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ABSTRACT

Estimating the Firm's Labor Supply Curve in a "New Monopsony" Framework: School Teachers in Missouri*

In the context of certain dynamic models, it is possible to infer the elasticity of labor supply to the firm from the elasticity of the quit rate with respect to the wage. Using this property, we estimate the average labor supply elasticity to public school districts in Missouri. We take advantage of the plausibly exogenous variation in pre-negotiated district salary schedules to instrument for actual salary. Instrumental variables estimates lead to a labor supply elasticity estimate of about 3.7, suggesting the presence of significant market power for school districts, especially over more experienced teachers. The presence of monopsony power in this labor market may be partially explained by institutional features of the teacher labor market.

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I. Introduction

There have been few attempts to estimate the labor supply elasticity to individual firms. In their survey of monopsony in the labor market, Boal and Ransom (1997) discussed only four studies that examine the question. Manning's (2003) recent book mentions another three, more recent papers. This dearth of research is somewhat surprising, as the elasticity of the labor supply curve has important implications for labor market policies, such as the minimum wage.

Though this small pool of research partly reflects the technical difficulty of estimating the firm's labor supply curve (due in part to a lack of convincing natural experiments or instruments to solve the inherent endogeneity problem) a more likely explanation may lie in the skepticism about the Robinsonian model of single-firm monopsony (Robinson, 1969), which was thought to be of limited empirical relevance. However, recent theoretical models of the labor market suggest that individual firms may face upward sloping labor supply curves even in markets with many competing firms. For example, Bhaskar and To (1999) propose a model of monopsonistic competition. In a much different approach, Manning (2003) develops the implications of a search model that also yields upward sloping labor supply curves to firm, even when there are many firms in the labor market.

We posit a dynamic model of labor market monopsony. In a model of the sort that Manning proposes, the elasticity of labor supply to the firm can be described in terms of the elasticity of quits to the wage, providing a very convenient way to estimate the firm's labor supply elasticity. We adopt this approach to examine the labor supply elasticity for a well defined skilled labor force, teachers in Missouri school districts during the 1980s.

This is a promising setting in which to examine labor supply to the firm. First, it is clear the work teachers do is very similar across districts within a single state, as the state sets the curriculum and certifies teacher skill level. Also, the labor market for school teachers has been suggested often as a likely place to observe monopsony power. (See Beck, 1993, for an example and a survey of the literature). Furthermore, the widespread public collection of education data means we can control for a variety of pertinent worker and workplace characteristics. Finally, we have salary schedule data for many Missouri districts that allow us to construct instruments to correct for measurement error in salaries, the potential confounding effects of unobserved teacher characteristics, or other sources of endogeneity. In our analysis, we estimate much larger elasticities when we control for these sources of endogeneity. Such endogeneity may explain why Manning (2003, Chapter 4) estimates such small labor supply elasticities in his analysis of large panel data sets, for which this sort of instrument is not available.

Our estimates indicate that school districts in Missouri have a large degree of monopsony power with supply elasticities around 3.7. We discuss institutional features of the teacher labor market in Missouri that may affect market power for school districts.

II. Dynamic Monopsony and Labor Supply to the Firm

At least two recent approaches to modeling the labor market suggest mechanisms by which relatively small employers may wield monopsony power. Bhaskar and To (1999) develop a model of monopsonistic competition in which workers have heterogeneous preferences over some non-wage characteristic of potential jobs. In their particular example this preference is over a measure of distance to the job (closer is better). Since the distance characteristic is predetermined for the potential job offers, workers facing equal wage offers accept the closer offer. Thus each employer has some market power to lower the wage without losing all employees. Similarly, to increase firm size beyond the set of employees who live nearby, the firm will have to offer a higher wage. Another model of monopsony power that also incorporates the idea of distance is presented by Staiger, Spetz and Phibbs (2008), who posit that hospitals face more intense competition for nurses from their nearest neighbors than other hospitals in the area. Boyd et. al. (2005) find that teachers are much more likely to end up in a job located close to the high school they attended, a fact they link to strong locational preference, a finding that lends interesting empirical support to the Bhaskar-To model.

