The maximum expenditure per pupil on the figure is $17,253 and that point is at where enrollment and competition are equal to 50 and 0 relatively. The minimum expenditure per pupil, on the other hand, is at enrollment equal to 20,518 and competition equal to 1. At that point, per pupil expenditure is $7,268. Between these two points are a whole range of iso-expenditure curves representing different levels of expenditure per pupil between $7,268 and $17,253. One of these curves is presented as E3 on the figure. Expenditure per pupil on the E3 curve is about $9,319. This level of per pupil expenditure can be attained by a large district of size 1,015—median enrollment of our sample—if the district is a monopoly. The same level of per pupil expenditure can also be attained by a rather smaller district with 412 students, if the district is in a perfectly competitive environment.

The competitive effect and the scale effect work in the opposite directions over the range from 50 to 20,518 students. To give an example, assume that district A has 573 students and the competition in their education market is about 0.5. Point A on the E3 curve represents the initial position of district A. Suppose another district, say district A2, in the same education market consolidates into district A and their total enrollment is less than 20,518 students. This consolidation would decrease the competition in their education market to a level below 0.5, which would push point A downwards to a higher level of expenditure per pupil. At the same time, the enrollment in the consolidated district is more than 573 students. Therefore the increase in enrollment would move point A rightwards to a lower level of expenditure per pupil. The final position of point A is ambiguous because the result depends on the size of district A2, and the number and size of the other districts in the same education market. Assume, for instance, that after consolidation, competition would become 0.2. In that case, if the size of district A2 is less than 201 students, then the competitive effect would dominate the scale effect and per pupil expenditure after consolidation would be more than $9,319. Conversely, if the size of district A2 is more than 201 students, then the scale effect would dominate the competitive effect and expenditure per pupil after consolidation would be less than $9,319. If the size of district A2 is exactly equal to 201, then the scale effect would perfectly balance out the competitive effect and the consolidated district would end up on the E3 iso-expenditure curve again.

In the first region, the iso-expenditure curves presenting higher levels of per pupil expenditure are steeper than those presenting lower expenditure per pupil levels. This has an interesting implication: at any given level of competition, holding everything else constant, the smaller the size of the district, the bigger the amount of per pupil savings after consolidation. Moreover, for the same reason, over this region, smaller districts are more likely to end up on a lower iso-expenditure per pupil curve and be cost saving after consolidation.

In the figure, there are diseconomies of scale in the second region meaning that expenditure per pupil decreases as enrollment decreases. In this region, more competition would also decrease the per pupil expenditures. The maximum per pupil expenditure in this range is about $8,344 at enrollment equal to 303,028 students and competition equal to 0. The minimum expenditure per pupil is again $7,268 at enrollment equal to 20,518 and competition equal to 1, and in between these two points are different levels of per pupil expenditures between $7,268 and $8,243.

The competitive effect and the scale effect work in the same directions in the second region. To illustrate, assume that district B has 90,000 students and the competition in their education market is 0.6. Point B on the E5 curve shows their initial expenditure per pupil level which is equal to $7,633. Suppose that another district from the same education market, say district B2, consolidates into district B and their total enrollment at the end is less than 303,028 students. Decrease in competition due to consolidation would move point B downwards. Moreover, the increase in size would move the point to the left. Since both forces push the point to a higher level of expenditure per pupil, the change in the expenditure per pupil is not ambiguous in this case. The consolidated district’s expenditure per pupil would be more than $7,633 and this result would not depend on the size of district B2, or the size and number of the other districts in their education market.[30] The only way to decrease per pupil expenditures in the second region is to deconsolidate district B. Creating some new districts from district B would increase the level of competition in their education market and move point B upwards. Also deconsolidation would decrease the size of district B which would move point B to the left. Unless this leftward scale effect does not carry point B to far beyond E5 curve, the per pupil expenditure of district B would be less than $7,633.

The third region of the figure is very similar to the first region in that there is a trade-off between the competitive effect and scale effect. That is, if consolidation makes a district’s size grow beyond 303,028 students, then any additional enrollment would decrease the expenditure per pupil. On the other hand, the iso-expenditure curves are flatter over the third region compared to their own extensions over the first region. This means that holding other variables constant, consolidation is relatively less cost saving for a district of size greater than 303,028 compared to a district of size less than 20,518.

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[30] If the assumption about the total size of the consolidated district is relaxed the result can change. In order to get a different result, however, the size of the consolidated district should be beyond 750,000, which is not displayed in the figure.

3.7.2. Simulation of a Consolidation Scenario

In January 2011, Texas State Representative Fred Brown, R-Bryan, proposed a bill (House Bill 106) which suggests reducing the number of public school districts in Texas from 1,235 to 254—only one school district for each county.[31] He advises that the savings from administrative costs would be billions of dollars each year, which, he says, could go back to the public education sector in Texas to improve its quality. Nevertheless, as we presented, actual outcomes of such a consolidation scenario depends heavily on multiple effects of school district consolidation.

Since the outcomes of a possible consolidation scenario is ambiguous, it is important to analyze the cases with the right specifications to have sound predictions. In order to have a better understanding of the outcomes of a consolidation scenario offered by Fred Brown, we provide a series of simulations that draw attention to how the magnitude of the trade-off between competition and size can affect the findings. Evaluating a real life consolidation scenario is one of the significant features of this study. Our econometric analyses and findings make more sense with a simulation of the actual world, and such an exercise allows us to capture the results visually and highlight the efficiency trade-off we found on maps.

It is important to note that our simulation exercise here is different than evaluating the monetary outcomes of a consolidation scenario using only a fixed school district funding formula without considering the competitive effect of consolidation. In

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[31] Currently, some of the states in the U.S., such as West Virginia, Maryland, Nevada, Florida and Georgia, are mostly county-district states. Hawaii is a state-district, with only one school district for the whole state but five counties.

real life, if the funding formula does not get changed to accommodate the changes in the competitive environment after consolidation, the competitive effect of consolidation would reflect itself in changes in the output quality rather than causing a change in expenditures per pupil. In our simulation exercise, however, we analyze the competitive effect of consolidation on per pupil expenditure holding every other variable constant. That is, we estimate the expenditure per pupil required to produce a certain level of output quality before consolidation, and compare that with the consolidated district's estimated expenditure per pupil required to produce that same level of output quality as before consolidation. To give an example, if competitive effect of a consolidation dominates its scale effect, then increased cost inefficiency of the consolidated district may reflect itself in decreased output quality. Holding everything else constant, the output quality may be increased to its previous level if expenditure per pupil is increased. Because they need to increase their expenditure per pupil to establish the same level of output quality as before, we call this type of districts as "losers" after the consolidation.

Our simulation exercise and findings in this section are based on the reasoning above. We showed that school district consolidation would involve a trade-off between competition among school districts and their size. Since, these forces work in opposite directions, consolidation of school districts does not necessarily result in cost savings. In some districts, expenditure per pupil can increase after consolidation if the loss caused by the decrease in the degree of competition they face dominates the savings from scale economies. Hence, after consolidation, along with some per pupil cost-saving winner districts, there can be some loser districts whose per pupil expenditures are more than their per pupil expenditures before consolidation, *ceteris paribus*. For larger districts, being a loser district even with a slight increase in per pupil expenditure after consolidation would mean big losses in total expenditures. Moreover, at the state level, total losses can outweigh total savings after consolidation; that is, not every consolidation scenario is necessarily favorable in overall.

In order to determine the winner and loser counties, we compare the sum of the predicted log expenditures of the districts in a county before consolidation, and the predicted total expenditure of the county after consolidation.[32] We predict the log expenditure per pupil of a district by using equation (37) with the actual variables of that district and the coefficient estimates from our stochastic frontier estimation presented in the "HHI-CBSA-ALL, Linear" column in Table 17.[33] Although the districts with missing values were excluded in our regressions, in order to have a completer picture of

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[32] It can be argued that the comparison should be between the actual total expenditures of the districts within a county, and the predicted expenditures of the county after consolidation. Although we found that this comparison does not change our results qualitatively, we think that comparing the predicted expenditures before and after is a better comparison with a more accurate analogy.