Another class of models that produces monopsony implications for small firms follows the general equilibrium search model of Burdett and Mortensen (1998). In the Burdett-Mortensen model, market power accrues to employers because of search frictions. Currently employed workers constantly search for jobs. As job offers arrive, an employee leaves his current employer if offered a higher wage. An employer who offers a higher wage will lose fewer employees to higher-paying competitors and will have greater success in recruiting. Thus a higher wage will yield a larger work force.

Regardless of the source of the market power, in any dynamic monopsony model, equilibrium implies that the flow of recruits to the firm must balance the flow of those who leave. Thus if the size of the firm at time t is defined in terms of labor units N_t, with a separation rate of $s(w_t)$ and a recruitment function $R(w_t)$ both depending on the wage, the firm's size in the next period will be:

$$N_t = [1 - s(w_t)]N_{t-1} + R(w_t),$$

It follows that in a steady state,

$$s(w)N(w) = R(w), \text{ or}$$

$$N(w) = R(w)/s(w), \qquad (1)$$

which can be interpreted as the long-run labor supply function to the firm, since it is based on a steady-state equilibrium. In elasticity terms, this dynamic labor supply function can be written as:

$$(2) \qquad \varepsilon_{Nw} = \varepsilon_{Rw} - \varepsilon_{sw}.$$

This provides a basic framework from which the elasticity of labor supply to the firm might be estimated. However, as Manning (2003, p. 97) points out, estimating the elasticity of recruits with respect to the wage is conceptually difficult. The Burdett-Mortensen-Manning model provides a powerful insight into the relationship between the recruitment and separation elasticities. In that model, the recruit to one firm is the separation from another.[1] The number of recruits that a firm might gain by increasing its offered wage is exactly the same magnitude as the number of quits that would be deterred. Thus, the recruitment elasticity is simply the negative of the separation elasticity. [See Manning (2003, p. 97) for a formal derivation of the result.] Therefore, the elasticity of labor supply to the firm can be written as:

$$(3) \qquad \varepsilon_{Nw} = \varepsilon_{Rw} - \varepsilon_{sw} = -2\varepsilon_{sw}.$$

This result makes it possible to estimate the firm's labor supply elasticity only from information on the firm's separations, conceptually a straightforward task if the necessary data are available.

Strictly, the simplification expressed in equation (3) derives from a very stylized model of the labor market. Many of the predictions of the Burdett-Mortensen model are clearly inconsistent with known facts about the labor market, as Kuhn (2004) points out in his thoughtful critique.

While we recognize such criticism, we believe that there is at least intuitive support for estimating the labor supply elasticity to the firm by equation (3). Essentially, our approach relies on two crucial results, both of which we argue are likely to hold outside the strict Burdett-

[1] Actually, the firm may also hire unemployed workers, but in the Burdett-Mortensen model, unemployed workers will accept any wage offered, so increasing the wage does not increase the number recruited from unemployment.

Mortensen framework. The first is that dynamic labor supply to the firm may be upward sloping, a result consistent with much more general versions of the search model, such as Mortensen (2003) or Bontemps, Robin and van den Berg (1999), as well as alternative models of monopsony such as Bhaskar and To (1999).

The second essential result is that recruitment and separation elasticities are equal in absolute value. The insight that one firm's quit is another firm's recruit has strong intuitive appeal. Those who quit must (usually) end up working for another employer who provides a better job. It is hard to imagine how the size of one employer's gain from offering a higher wage can be much different than the size of the loss suffered by another because it offers a lower wage. However, like many steady state results, the equality between recruitment and separation elasticities might be better viewed as an approximation.

III. Data

The analysis makes use of data from several sources. The data about individual school teachers as well as some district characteristics comes from the Missouri Department of Elementary and Secondary Education (MSDESE) census of teachers. For the 1988-89 and 1989-90 school years this provides the actual salary, fraction of time employed (full-time equivalent), years total teaching experience, years seniority in current district, and highest educational degree held, along with a unique identification number for each teacher.

Most school districts in Missouri have established a salary "schedule" — a guideline that defines the salary in terms of the teacher's highest degree and seniority, and in some cases, teaching experience in other districts. Each year the Missouri State Teachers Association (MSTA) surveys districts in the state and collects salary schedules from those that respond to their survey. From this survey we obtain the salary point for a teacher with a bachelors degree and no experience, referenced hereafter as the "base salary" and calculate the average pay increase from moving up one step on the schedule (the salary increase that results from one additional year of seniority), which we refer to as the "salary slope." Not all districts respond to the MSTA survey, and not all districts that do respond have a salary schedule in place, but most districts (451 of 540) provided base salary information for the 1988-89 year (which will be the primary focus of this analysis) and all but 13 of those provide enough information to calculate a slope measuring expected salary increases. Additional characteristics of Missouri school districts such as student averages for race, ethnicity, IEP (special education) status, and free lunch eligibility as well as per pupil spending data for the 1989-1990 school year come from the National Center of Education Statistics Core of Common Data.

The final source for data is the 1990 Decennial Census of the United States from which we have obtained variables that measure the urban status and economic characteristics of residents who live within the district. These variables include the percentage of the population of a school district that lives in a rural area, population density, and the median household income in each district. These data have been aggregated from census geographical units to match the school district boundaries by the Office of Social and Education Data Analysis of the Missouri State Census Data Center.

There were a total of 49,874 teachers in the MSDESE data for the 1988-89 school year, of which 177 had a full-time equivalent of zero or missing. Of the remaining 49,697, there were 340 teachers working at less that 50 percent FTE, and these have been excluded from the sample. (This number represents less than 0.7 percent of the sample.) Table 1 summarizes this individual-level data.

A "separation" occurs if a teacher who was present in the 1988-89 school year is not present in the 1989-90 school year, or if the teacher works for a different district in the latter year. The overall separation rate is just less than 10 percent. Average full-time-equivalent salary is $25,856 for 1988, though the data indicate a range from $505 to $91,692. Both these extremes are likely the result of some sort of clerical error as there are only twenty-three recorded salaries below $5,000 and one above $65,000. The following analysis includes all observations but results are not sensitive to omitting these twenty-four outliers.

Slightly more than 50 percent of all teachers work for districts located in the St. Louis or Kansas City metropolitan areas. The average teacher teaches in a district that contains about 10,000 students, although the number of students in a district ranges in value from 14 to 46,128 and is highly skewed in distribution.

Table 2 presents the district aggregate data. Column (1) considers all districts in the sample. The separation rate for the average district is about 14 percent. This reflects the skewness of the size of school districts. Smaller districts tend to have higher separation rates, and most districts are small. Similar patterns are also visible in other variables, such as the number of pupils in the district, or the metropolitan area dummies. The average district has only about 1,500 students, while the average teacher is employed by a district that has about 10,000 students! All of these results reflect the fact that the majority of the districts in the state are small and rural, while there are a few very large districts. Column (2) considers the subsample of districts for which base salary data is available. A comparison of the columns does not reveal any striking (or indeed statistically significant) differences in most characteristics, but it shows a number of small differences consistent with the fact that the smallest school districts, those with less than 25 teachers, are less likely to have a salary schedule.

Figure 1 displays the geographical boundaries of school districts in Missouri and shows the relative size in terms of number of students enrolled. The map also outlines the boundaries of the six Metropolitan Statistical Areas (MSAs) in Missouri. It is clear from the map that almost all districts in Missouri are quite small. The few large districts are typically located in the principal cities of MSAs. Even the largest metropolitan areas of the state contain some small school districts.

Figure 2 illustrates the geographical distribution of base salaries across school districts. The blank areas represent districts for which we do not have a base salary. There is no obvious geographical pattern of missing data. Darker shading indicates higher salaries. Although districts within the Kansas City and St. Louis metro areas appear to have higher salaries, it is also apparent that there is a fairly large amount of geographical variation in base salaries, even in areas of the state that are clearly rural in nature.