[33] Even though using the same formula to predict the log expenditures before and after consolidation constitutes a proper assessment methodology, one can also use equation (35) to calculate the sum of the predicted log expenditures of districts in a county before consolidation, to compare that with the predicted total expenditure of the county after consolidation calculated by using equation (37). We find that if such a methodology is followed, the number of districts incurring losses after consolidation is more than that presented in this section, and the total gains for the state after consolidation is less than that presented in this section. However, we also find that following this methodology would not chance our qualitative findings critically.

winners and losers, we fill in the missing values with state averages of the variables.[34] However, we excluded two counties due to complex non-availability of data.[35]

We use equation (37) and the coefficient estimates from our stochastic frontier estimation presented in the "HHI-CBSA-ALL, Linear" column in Table 17 also to predict the log expenditure per pupil of a county after consolidation. However, since the values of the variables determining the log expenditure per pupil of a hypothetical county district are unavailable, predicting the total expenditure of a county after consolidation requires some assumption. First, we assume that after consolidation, the total enrollment of a county would be equal to the total enrollment of the districts in that county before consolidation. This assumption is plausible considering that the total enrollments in counties would not change much especially right after a county level consolidation. Secondly, we assume that the average remoteness of a consolidated county to a major metropolitan is the average remoteness of the districts within that county to a major metropolitan area. We recalculate the HHI-CBSA-ALL measures of

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[34] Replacing the missing values with county averages instead of state averages can be an alternative approach. Although following this alternative approach causes quantitative differences, our general conclusions in the simulation section about the efficiency trade-off, and winners and loser after consolidation do not change.

[35] We excluded Loving County from the simulation analysis because their school system was completely closed and consolidated into Wink County's ISD in 1972 due to the on-going low levels of enrollment. Bowie County is excluded from the simulation analysis because Texarkana metropolitan statistical area encompasses Miller County in Arkansas as well, which complicates the calculation of the competition measure we use in this section.

counties after consolidation assuming that there would be no changes to the private schools after the public district consolidation. We also recalculate the Chapter 41 status of the counties after consolidation using the original formula used to determine the Chapter 41 status of the districts. That is, we determine the status by comparing the county's total tax base in the previous year over the county's total Chapter 41 WADA with $319,500. Finally, we assumed that rest of the variables of a county after consolidation are the enrollment weighted averages of those variables of the districts in that county. For example, we assume that a county's change in passing rates after consolidation would be equal to the enrollment weighted average of the change in passing rates of the districts in that county. The underlying assumption, again, is that the enrollment in a county would not change immediately after a county level consolidation, and hence, the consolidated county's characteristics would reflect the enrollment weighted averages of its districts' characteristics. The summary statistics before and after consolidation are presented in Table 32 and Table 33.

TABLE 32.—DESCRIPTIVE STATISTICS BEFORE CONSOLIDATION

Variable	Mean	Standard Deviation	Minimum	Maximum
Enrollment	4,427	12,674	22	202,449
Change in TAKS passing rate	0.012	0.051	-0.286	0.4
Percent taking advanced courses	0.183	0.086	0	0.853
Lagged passing rate	0.703	0.106	0.407	0.985
Percent low income students	0.532	0.186	0	0.999
Percent limited English proficiency	0.077	0.093	0	0.687
Percent Special Education Students	0.123	0.033	0	0.305
Percent High school Students	0.285	0.078	0	0.557
Distance from major metropolitan areas	107.9	81.6	3.4	365.3
Hedonic predicted salary	1.206	0.092	1	1.463
High school comparable wage index	3.059	0.451	2.493	3.995
Chapter 41 district	0.193	0.395	0	1
HHI-CBSA-ALL	0.32	0.231	0.059	1

Number of observations = 1011

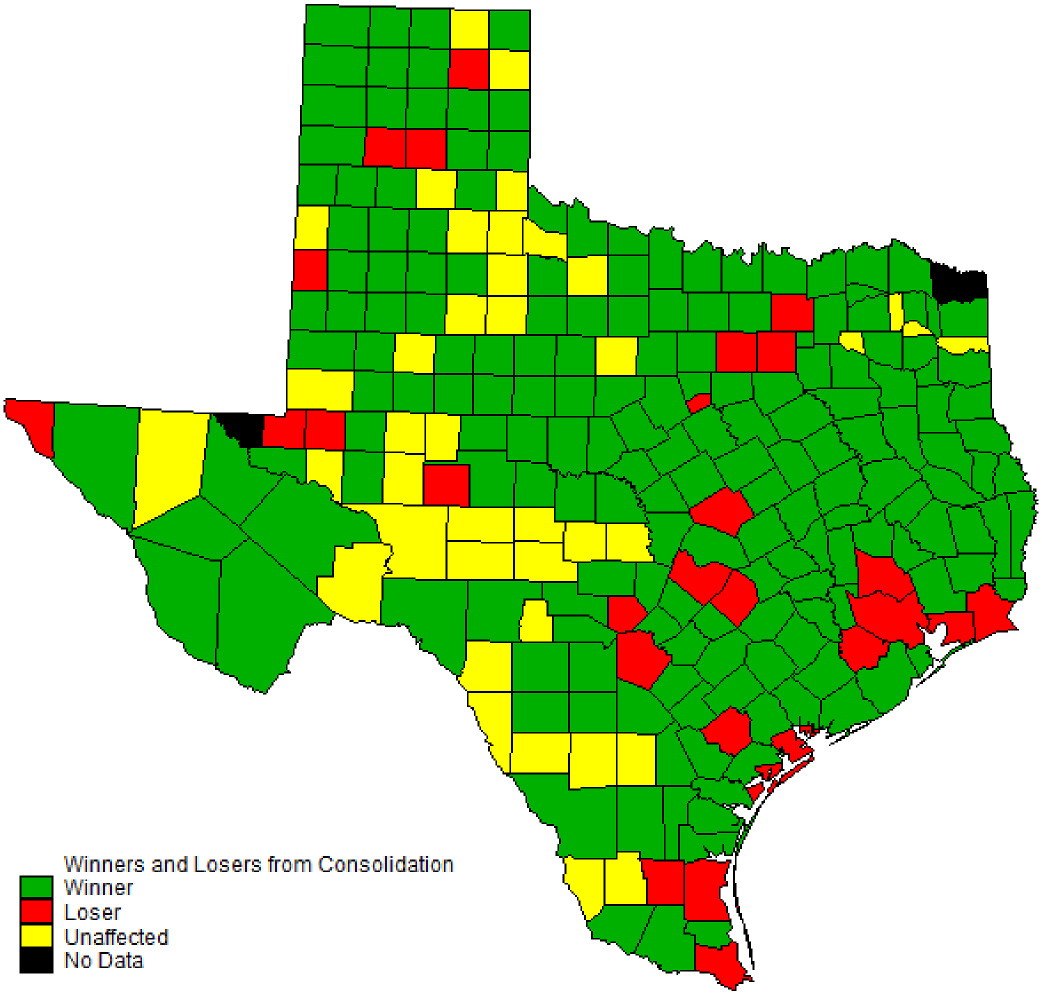
TABLE 33.—DESCRIPTIVE STATISTICS AFTER CONSOLIDATION

Variable	Mean	Standard Deviation	Minimum	Maximum
Enrollment	17,761	63,169	83	736,972
Change in TAKS passing rate	0.011	0.028	-0.108	0.113
Percent taking advanced courses	0.193	0.066	0.041	0.636
Lagged passing rate	0.7	0.078	0.435	0.883
Percent low income students	0.553	0.135	0.189	0.913
Percent limited English proficiency	0.083	0.081	0	0.547
Percent Special Education Students	0.122	0.025	0.06	0.267
Percent High school Students	0.298	0.037	0	0.48
Distance from major metropolitan areas	132.8	85.4	8.4	363.7
Hedonic predicted salary	1.194	0.083	1	1.463
High school comparable wage index	2.917	0.389	2.493	3.995
Chapter 41 district	0.183	0.387	0	1
HHI-CBSA-ALL	0.854	0.213	0.337	1

Number of observations = 252

Figure 27 presents a Texas county map of winners and losers after the Fred Brown consolidation. Out of 254 counties, 184 are cost saving winners, and 28 incur losses after consolidation. There are 40 unaffected counties, which are already county-districts before consolidation and their HHI are equal to 1. The predicted total expenditure of Texas before consolidation is 32.5 billion dollars. We found that the total gains for the state after consolidation would be about 1.3 billion dollars—similar to but probably less than what Fred Brown estimated.

FIGURE 27.—TEXAS MAP OF WINNERS AND LOSER AFTER THE CONSOLIDATION



A closer look at the winners-losers map would help us see the trade-off between competition and size. Some of the biggest counties in Texas in terms of enrollment, including Harris, Dallas, Tarrant, Bexar, El Paso and Travis, are losers after the consolidation. Bexar, El Paso and Travis have enrollments less than 300,000 but more than 100,000 students. Bexar County, for example, is one of the 8 counties in Greater San Antonio—one of the biggest metropolitan areas in the U.S. In 2007, there are 39 public school districts in Greater San Antonio and 15 of them are in Bexar. Before consolidation, the level of HHI in Bexar districts is 0.101. After consolidation, the HHI increases to 0.590. At the same time, consolidation changes the size of the districts. Before consolidation, the average school district enrollment in Bexar is 19,297 students with smallest having 872 students. After consolidation, the enrollment in the new Bexar County-district is 289,451 students. The change in scale is huge, but too huge that the consolidated district ends up experiencing diseconomies of scale which couples up with the increased cost inefficiency mainly due to weakened competition. On the other hand, in 2006, Alamo Heights ISD is the only Chapter 41 district in Bexar. After consolidation, Bexar County becomes a property-poor district. There is a minor increase in the cost efficiency due to this change but at the end, their overall loss per pupil is $217.

Tarrant, Dallas and Harris, on the other hand, are in the second region of declining average costs as their enrollments are more than 310,000. Therefore they may be expected to experience some cost savings after consolidation. Our simulation results, however, present that in case of these counties, the competitive effect dominates the scale effect and they become losers after consolidation. For example, in Harris, HHI before consolidation is 0.058, but after consolidation, their HHI increases to 0.455. They lose much of their competition due to consolidation and the decrease in competition level causes a negative pressure on their cost efficiency, which increases their per pupil expenditure significantly. In addition to that, the smallest district in Harris is Huffman ISD with 3,045 students, and the average district size is 36,849 students. Even though a couple of districts in Harris such as Aldine ISD and Houston ISD experience some savings due to the big change in total enrollment, other, rather smaller districts such as Spring ISD, Tomball ISD and Sheldon ISD suffer an eventual increase in their predicted cost per pupil. Since some districts cannot benefit from decreasing average costs and there is a considerable change in the concentration, the negative effects on the expenditure per pupil is big enough to dominate, and actually dwarf the positive effects of becoming a property-poor district after consolidation and scale effect’s cost savings in a couple of districts. Harris County-district’s eventual loss is $271 per pupil.

Significance of the competitive effect is maybe more evident for counties such as Bastrop, Kendall or Chambers, which belong to the biggest core based statistical areas of Texas, and have total enrollments less than 15,000 students. These counties are in the primary region of declining average costs, and for that reason, would wrongfully be expected to save costs if the districts within these counties consolidate. Since the lessening degree of competition in these core based statistical areas impact the cost inefficiency of these counties up to a level that wipes out their scale savings, they turn out to be losers after such a consolidation scenario. In Bastrop, for instance, there are four districts which are all property-poor. Average enrollment in Bastrop is 3,406 students, and the smallest district in Bastrop has 181 students. Consolidation increases the HHI from 0.131 to 0.337, and size to 13,623 students. There are significant savings due to the change in size. Nonetheless, these savings are offset by the change in competitive environment and Bastrop ends up being a loser after consolidation.

Aransas County is an example of a single district county, which is in Corpus Christi CBSA and has an enrollment of 3,244 students. Their HHI is 0.286, and predicted expenditure per pupil is $7,937 before consolidation. After consolidation, however, their HHI increase to 0.606 and the associated competitive effect dominates the economies of scale and increases the predicted per pupil expenditure to $8,225—a loss of $288 per pupil.

Comal County is another county in Greater San Antonio. There are 2 districts in Comal in 2007, one of which is a property-rich district, and their average enrollment is 10,600 students. After consolidation their level of HHI would increase from 0.101 to 0.590 as well. In this case, however, the total enrollment of the consolidated district is 21,199—a range with high scale savings which is sufficient enough to offset competitive effects. Moreover, the district after consolidation is a property-poor district, which also contributes to the expenditure per pupil savings. Therefore, although there are negative competitive effects on cost efficiency, these effects get dominated by the scale and Chapter 41 effects, and Comal County-district is a winner after consolidation with savings of $290 per pupil.

Val Verde County is also a winner after our consolidation scenario. There are two districts in Val Verde and they do not have much competition in their education market to begin with. After consolidation, their HHI increases from 0.862 to 0.896. However, when the smaller district of size 199 consolidates with the bigger district, there are big savings due to economies of scale. Furthermore, although one of the districts of Val Verde is property-rich, Val Verde is property-poor in overall. Hence, there are associated efficiency effects due to becoming property-poor after consolidation. These savings outweigh the small loss due to the change in competitive environment, and hence, the county saves $60 per pupil after consolidation.

The results presented in this section are dependent on our original specification of cost inefficiency. A misspecified model of cost, which does not include competition at all, would generate a different result than our finding above. In order to investigate the effects of competition, we first exclude it from our specification and conduct our simulation exercise using the estimates from this misspecified model. Our results are striking. When the simulation is run with the estimates from the misspecified model, the number of winner counties increases to 196. The number of losers, on the other hand, decreases to 5 after consolidation. Harris, Dallas and Bexar counties are losers solely because of the diseconomies of scale. Travis and Collin counties, however, are property-rich districts after consolidation.[36] Thus, their overall losses are due to both losses due to changes in the size and additional cost inefficiency due to the new Chapter 41 status. The total gains of the state with consolidation are about 2 billion dollars—700 million dollars more than what our correctly specified model with competition predicts. Therefore, it is evident that ignoring the competitive effect creates a misleading

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[36] Five of the seven districts in Travis are property-rich districts. Wealth per student ratio in Travis after consolidation is more than 350,000 which would correspond to an overall property-rich status. Collin County’s case is similar to that of Travis County.

impression that consolidation is more cost saving than it actually is, because many counties who would actually oppose consolidation appear as cost saving winners.

Secondly, as an alternative examination of the effects of competition we fixed the total competitive effects on the predicted log expenditures of the districts in a county before consolidation equal to the total competitive effect on the predicted expenditure of the county after consolidation.[37] By this, the corresponding losses due to the competitive environment before and after consolidation cancel each other out when comparing the predicted expenditures, and hence, competitive effect would not play a role in determining the winners and losers. The easiest way to do so is to set the HHI measure at the same constant level equal to 0 across the state before and after consolidation. Again we find that paying no attention to the competitive effect leads us to overestimated conclusions in favor of consolidation of school districts. We find that the total saving of the state in this case is around 1.9 billion dollars with the same 5 counties as losers. Therefore, the models ignoring the potential efficiency implications of competition in the education markets can result in miscalculated and misjudged assessment of the benefits of consolidation or deconsolidation proposals.

3.8. Concluding Discussion

To summarize the major results in this study, first, findings from the stochastic cost frontier analysis support our competitive efficiency hypothesis. A decrease in the

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[37] That is, we set $\sum_{i=1}^{n}(\partial\hat{u}_i/\partial\text{HHI}_{bc})\cdot N_i = (\partial\hat{u}_{ac}/\partial\text{HHI}_{ac})\cdot\sum_{i=1}^{n}N_i$, where n denotes the number of districts in a county, HHI_{bc} is the concentration measure of the districts before consolidation, $\hat{u}_{ac}$ is $\hat{u}$ of the county after consolidation, and HHI_{ac} is the concentration measure of the county after consolidation.

competitive structure, which is measured as an increase in the education market concentration, increases the school district cost inefficiency. We find that the marginal effect of concentration on cost inefficiency is equal to 0.03. Secondly, we present that there are economies of scale up to a district enrollment of 20,518. We also report a region of weak diseconomies of scale for districts with a total enrollment bigger than 20,518. Moreover, our simulation exercises illustrate the significance of the trade-off between the competitive effect and the scale effect. We show that in some cases of consolidation, competitive effect can actually dominate the scale effect resulting in an overall increase in the district expenditure per pupil after consolidation. When viewed from a public policy perspective, our finding implies that the competitive effect should also be considered when a district consolidation proposal is made with savings due to the economies of scale in mind.