IV. Estimation Strategy

A. Background

The task at hand, essentially, is to estimate the elasticity of separations with respect to the wage. There is already a large literature in labor economics that examines separations. Much of this literature concentrates on the relationship between demographic characteristics and the likelihood of quitting or being laid off, and although these issues are related to this study, they are not particularly relevant to the analysis. This literature is surveyed, for example, in Farber (1999).

More germane are a number of studies that examine the sensitivity of quits to wages, such as Pencavel (1972), and Parsons (1973). In fact the Pencavel model has some searchtheoretic elements, including the "monopsonistic" idea that the firm can influence the turnover rate by choosing a high or low wages. However, most of this literature focuses on the question of specific human capital, since turnover is particularly costly for firms and workers in industries where there is a large amount of specific training. District or school specific human capital is probably relatively unimportant in the market for public school teachers, as states set the curriculum, and what an instructor teaches in one school she could just as well teach in another.

Although these previous papers do not address the issue of the labor supply to the firm directly, a few recent studies that apply a similar approach to estimate labor supply to the firm. Manning's (2003) book contains extensive empirical analyses, some of which are comparable to the analysis presented here. Ransom and Oaxaca (2008) and Hirsch, et. al. (2008) estimate models that are similar to ours in order to explain differences in pay between men and women.

B. Identification Strategy

The primary obstacle to estimating a separation elasticity and hence an elasticity of labor supply to the firm is likely to be an identification issue. To see this, consider estimating a regression of a dichotomous indicator for teacher separations on the natural logarithm of teacher salary with the goal of converting the parameter estimate into separation elasticity (through dividing by the average separation rate) as in the following equation:

(4) $$S_{i,d} = \alpha + \beta \ln W_{i,d} + \varepsilon_{i,d} ,$$

where *i* indexes teacher and *d* district.

The variation in observed wages is likely attributable to a number of factors including teacher attributes, union rules, district attributes, district desire for a certain workforce size (as suggested in our model), and even errors in measuring true salary levels. As a result, the estimate of β produced by this regression is unlikely to capture the true relationship insofar as many of these unobservable correlates of teacher salary also affect separation rates.

In particular we are concerned that teachers may possess unobservable attributes that lead to both differential salaries and different separation rates. Indeed prior research suggests that teacher attributes beyond experience and possession of an advanced degree are correlated with their pay levels (Figlio 1997; Ehrenberg and Brewer 1994) as well as with separation rates (Murnane and Olsen 1989, 1990). Though we will run our regressions at a district level, these characteristics are unlikely to be randomly distributed across schools or districts (Lankford, Loeb and Wyckoff 2002). Also, these characteristics do not necessarily have to be productive in the sense of improving student learning. For example, certain types of teacher personalities may be perceived as more accommodating to administrators which may result in higher salaries as well as greater stability of employment. [2]

Fortunately, our data allow us to address this potential problem through the use of an instrumental variables strategy with the district base salary and the average slope of its salary increments from the salary schedule as instruments for actual salary. Since both base salaries and salary increments are directly correlated with actual salary, and unlikely correlated with the characteristics of teachers they may provide an identification to estimate the separation elasticity. Such instrumental variables estimates also account for the potential attenuation bias due to errors in measuring actual salary.

However, even with this instrumental variables strategy, there are still remaining threats to identification, most particularly from unobservable district characteristics. To illustrate this,

[2] Beyond this simple consideration, the salary of a particular individual may also represent some match-specific rents. This raises complicated issues that are beyond the scope of this paper, but are discussed, for example, in Altonji and Shakotko (1987).

consider a more generalized regression model:

$$(5) \qquad S_d = \beta \ln\left(W_d \big/ C_d \right) + X_d \gamma + \varepsilon_d = \alpha + \beta \ln W_d - \beta \ln C_d + X_d \gamma + \varepsilon_d \,,$$

where S_d and $\ln W_d$ remain as previously defined, while C_d is a district level cost of living index and X_d is a vector including other district characteristics that may affect teacher salaries. In this formulation, the firm's elasticity of separations with respect to the wage may be calculated as β/S_d. An "average" elasticity is $\beta/\bar{S}$, where $\bar{S}$ is the sample mean separation rate. Although the model does suggest the possibility of identifying different elasticities for teachers or districts with particular characteristics, we initially confine our interest to estimating the average elasticity.

Equation (4) shows that a cost index is necessary because salary differentials likely reflect, in part, the higher cost of living in some areas. Furthermore, it is possible that our instruments, especially the base salary, preserve this variation due to cost of living, meaning our IV specification will fail to consistently estimate β without further controls. Although exact differences in the cost of living depend on the teachers' housing locations, we will assume that housing locations are closely proxied by job location. Thus, we include the census estimated median household income of the school district in our regressions to control for the salary differential due to locational factors. Recognizing the limited nature of any single cost index we also include a population density index for the district and the fraction of the district's residents who live in "rural" areas, since some who live in MSAs actually live in the rural parts of counties. (MSA boundaries follow the boundaries of counties, not necessarily the boundaries of the urbanized area of the city.)

Urban economic models of location choice, such as the "open city" model in Mills and Hamilton (1989, p. 115), explain differences in wages across geographical areas as compensating differences for the higher cost of housing and/or the longer commutes required of those who live in larger cities. Since in locational equilibrium the cost of living is the same for everyone living in the same city, and because all of those living outside of metropolitan areas experience roughly the same cost of living, these models suggest another candidate index for the geographical variation in cost of living can be captured with a set of dummy variables that identify the major cities of the state. In this spirit we also present regressions with dummy variable controls for census Metropolitan Statistical Areas (MSA) of the state (an approximation to these "cities."). Our results indicate that using either or both methods of accounting for cost of living differences produces similar estimates of the labor supply elasticity.

Beyond the cost of living issues there are other potential district characteristic pitfalls. For example Hanushek, Rivkin, and Kain (2004) show that teacher separations depend on the race and socioeconomic characteristics of the students in the district. If there is some sort of bonus "combat pay" attached to districts with those characteristics this would represent another potential source of bias. Consequently we will control for student characteristics in all of our regression estimates.

Though we are concerned about the potential effects of both unobservable teacher and district characteristics on the identification of our estimates, there is less cause for concern about union influence. Teachers' unions in Missouri are prohibited by state law from formal collective bargaining. The law requires districts to "meet and confer" with teachers or their representatives. This means that "bargaining" takes place at the discretion of the local school district. Teachers are legally proscribed from striking and cannot enter into a binding collective bargaining contract with local school districts. Nevertheless, a more-or-less formal bargaining process does take place in the large St. Louis and Kansas City districts.[3] While it is possible that teachers' unions exert some influence in the salary determination process this is unlikely a source of much salary variation as we will show that excluding urban districts will not change our estimates. Even if unions had a strong role in setting base salaries, our estimates would still be interpretable as the labor supply elasticity to the firm, regardless of districts' inability to exercise the full implied monopsony power.

As our theory suggests that districts set wages to achieve a certain size (in employees) in steady state, an ideal instrument would encapsulate that part of teacher salary that reflects the predetermined wage setting policy of an employer. While the variation in base salary may also reflect cost of living and working conditions considerations, we believe we can successfully control for these undesirable sources of variation. Given a successful control strategy, the remaining variation in base salary is likely to be due to differential district level demand for teachers, exactly what we require to identify a supply parameter. Estimation then proceeds via two-stage least squares on equation (5) with the natural logarithm of a district's base salary as the excluded instrument. The elimination of bias due to unmeasured teacher characteristics and measurement error should lead to substantial improvements over the OLS estimates that could be produced using standard national data sources.

While the base salary instrument captures level differences between district compensation policies, the average slope of their schedule captures differences in trajectory. Nevertheless, the variation in the salary slope instrument is likely to come from similar sources as the base instrument--some combination of cross district variation in demand for retaining experienced teachers and a set of district characteristics that affect the teachers' willingness to supply labor.

[3]This information is based on a discussion with Professor Michael Podgursky, professor of economics at the University of Missouri.