In addition to the major finding of this study, we also provide some sensitivity analysis. We show that the effects of competition are robust to measuring the competition with different sets of competitors. Conversely, we present that the competitive effect is mildly sensitive to using different definitions of the education markets. When different definitions of the education markets are used to measure the market concentration, we find that the marginal effect of concentration on district cost inefficiency remains significant and positive but lies in a range of [0.02, 0.06]. Furthermore, we control for the endogeneity of competition with several instrumental variables and report indirect evidence that the effect of competition on school district efficiency may be underestimated due to the endogeneity.

4. CONCLUSION

In this dissertation, I analyze the effects of competition on education markets outcomes. My first essay explores the effects of different concentration measures on school personnel salaries. In my second essay, I evaluate the significance and sensitivity of the effects of various measures of competition on school district cost inefficiency.

In conclusion, the effects of competition are hardly responsive to measuring the competition with different sets of relevant competitors in an education market. My findings using different definitions of the education markets, however, indicate the opposite that the effects of competition change significantly when the market definition of the concentration measure changes. Still, variation in the estimated effects of competition with different definitions of markets is considerably small relative to the estimated competitive effects with a generally preferred CBSA definition of markets. Also the sign and the significance of the effect of competition do not change in most of the cases especially if the measure concentration is based on an appropriate definition of education markets.

Moreover, I control for the potential endogeneity of the concentration measures employed in my essays. The interpretation of the results from my endogeneity analyses is that the hypothesized effects of competition may be underestimated due to the endogeneity. This interpretation supports my general conclusions that competition is a multi-dimensional concept and the true discovery of its effects on education market outcomes depends on considering its many facets.

REFERENCES

Abraham, J. E., and John Douglas Hunt, "Specification and Estimation of Nested Logit Model of Home, Workplaces, and Commuter Mode Choices by Multiple-Worker Households," *Transportation Research Record: Journal of the Transportation Research Board* 1606:1 (1997), 17-24.

Adamache, Killard W., and Frank A. Sloan, "Unions and Hospitals: Some Unresolved Issues," *Journal of Health Economics* 1:1 (1982), 81-108.

Alonso, William, *Location and Land Use: Toward a General Theory of Land Rent* (Cambridge: Harvard University Press, 1964).

Alvarez, Antonio, Christine Amsler, Luis Orea, and Peter Schmidt, "Interpreting and Testing the Scaling Property in Models Where Inefficiency Depends on Firm Characteristics," *Journal of Productivity Analysis* 25:3 (2006), 201-212.

Anderson, Theodore W., and Herman Rubin, "Estimation of the Parameters of a Single Equation in a Complete System of Stochastic Equations," *The Annals of Mathematical Statistics* 20:1 (1949), 46-63.

Andrews, Matthew, William Duncombe, and John Yinger, "Revisiting Economies of Size in American Education: Are We Any Closer to a Consensus?," *Economics of Education Review* 21:3 (2002), 245-262.

Angrist, Joshua D., and Jorn-Steffen Pischke, *Mostly Harmless Econometrics: An Empiricist's Companion* (Princeton and Oxford: Princeton University Press, 2009).

Archibald, G. C., "The Factor Gap and the Level of Wages," *Economic Record* 30: (1954), 187-199.

Areeda, P., D.F. Turner, and H. Hovenkamp, *Antitrust Law: An Analysis of Antitrust Principles and Their Application* (California: Aspen Law & Business, 1978).

Bain, Joe Staten, *Price Theory* (Michigan: Holt, 1952).

Baird, Robert N., and John H. Landon, "The Effects of Collective Bargaining on Public School Teachers' Salaries: Comment," *Industrial and Labor Relations Review* 25:3 (1972), 410-417.

Ball, R. M., "The Use and Definition of Travel-to-Work Areas in Great Britain: Some Problems," *Regional Studies* 14:2 (1980), 125-139.

Bard, J., C. Gardener, and R. Wieland, "Rural School Consolidation Report: History, Research Summary, Conclusions and Recommendations," *The Rural Educator* 27:2 (2006), 40-48.

Battese, George E., and Timothy J. Coelli, "Prediction of Firm-Level Technical Efficiencies with a Generalized Frontier Production Function and Panel Data," *Journal of Econometrics* 38:3 (1988), 387-399.

———, "A Model for Technical Inefficiency Effects in a Stochastic Frontier Production Function for Panel Data," *Empirical Economics* 20:2 (1995), 325-332.

Baum, Christopher F., Mark E. Schaffer, and Steven Stillman, "Instrumental Variables and Gmm: Estimation and Testing," *Stata Journal* 3:1 (2003), 1-31.

Belfield, Clive R., and Henry M. Levin, "The Effects of Competition between Schools on Educational Outcomes: A Review for the United States," *Review of Educational Research* 72:2 (2002), 279-341.

Bell, Douglas Adrian, "Office Location--City or Suburbs? Travel Impacts Arising from Office Relocation from City to Suburbs," *Transportation* 18:3 (1991), 239-239.

Benson, Bruce L., "Spatial Competition: Implications for Market Area Delineation in Antimerger Cases," *Antitrust Bulletin* 25:4 (1980), 729-749.

Benton, Davis, "A Consolidation Success Story," *American School Board Journal* 179:4 (1992), 42-43.

Berry, Brian J. L., and Hak-Min Kim, "Challenges to the Monocentric Model," *Geographical Analysis* 25:1 (1993), 1-4.

Berry, Christopher, "School Consolidation and Inequality," *Brookings Papers on Education Policy* 06-07:1 (2007), 49-75.

Bettinger, Eric P., "The Effect of Charter Schools on Charter Students and Public Schools," *Economics of Education Review* 24:2 (2005), 133-147.

Bifulco, Robert, and Helen F. Ladd, "The Impacts of Charter Schools on Student Achievement: Evidence from North Carolina," *Education Finance and Policy* 1:1 (2006), 50-90.

Bish, Robert L., and Patrick D. O'Donoghue, "A Neglected Issue in Public-Goods Theory: The Monopsony Problem," *Journal of Political Economy* 78:6 (1970), 1367-1371.

Black, Sandra E., and Philip E. Strahan, "The Division of Spoils: Rent-Sharing and Discrimination in a Regulated Industry," *The American Economic Review* 91:4 (2001), 814-831.

Blanchflower, David G., Andrew J. Oswald, and Peter Sanfey, "Wages, Profits, and Rent-Sharing," *The Quarterly Journal of Economics* 111:1 (1996), 227-227.

Boal, William M., "Testing for Employer Monopsony in Turn-of-the-Century Coal Mining," *RAND Journal of Economics* 26:3 (1995), 519-536.

Boal, William M., and Michael R. Ransom, "Monopsony in the Labor Market," *Journal of Economic Literature* 35:1 (1997), 86-112.

Booker, Kevin, Scott M. Gilpatric, Timothy Gronberg, and Dennis Jansen, "The Effect of Charter Schools on Traditional Public School Students in Texas: Are Children Who Stay Behind Left Behind?," *Journal of Urban Economics* 64:1 (2008), 123-145.

Borcherding, Thomas E., "A Neglected Social Cost of a Voluntary Military," *The American Economic Review* 61:1 (1971), 195-195.

Borland, Melvin V., and Roy M. Howsen, "Student Academic Achievement and the Degree of Market Concentration in Education," *Economics of Education Review* 11:1 (1992), 31-39.

———, "On the Determination of the Critical Level of Market Concentration in Education," *Economics of Education Review* 12:2 (1993), 165-169.

———, "Competition, Expenditures and Student Performance in Mathematics: A Comment on Couch Et Al," *Public Choice* 87:3-4 (1996), 395-400.

Bound, John, David A. Jaeger, and Regina M. Baker, "Problems with Instrumental Variables Estimation When the Correlation between the Instruments and the Endogenous Explanatory Variable Is Weak," *Journal of the American Statistical Association* 90:430 (1995), 443-450.

Boyd, Donald, Hamilton Lankford, Susanna Loeb, and James Wyckoff, "The Draw of Home: How Teachers' Preferences for Proximity Disadvantage Urban Schools," *Journal of Policy Analysis and Management* 24:1 (2005), 113-132.

Brainard, W. C., and F. T. Dolbear, Jr., "The Possibility of Oversupply of Local "Public" Goods: A Critical Note [with Rejoinder by A. Williams]," *Journal of Political Economy* 75: (1967), 86-92.

Brennan, Geoffrey, "The Optimal Provision of Public Goods: A Comment," *Journal of Political Economy* 77:2 (1969), 237-241.

Brown, Charles, and James Medoff, "The Employer Size-Wage Effect," *Journal of Political Economy* 97:5 (1989), 1027-1059.

Brown, J., "Changes in Workplace and Residential Locations," *Journal of American Institute of Planners* 41:1 (1975), 32-39.

Bruggink, Thomas H., Keith C. Finan, Eugene B. Gendel, and Jeffrey S. Todd, "Direct and Indirect Effects of Unionization on the Wage Levels of Nurses: A Case Study of New Jersey Hospitals," *Journal of Labor Research* 6:4 (1985), 405-416.

Buchanan, J. M., *The Demand and Supply of Public Goods* (Michigan: Rand McNally, 1968).

Carroll, J. D., Jr., "Some Aspects of the Home-Work Relationships of Industrial Workers," *Land Economics* 25: (1949), 414-422.

Casado-Diaz, J. M., "Local Labour Market Areas in Spain: A Case Study," *Regional Studies* 34:9 (2000), 843-856.

Case, Anne C., Harvey S. Rosen, and James R. Hines, Jr., "Budget Spillovers and Fiscal Policy Interdependence: Evidence from the States," *Journal of Public Economics* 52:3 (1993), 285-307.

Caudill, Steven B., Jon M. Ford, and Daniel M. Gropper, "Frontier Estimation and Firm-Specific Inefficiency Measures in the Presence of Heteroscedasticity," *Journal of Business and Economic Statistics* 13:1 (1995), 105-111.

Cervero, Robert, and John Landis, "Suburbanization of Jobs and the Journey to Work: A Submarket Analysis of Commuting in the San Francisco Bay Area," *Journal of Advanced Transportation* 26:3 (1992), 275-297.

Cervero, Robert, and K. L. Wu, "Polycentrism, Commuting, and Residential Location in the San Francisco Bay Area," *Environment and Planning* 29:5 (1997), 865-886.

Cladera, Josep Roca, Montserrat Moix Bergadà, and Stephen Roper, "The Interaction Value: Its Scope and Limits as an Instrument for Delimiting Urban Systems," *Regional Studies* 39:3 (2005), 357-373.

Clark, William A. V., and James E. Burt, "The Impact of Workplace on Residential Relocation," *Annals of the Association of American Geographers* 70:1 (1980), 59-66.

Clark, William A. V., and Marianne Kuijpers-Linde, "Commuting in Restructuring Urban Regions," *Urban Studies* 31:3 (1994), 465-483.

Clark, William A. V., and Suzanne Davies Withers, "Changing Jobs and Changing Houses: Mobility Outcomes of Employment Transitions," *Journal of Regional Science* 39:4 (1999), 653-674.

Clark, Willim A. V., Youqin Huang, and Suzanne Withers, "Does Commuting Distance Matter? Commuting Tolerance and Residential Change," *Regional Science and Urban Economics* 33:2 (2003), 199-221.

Cole, Raymond E., "Some Salary Effects on Arkansas Teachers of Professional Negotiations Occurring in the Absence of Statutory Sanctions," *Journal of Collective Negotiations in the Public Sector* 6:1 (1977), 63-72.

Coombes, M. G., A. E. Green, and S. Openshaw, "An Efficient Algorithm to Generate Official Statistical Reporting Areas: The Case of the 1984 Travel-to-Work Areas Revision in Britain," *The Journal of the Operational Research Society* 37:10 (1986), 943-943.

Coombes, M. G., and S. Openshaw, "The Use and Definition of Travel-to-Work Areas in Great Britain: Some Comments," *Regional Studies* 16:2 (1982), 141-149.

Coombes, Mike, S. Raybould, and C. Wymer, *Travel to Work Areas and the 2001 Census: Initial Research* (London: Office for National Statistics, 2005).

Cotton, Kathleen, "Affective and Social Benefits of Small-Scale Schooling," *Eric Digest* 96:12 (1996), ED401088, 1-7.

Couch, Jim F., William F. Shughart, II, and Al L. Williams, "Private School Enrollment and Public School Performance," *Public Choice* 76:4 (1993), 301-312.

Cragg, John G., and Stephen G. Donald, "Testing Identifiability and Specification in Instrumental Variable Models," *Econometric Theory* 9:02 (1993), 222-240.

Cubberley, Ellwood Patterson, *Public Education in the United States: A Study and Interpretation of American Educational History; an Introductory Textbook Dealing with the Larger Problems of Present-Day Education in the Light of Their Historical Development* (Boston: Houghton Mifflin, 1919).

Dee, Thomas S., "Competition and the Quality of Public Schools," *Economics of Education Review* 17:4 (1998), 419-427.

Deller, Steven C., and Edward Rudnicki, "Managerial Efficiency in Local Government: Implications on Jurisdictional Consolidation," *Public Choice* 74:2 (1992), 221-231.

Dickens, William T., and Lawrence F. Katz, *Inter-Industry Wage Differences and Theories of Wage Determination / William T. Dickens, Lawrence F. Katz* (Cambridge, MA: National Bureau of Economic Research, 1987).

Doorn, Peter K., and Anton Van Rietberger, "Lifetime Mobility: Interrelationships of Labour Mobility, Residential Mobility and Household Cycle," *Canadian Geographer* 34:1 (1990), 33-48.

Downes, Thomas A., and Thomas F. Pogue, "Adjusting School Aid Formulas for the Higher Cost of Educating Disadvantaged Students," *National Tax Journal* 47:1 (1994), 89-110.

Duncombe, William, Jerry Miner, and John Ruggiero, "Potential Cost Savings from School District Consolidation: A Case Study of New York," *Economics of Education Review* 14:3 (1995), 265-284.

———, "Empirical Evaluation of Bureaucratic Models of Inefficiency," *Public Choice* 93:1-2 (1997), 1-18.

Duncombe, William, John Ruggiero, and John Yinger, *Alternative Approaches to Measuring the Cost of Education* (Washington, DC: Brookings Institution, 1996).

Duncombe, William, and John Yinger, "An Analysis of Returns to Scale in Public Production, with an Application to Fire Protection," *Journal of Public Economics* 52:1 (1993), 49-72.

———, "Why Is It So Hard to Help Central City Schools?," *Journal of Policy Analysis and Management* 16:1 (1997), 85-113.

———, "School Finance Reform: Aid Formulas and Equity Objectives," *National Tax Journal* 51:2 (1998), 239-262.

———, "Financing Higher Student Performance Standards: The Case of New York State," *Economics of Education Review* 19:4 (2000), 363-386.

———, "Does School District Consolidation Cut Costs?," *Education Finance and Policy* 2:4 (2007), 341-375.

Ehrenberg, Ronald G., and Robert S. Smith, *Modern Labor Economics: Theory and Public Policy* (Boston: Pearson/Addison Wesley, 2009).

Elzinga, Kenneth G., "Defining Geographic Market Boundaries [the Problem of Geographic Market Definition in Antimerger Suits]," *Antitrust Bulletin* 26:4 (1981), 739-752.

Elzinga, Kenneth G., and Thomas F. Hogarty, "The Problem of Geographic Market Delineation in Antimerger Suits," *Antitrust Bulletin* 18:1 (1973), 45-81.

———, "The Problem of Geographic Market Delineation Revisited: The Case of Coal," *Antitrust Bulletin* 23:1 (1978), 1-18.

Feldman, Roger, and Richard Scheffler, "The Union Impact on Hospital Wages and Fringe Benefits," *Industrial & Labor Relations Review* 35:2 (1982), 196-196.

Filer, R.K., D.S. Hamermesh, and A. Rees, *The Economics of Work and Pay* (New York: HarperCollins College Publishers, 1996).

Fitzwater, C.O., and W.O. Reed, *Educational Change in Reorganized School Districts* (Washington, DC: U.S. Government Printing Office, 1953).

Fleisher, B.M., and T.J. Kniesner, *Labor Economics: Theory, Evidence, and Policy* (New Jersey: Prentice-Hall, 1980).

Fox, William F., "Reviewing Economies of Size in Education," *Journal of Education Finance* 6:3 (1981), 273-96.

Freedman, Ora, and Clifford R. Kern, "A Model of Workplace and Residence Choice in Two-Worker Households," *Regional Science and Urban Economics* 27:3 (1997), 241-260.