If we can control for the latter source of variation we can also expect the salary slope instrument to yield consistent estimates, though the teachers for whom it induces variation might not be representative of Missouri teachers as a whole.

V. Results

A. Estimation

As we will be using district level variation in salary schedule instruments to identify our separation elasticity, working with district level observations seems sensible. However, we still wish to account for the fact that observable teacher level characteristics such as experience are likely to have an important role in explaining separations and salary levels. Consequently we begin by estimating:

(6) $$S_{i,d} = \alpha + X_{i,d}\lambda + \delta_d + \eta_{i,d}$$

via a linear probability model. $S_{i,d}$ is a dummy variable equal to one if the teacher leaves his or her district after the 1988-89 school year, $X_{i,d}$ is a vector of teacher characteristics including experience, time with current employer, sex, and education level, and δ_d is a district fixed effect. We then form district average residuals from this regression, $\widehat{S}_d$ for each district. We use a similar methodology to produce a district level regression adjusted log salary residual, $\ln \widehat{W}_d$. Regression coefficients for these models are reported in Table A1.

The regression adjustment allows us to easily see the relationship between salaries $\ln \widehat{W}_d$ and separations $\widehat{S}_d$ at a district level, presented as Figure 3. Note that the separation rate is declining with increases in salary as expected, although the slope does not appear particularly steep. Also, it appears that several districts had very few separations during this year, and that one of the districts experienced a full turnover of 100 percent of their teachers. (That district had only 30 students and 3 teachers in 1988).

Figure 4 illustrates the positive bivariate first-stage relationship between log base salary and our district regression adjusted average salary, $\ln \widehat{W}_d$. It also suggests that the positive relationship between base and actual salary is not confined to large districts. Table 3 provides the regression estimates of the first stage relationship, and shows a strong positive correlation between both potential instruments and actual salaries. This relationship persists with the addition of numerous control covariates including SMSA fixed effects. The F-statistic on the null hypothesis that the two instruments jointly have zero effect the first stage is close to 60 in all cases suggesting that the analysis is unlikely to suffer from weak instrument issues. Also the instruments and included controls do a good job of explaining cross district salary differences, with a coefficient of variation of 0.90 in one specification.

As a benchmark, Columns (1) – (3) of Table 4 present OLS estimates of the elasticity of separations from equation (5), along with the implied elasticity of the labor supply curve to Missouri school districts. Column (1) includes controls designed to capture differences in the cost of living across districts. The estimates here suggest that it would require almost a 10% increase in average teacher salary to reduce separations by a single percentage point. These coefficient estimates are robust to the addition of other district characteristics in column (2) and the addition of MSA fixed effects in column (3).[4]

Because of the lack of sensitivity of separations to wage changes, these OLS estimates generate a low implied elasticity of labor supply to the firm, around 1.6. If true, these estimates

[4] The use of a Probit model produces similar estimated marginal effects of log salary on separations, so we do not believe that model linearity is important in our results.

suggest that Missouri school districts have a great deal power to set wages. A standard measure of monopsony power is Pigouvian "exploitation:"

$$E = \frac{(MRP - w)}{w} = \frac{1}{\varepsilon_{N,w}} . \qquad (7)$$

(See Boal and Ransom, 1997, p. 87 for a discussion.)   A profit-maximizing monopsonist facing a labor supply elasticity of less than two would pay a wage less than half of the marginal value of output! Of course, in the context of equilibrium search models, the comparison is not quite so straightforward, as the monopsony power arises from imperfect information and other frictions in the labor market, and it is likely that labor market institutions, such as unions, may limit the exercise of this power. Nevertheless, this is an extremely low elasticity of labor supply to the firm. The OLS estimates here are robust to the choice of covariates. Additional robustness checks not reported in the table find that the only specification that results in estimated elasticities that are much greater in magnitude is one that eliminates all cost of living controls (including SMSA fixed effects) from the regression.