Fried, Harold O., C. A. Knox Lovell, and Shelton S. Schmidt, *The Measurement of Productive Efficiency and Productivity Growth* (Oxford: Oxford University Press, 2008).

Getis, Arthur, "Residential Location and the Journey to Work," *Proceedings, Association of American Geographers* 69:1 (1969), 55-59.

Gold, Steven D., D. M. Smith, and S. B. Lawton, *Public School Finance Programs of the United States and Canada, 1993-94. Volume 1* (Albany, NY: Center for the Study of the States, 1995).

Gordon, Peter, Ajay Kumar, and Harry W. Richardson, "The Spatial Mismatch Hypothesis: Some New Evidence," *Urban Studies* 26:3 (1989), 315-326.

Granger, C. W. J., "Investigating Causal Relations by Econometric Models and Cross-Spectral Methods," *Econometrica* 37:3 (1969), 424-438.

Green, Francis, Stephen Machin, and Alan Manning, *The Employer Size-Wage Effect: Is Monopsony the Explanation?* (London: Centre for Economic Performance, 1992).

Gronberg, Timothy J., Dennis W. Jansen, and George S. Naufal, "Efficiency and Performance in Texas Public Schools," *Advances in Applied Microeconomics: A Research Annual* 06:14 (2006), 81-101.

Gronberg, Timothy J., Dennis W. Jansen, and Lori L. Taylor, "The Adequacy of Educational Cost Functions: Lessons from Texas," *Peabody Journal of Education* 86:1 (2011a), 3-27.

———, "The Impact of Facilities on the Cost of Education," *National Tax Journal* 64:1 (2011b), 193-218.

Gronberg, Timothy J., Dennis W. Jansen, Lori L. Taylor, and Kevin Booker, *School Outcomes and School Costs: A Technical Supplement* (Austin, Texas: Texas Joint Select Committee on Public School Finance, 2005).

Grosskopf, Shawna, Kathy J. Hayes, and Lori L. Taylor, "Competition and Efficiency: The Impact of Charter Schools on Public School Performance," (Unpublished Manuscript, 2004).

Grosskopf, Shawna, Kathy J. Hayes, Lori L. Taylor, and William L. Weber, *Allocative Inefficiency and School Competition* (Washington, DC: National Tax Association, 1999).

———, "On the Determinants of School District Efficiency: Competition and Monitoring," *Journal of Urban Economics* 49:3 (2001), 453-478.

Guan, Zhengfei, Subal C. Kumbhakar, Robert J. Myers, and Alfons Oude Lansink, "Measuring Excess Capital Capacity in Agricultural Production," *American Journal of Agricultural Economics* 91:3 (2009), 765-776.

Gustman, Alan L., and M. O. Clement, "Teachers' Salary Differentials and Equality of Educational Opportunity," *Industrial and Labor Relations Review* 31:1 (1977), 61-70.

Hall, R., *School District Reorganization in Illinois: Improving Educational Opportunities* (Burlington Vermont: NREA, 1993).

Haller, Emil J., and David H. Monk, "New Reforms, Old Reforms, and the Consolidation of Small Rural Schools," *Educational Administration Quarterly* 24:4 (1988), 470-483.

Hildreth, Andrew K. G., and Andrew J. Oswald, "Rent-Sharing and Wages: Evidence from Company and Establishment Panels," *Journal of Labor Economics* 15:2 (1997), 318-337.

Holmes, Alexander B., "Union Activity and Teacher Salary Structure," *Industrial Relations* 79:18 (1979), 79-85.

Holmes, George M., Jeff Desimone, and Nicholas G. Rupp, "Does School Choice Increase School Quality? Evidence from North Carolina Charter Schools," *Advances in Applied Microeconomics: A Research Annual* 06:14 (2006), 131-155.

Hooker, Clifford P., and Van D. Mueller, *The Relationship of School District Organization to State Aid Distribution Systems. Part Ii: Generalizations to State Finance Models* (Minneapolis, Minnesota: University of Minnesota, 1970).

Horowitz, Ira, "Market Definition in Antitrust Analysis: A Regression-Based Approach," *Southern Economic Journal* 48:1 (1981), 1-16.

Howell, William G., *Besieged: School Boards and the Future of Education Politics* (Washington, DC: Brookings Institution Press, 2005).

Howley, Craig, *The Academic Effectiveness of Small-Scale Schooling (an Update)* (Charleston, WV: ERIC/CRESS, 1994).

Hoxby, Caroline M., "Does Competition among Public Schools Benefit Students and Taxpayers?," *American Economic Review* 90:5 (2000), 1209-1238.

———, "Would School Choice Change the Teaching Profession?," *Journal of Human Resources* 37:4 (2002), 846-891.

———, *School Choice and School Productivity: Could School Choice Be a Tide That Lifts All Boats?* (Chicago and London: University of Chicago Press, 2003).

Huang, Yao, "Appendix B: A Guide to State Operating Aid Programs for Elementary and Secondary Education." in *Helping Children Left Behind: State Aid and the Pursuit of Educational Equity* (Cambridge, MA: MIT Press, 2004).

Hurd, Richard W., "Equilibrium Vacancies in a Labor Market Dominated by Non-Profit Firms: The "Shortage" of Nurses," *Review of Economics and Statistics* 55:2 (1973), 234-240.

Husted, Thomas A., and Lawrence W. Kenny, *Efficiency in Education: Evidence from the States* (Columbus: National Tax Association, 1997).

Imazeki, Jennifer, and Andrew Reschovsky, "Financing Education So That No Child Is Left Behind: Determining the Costs of Improving Student Performance." in *Developments in School Finance 2003* (Washington, DC: National Center for Education Statistics, 2004a).

———, "Is No Child Left Behind an Un (or under) Funded Federal Mandate? Evidence from Texas," *National Tax Journal* 57:3 (2004b), 571-588.

———, "Does No Child Left Behind Place a Fiscal Burden on States? Evidence from Texas," *Education Finance and Policy* 1:2 (2006), 217-246.

Jondrow, James, C. A. Knox Lovell, Ivan S. Materov, and Peter Schmidt, "On the Estimation of Technical Inefficiency in the Stochastic Frontier Production Function Model," *Journal of Econometrics* 19:23,8 (1982), 233-233.

Kain, J. F., "The Journey-to-Work as a Determinant of Residential Location," *Regional Science Association. Papers and Proceedings* 62:9 (1962), 137-160.

Kang, Byung-Goo, and Kenneth V. Greene, "The Effects of Monitoring and Competition on Public Education Outputs: A Stochastic Frontier Approach," *Public Finance Review* 30:1 (2002), 3-26.

Kaserman, David L., and Hans Zeisel, "Market Definition: Implementing the Department of Justice Merger Guidelines," *Antitrust Bulletin* 41:3 (1996), 665-690.

Kaufman, B.E., and J.L. Hotchkiss, *The Economics of Labor Markets* (New York: Thomson/South-Western, 2006).

Kenny, Lawrence W., "Economies of Scale in Schooling," *Economics of Education Review* 2:1 (1982), 1-24.

Kimmel, Sheldon, *Price Correlation and Market Definition* (Washington, D.C.: U.S. Dept. of Justice, Antitrust Division, Economic Analysis Group, 1987).

Kingdon, Geeta, and Francis Teal, "Teacher Unions, Teacher Pay and Student Performance in India: A Pupil Fixed Effects Approach," *Journal of Development Economics* 91:2 (2010), 278-288.

Kleibergen, Frank, and Richard Paap, "Generalized Reduced Rank Tests Using the Singular Value Decomposition," *Journal of Econometrics* 133:1 (2006), 97-126.

Kleiner, Morris M., and Daniel L. Petree, *Unionism and Licensing of Public School Teachers: Impact on Wages and Educational Output* (Chicago and London: University of Chicago Press, 1988).

Kristensen, Knud, *Functional Economic Areas of Denmark : Applying Input-Output Techniques to Commuting* (Nexø: Bornholms Forskningscenter, 1998).

Laan, Lambert van der, *Spatial Labour Markets in the Netherlands* (Rotterdam: Eburon, 1991).

Laan, Lambert van der, and Richard Schalke, "Reality Versus Policy: The Delineation and Testing of Local Labour Market and Spatial Policy Areas," *European Planning Studies* 9:2 (2001), 201-221.

Landon, John H., and Robert N. Baird, "Monopsony in the Market for Public School Teachers," *American Economic Review* 61:5 (1971), 966-971.

Lemke, Robert J., "Estimating the Union Wage Effect for Public School Teachers When All Teachers Are Unionized," *Eastern Economic Journal* 30:2 (2004), 273-291.

Levinson, David M., "Job and Housing Tenure and the Journey to Work," *Annals of Regional Science* 31:4 (1997), 451-473.

———, "Accessibility and the Journey to Work," *Journal of Transport Geography* 6:1 (1998), 11-21.

Link, Charles R., and John H. Landon, "Monopsony and Union Power in the Market for Nurses," *Southern Economic Journal* 41:4 (1975), 649-659.

Lipsky, David B., and John E. Drotning, "The Influence of Collective-Bargaining on Teachers' Salaries in New York State," *Industrial & Labor Relations Review* 27:1 (1973), 18-18.

Lovenheim, Michael F., "The Effect of Teachers' Unions on Education Production: Evidence from Union Election Certifications in Three Midwestern States," *Journal of Labor Economics* 27:4 (2009), 525-587.

Luizer, James, and Robert Thornton, "Concentration in the Labor Market for Public School Teachers," *Industrial & Labor Relations Review* 39:4 (1986), 573-573.

MacDonald, Heather I., "Women's Employment and Commuting: Explaining the Links," *Journal of Planning Literature* 13:3 (1999), 267-283.

Martin, R., "Local Labor Markets: Their Nature, Performance, and Regulation." in *The Oxford Handbook of Economic Geography* (Oxford: Oxford University Press, 2000).

Massey, Patrick, and Paula O'Hare, *Competition Law and Policy in Ireland* (Ireland: Oak Tree Press, 1996).

McConnell, C.R., S.L. Brue, and D.A. MacPherson, *Contemporary Labor Economics* (New York: McGraw-Hill Higher Education, 2007).

Medcalfe, Simon, and Robert J. Thornton, "Monopsony and Teachers' Salaries in Georgia," *Journal of Labor Research* 27:4 (2006), 537-554.

Merrifield, John, "Monopsony Power in the Market for Teachers: Why Teachers Should Support Market-Based Education Reform," *Journal of Labor Research* 20:3 (1999), 377-391.

Millimet, Daniel L., and Trevor Collier, "Efficiency in Public Schools: Does Competition Matter?," *Journal of Econometrics* 145:1-2 (2008), 134-157.

Murray, Michael P., "Avoiding Invalid Instruments and Coping with Weak Instruments," *Journal of Economic Perspectives* 20:4 (2006), 111-132.

Musgrave, Richard A., *The Theory of Public Finance: A Study in Public Economy* (New York: McGraw-Hill Book Company, Inc., 1959).

Muth, Richard M., *Cities and Housing: The Spatial Pattern of Urban Residential Land Use* (Chicago: University of Chicago Press, 1969).

Ni, Yongmei, "The Impact of Charter Schools on the Efficiency of Traditional Public Schools: Evidence from Michigan," *Economics of Education Review* 28:5 (2009), 571-584.

OMB, *Bulletin No. 08 - 01*, (Washington, D.C.: OMB, 2007)

Ommeren, Jos van, "On-the-Job Search Behavior: The Importance of Commuting Time," *Land Economics* 74:4 (1998), 526-540.

Ommeren, Jos van, Piet Rietveld, and Peter Nijkamp, "Commuting: In Search of Jobs and Residences," *Journal of Urban Economics* 42:3 (1997), 402-421.

———, "Job Moving, Residential Moving, and Commuting: A Search Perspective," *Journal of Urban Economics* 46:2 (1999), 230-253.

Pagan, Adrian Rodney, and Anthony David Hall, "Diagnostic Tests as Residual Analysis," *Econometric Reviews* 2:2 (1983), 159-218.

Papps, Kerry L., and James O. Newell, "Identifying Functional Labor Market Areas in New Zealand: A Reconnaissance Study Using Travel-to-Work Data," *IZA Discussion Papers* (2002), No. 443.

Piercy, James W., *Reopening of Kenton School, Elkview, West Virginia* (Unpublished Presentation, 1996).

Pratten, Cliff, *The Competitiveness of Small Firms* (Cambridge; New York and Melbourne: Cambridge University Press, 1991).

Quigley, John M., and Daniel H. Weinberg, "Intra- Urban Residential Mobility: A Review and Synthesis," *International Regional Science Review* 2:1 (1977), 41-66.

Ransom, Michael R., "Seniority and Monopsony in the Academic Labor Market," *The American Economic Review* 83:1 (1993), 221-221.

Ratcliffe, Kerri, Bruce Riddle, and John Yinger, "The Fiscal Condition of School Districts in Nebraska: Is Small Beautiful?," *Economics of Education Review* 9:1 (1990), 81-99.

Reschovsky, Andrew, and Jennifer Imazeki, "The Development of School Finance Formulas to Guarantee the Provision of Adequate Education to Low-Income Students." in *Developments in School Finance* (Washington, DC: U.S. Department of Education, 1997).

———, "Achieving Educational Adequacy through School Finance Reform," *Journal of Education Finance* 26:4 (2001), 373-396.

Riew, John, "Scale Economies, Capacity Utilization, and School Costs: A Comparative Analysis of Secondary and Elementary Schools," *Journal of Education Finance* 11:Spring (1986), 443-446.

Robinson, Joan, *The Economics of Imperfect Competition* (Minnesota: Macmillan, 1933).

Rothstein, Jesse, "Does Competition among Public Schools Benefit Students and Taxpayers? Comment," *The American Economic Review* 97:5 (2007), 2026-2037.

Rouwendal, Jan, "Spatial Job Search and Commuting Distances," *Regional Science and Urban Economics* 29:4 (1999), 491-517.

Rouwendal, Jan, and Piet Rietveld, "Changes in Commuting Distances of Dutch Households," *Urban Studies* 31:9 (1994), 1545-1558.

Samuelson, P. A., "The Pure Theory of Public Expenditure," *Review of Economics and Statistics* 54:36 (1954), 387-389.

Sass, Tim R., "Charter Schools and Student Achievement in Florida," *Education Finance and Policy* 1:1 (2006), 91-122.

Schmitt, Bertrand, and Mark S. Henry, "Size and Growth of Urban Centers in French Labor Market Areas: Consequences for Rural Population and Employment," *Regional Science and Urban Economics* 30:1 (2000), 1-21.

Sermons, N. W., and F. S. Koppelman, "Understanding the Differences between Female and Male Commute Behavior in Two-Worker Households," *78th Annual Meeting of the Transportation Research Board*, (Washington DC, 1999).

Sharp, Ansel M., and Donald R. Escarraz, "A Reconsideration of the Price or Exchange Theory of Public Finance," *Southern Economic Journal (pre-1986)* 31:2 (1964), 132-132.

Shea, John, "Instrument Relevance in Multivariate Linear Models: A Simple Measure," *Review of Economics and Statistics* 79:2 (1997), 348-352.

Shibata, Hirofumi, "Public Goods, Increasing Cost, and Monopsony: Comment," *Journal of Political Economy* 81:1 (1973), 223-230.

Shrieves, Ronald E., "Geographic Market Areas and Market Structure in the Bituminous Coal Industry," *Antitrust Bulletin* 23:3 (1978), 589-625.

Simar, Léopold, C. A. Knox Lovell, and P. Vanden Eeckaut, "Stochastic Frontiers Incorporating Exogenous Influences on Efficiency," *Discussion papers* 9403, (Institut de Statistique and CORE, Université Catholique de Louvain, 1994).

Simpson, Wayne, "Workplace Location, Residential Location and Urban Community," *Urban Studies* 24:2 (1987), 119-128.

Sims, Christopher A., "Money, Income, and Causality," *American Economic Review* 62:4 (1972), 540-552.

Slade, Margaret E., "Exogeneity Tests of Market Boundaries Applied to Petroleum Products," *Journal of Industrial Economics* 34:3 (1986), 291-303.

Smart, M. W., "Labor Market Areas: Uses and Definition," *Progress in Planning* 74:2 (1974), 239-351.

Stigler, George J., "The Economists and the Problem of Monopoly," *American Economic Review* 72:2 (1982), 1-11.

Stigler, George J., and Robert A. Sherwin, "The Extent of the Market," *Journal of Law and Economics* 28:3 (1985), 555-585.

Stock, James H., and Jonathan H. Wright, "Gmm with Weak Identification," *Econometrica* 68:5 (2000), 1055-1096.

Stock, James H., and Motohiro Yogo, "Testing for Weak Instruments in Linear Iv Regression." in *Identification and Inference for Econometric Models: Essays in Honor of Thomas J. Rothenberg* (Cambridge: Cambridge University Press, 2005).

Strang, David, "The Administrative Transformation of American Education: School District Consolidation, 1938-1980," *Administrative Science Quarterly* 32:3 (1987), 352-366.

Streifel, James S., George Foldesy, and David M. Holman, "The Financial Effects of Consolidation," *Journal of Research in Rural Education* 7:2 (1991), 13-20.

Sullivan, Daniel, "Monopsony Power in the Market for Nurses," *Journal of Law and Economics* 32:2 (1989), S135-S178.

Taylor, Lori L., "The Evidence on Government Competition," *Federal Reserve Bank of Dallas Economic and Financial Review, 2000* (2000), 2-10.

———, "Competition and Teacher Pay," *Economic Inquiry* 48:3 (2010), 603-620.

Taylor, Lori L., and William J. Fowler, Jr., *A Comparable Wage Approach to Geographic Cost Adjustment* (Washington DC: U.S. Department of Education, National Center for Education Statistics, 2006).

Texas Education Agency, *Annual Statistical Report 1975-1976*, (Austin, Texas: TEA, 1976)

Texas Education Agency, *Biennial Report 1982-1984*, (Austin, Texas: TEA, 1984)

Texas House of Representatives, House Research Organization, *Formula Adjustments and the School Finance System*, (Austin, Texas: House Research Organization, 2004)

Texas Education Agency, *Texas Public School Statistics Pocket Edition 1991-2010*, (Austin, Texas: TEA, 2010)

Tholkes, Robert J., "Economies of Scale in Rural School District Reorganization," *Journal of Education Finance* 16:Spring (1991), 497-514.

Thornton, Robert J., "Monopsony and Teachers' Salaries: Some Contrary Evidence: Comment," *Industrial and Labor Relations Review* 28:4 (1975), 574-575.

Tiebout, Charles Mills, "A Pure Theory of Local Expenditures," *Journal of Political Economy* 56:64 (1956), 416-424.

Tyack, David B., *The One Best System: A History of American Urban Education* (Cambridge: Harvard University Press, 1974).

U.S. Supreme Court, *United States V. E. I. Du Pont De Nemours & Co. - 351 U.S. 377*, (Washington, DC: U.S. Supreme Court, 1956)

U.S. Department of Education, *Equality of Educational Opportunity*, (Washington, DC: U.S. Department of Education, 1966)

National Commision on Excellence in Education, *A Nation at Risk: The Imperative for Educational Reform*, (Washington, DC: NCEE, 1983)

U.S. Congress, 107th Congress, *No Child Left Behind Act of 2001*, (Washington, DC, U.S. Congress, 2001)

U.S. Congress, 111th Congress, *American Recovery and Reinvestment Act of 2009*, (Washington, DC: U.S. Congress, 2009)

U.S. State Department of Education, *29th Biennial Report*, (Washington, DC: U.S. State Department of Education, 1935)

U.S. State Department of Education, *29th Biennial Report*, (Washington, DC: U.S. State Department of Education, 1936)

U.S. Department of Education, National Center for Education Statistics, *Digest of Education*, (Washington, DC: U.S. Department of Education, 2010)

Vedder, Richard, and Joshua Hall, "Private School Competition and Public School Teacher Salaries," *Journal of Labor Research* XXI:1 (2000), 161-168.

Wachs, Martin, Brian D. Taylor, Ned Levine, and Paul Ong, "The Changing Commute: A Case-Study of the Jobs-Housing Relationship over Time," *Urban Studies* 30:10 (1993), 1711-1729.

Wang, Hung-jen, and Peter Schmidt, "One-Step and Two-Step Estimation of the Effects of Exogenous Variables on Technical Efficiency Levels," *Journal of Productivity Analysis* 18:2 (2002), 129-144.

Weast, Jerry D., "When Bigger Can Be Better," *School Administrator* 54:9 (1997), 38-40, 42-43.

Werden, Gregory J., "The Use and Misuse of Shipments Data in Defining Geographic Markets [the Problem of Geographic Market Definition in Antimerger Suits]," *Antitrust Bulletin* 26:4 (1981), 719-737.

———, "Demand Elasticities in Antitrust Analysis," *Antitrust Law Journal* 66:2 (1998), 363-414.

Williams, A., "The Optimal Provision of Public Goods in a System of Local Government," *Journal of Political Economy* 74:1 (1966), 18-33.

Wingo, Lowdon, *Transportation and Urban Land* (Washington, DC: Resources for the Future, 1961).

Wu, De-Min, "Tests of Causality, Predeterminedness and Exogeneity," *International Economic Review* 24:3 (1983), 547-558.

Yett, D. E., *An Economic Analysis of the Nurse Shortage* (Maryland: Lexington Books, 1975).

Zanzig, Blair R., "Measuring the Impact of Competition in Local Government Education Markets on the Cognitive Achievement of Students," *Economics of Education Review* 16:4 (1997), 431-444.

APPENDIX A

In order to analyze the marginal effect of each variable that explains the variance of cost inefficiency on the cost inefficiency, we take the derivative of $\hat{u}_{je}$ with respect to that x_j variable. In this appendix, we present how we calculate $\partial\hat{u}_{je}/\partial x_j$. First, let's rewrite equation (29)

$$\hat{u}_{je} = \mathrm{E}(u_i \mid \varepsilon_i) = \mu_{*i} + \sigma_* \left\{\frac{\phi(-\mu_{*i}/\sigma_*)}{1 - \Phi(-\mu_{*i}/\sigma_*)}\right\} \tag{39}$$

where $\mu_{*i} = (\varepsilon_i\sigma_u^2)/(\sigma_u^2 + \sigma_v^2)$, $\sigma_* = \sigma_u\sigma_v/\sqrt{\sigma_u^2 + \sigma_v^2}$, $\sigma_u^2 = \exp(\delta_0 + \delta \cdot x_i')$, $\phi(\cdot)$ is the standard normal density function, and $\Phi(\cdot)$ is the cumulative distribution function of the standard normal distribution. Now, let Γ equal to the derivative of μ_{*i} with respect to x_j, that is

$$\Gamma = \frac{\partial\mu_{*i}}{\partial x_j} = \frac{\delta_j \cdot \varepsilon_i \cdot \sigma_u^2 \cdot \sigma_v^2}{(\sigma_u^2 + \sigma_v^2)^2} \tag{40}$$

where δ_j is the coefficient of x_j. Moreover, let Λ equal to the derivative of σ_* with respect to x_j, that is

$$\Lambda = \frac{\partial\sigma_*}{\partial x_j} = \frac{\delta_j \cdot \sigma_u \cdot \sigma_v^3}{2 \cdot (\sigma_u^2 + \sigma_v^2)^{3/2}} \tag{41}$$

Finally, let Ω equal to the derivative of $\phi(-\mu_{*i}/\sigma_*)/[1 - \Phi(-\mu_{*i}/\sigma_*)]$, that is

$$\Omega = \frac{\partial\left\{\frac{\phi(-\mu_{*i}/\sigma_*)}{1-\Phi(-\mu_{*i}/\sigma_*)}\right\}}{\partial x_j} = \frac{\phi(-\mu_{*i}/\sigma_*)\cdot(-\Gamma\,\sigma_* + \Lambda\,\mu_{*i})\cdot[\mu_{*i} - \mu_{*i}\cdot\Phi(-\mu_{*i}/\sigma_*) + \sigma_*\cdot\phi(-\mu_{*i}/\sigma_*)]}{\sigma_*^3\cdot(1-\Phi(-\mu_{*i}/\sigma_*))^2} \tag{42}$$

So we write the derivative of $\hat{u}_{je}$ with respect to that x_j as

$$\frac{\partial \hat{u}_{je}}{\partial x_j} = \Gamma + \Lambda\cdot\left\{\frac{\phi(-\mu_{*i}/\sigma_*)}{1-\Phi(-\mu_{*i}/\sigma_*)}\right\} + \sigma_*\cdot\Omega \tag{43}$$