In order to provide estimates that will be directly comparable to the instrumental variable regressions, columns (4) – (6) repeat the previous analysis using only those districts that have base salary data available. Figure 2 shows the districts for which the base salary data is not available, most notably the St. Louis school district, the largest in the state. The effect of salary on separations is not much different from the OLS coefficient obtained from the whole sample, so the IV results discussed below are not driven by selecting a particular composition of districts. As further least squares estimates using the 438 districts for which both instruments are available differ only marginally from those shown in columns (4) – (6) we do not report the coefficients.

These instrumental variables estimates are presented in Table 5 whose columns contain specifications whose control variables match those of the corresponding column numbers in the preceding table. The first three columns use the base salary from the salary schedule as the excluded instrument. Here, the estimated coefficient on salary is much larger than that estimated by OLS--only a 4-5 percent salary increase would be required to produce a one percentage point decrease in separation rates. This is likely due to bias in the OLS estimates from some combination of omitted variables and measurement error. These results in turn imply a much higher elasticity of labor supply to the firm, though the implied elasticity is still only about 3.7. Furthermore, the parameter on which the elasticity estimate is based is estimated with relatively high precision, and it is evident that the elasticity of labor supply to the firm is much smaller than the infinity of the perfectly competitive model. Interestingly, the Pigou's E for this estimate is still around 27 percent, which seems rather large. These results indicate that Missouri school districts have a meaningful level of market power. The IV results are also quite robust to changes in included covariates.

Columns (4) – (6) of Table 5 use both the base level and average slope of the salary schedule as dual excluded instruments. Although this does lower the standard errors on the log salary coefficient, it does not substantially change the coefficient estimates, which continue to imply a labor supply elasticity to the firm in the range of 3.6 - 3.7 when district level controls are fully considered. This might be taken as evidence that the salary scale is set in a consistent manner to consider both new hiring and retention.

Though the primary identifying assumption of the instrumental variables model, the excludability of base salary from the reduced form regression, is not directly testable there are a couple of plausible theories that might lead us to question it. Both revolve around differences between rural and urban school districts. In the first, urban school districts might provide higher salaries in an attempt to compensate for poor working conditions not captured by our included controls, yet still suffer higher separation rates due to these conditions. Alternatively, the higher salaries and quit rates might reflect cost of living differences or other factors inherent to cities. Even if the exclusion restriction holds, urban and rural districts might pick equilibrium points with different labor supply elasticities.

Table 6 investigates the possible divergence of urban and rural supply elasticities by examining different cuts of the data. Using two stage least squares regressions following the middle specification of the previous table, column (2) contrasts a sample omitting all districts in the Kansas City and St. Louis MSAs with the whole base salary sample results reported in column (1). Since those are the most urbanized areas and represent more than half of the teachers in Missouri, it is perhaps surprising to see a statistically insignificant change of less than 0.02 in the estimated coefficient. Further examination of labor supply to rural districts also shows few changes. Column (3) excludes from the sample all districts in metropolitan areas and column (4) looks only at districts with entirely rural populations. These specifications demonstrate that there are few differences in labor supply elasticity to school districts in Missouri that arise from urban-rural differences, once we condition on included control variables. Indeed the implied labor supply elasticites remain in a 2.98 to 3.80 range around our baseline estimate of 3.57.

B. Discussion

Is the estimated labor supply elasticity to firms too low to be plausibly believed? Is the number really an indication of a shortcoming in the applicability of a monopsony model to the teacher labor market? While both of those conclusions are possible, there are some institutional features of the labor market for teachers that suggest that a high degree of district market power is plausible.

First, there is the Boyd et. al. (2005) evidence on the strong locational preferences of teachers. They show that teacher have strong preference to work in geographical areas near the high school they attended. In their study of teachers in the state of New York, they found that new teachers were four times more likely to accept a teaching position within five miles of their hometown than one more than forty miles away. A second fact that is consistent with district market power is that a substantial fraction of teachers are also second earners within their families which may limit their mobility. An analysis of the 1990 PUMS census data (Ruggles et al. 2004) reveals that almost two-thirds of Missouri school teachers in 1990 were born in Missouri, a fact consistent with strong locational preferences of teachers. If the sample is further restricted to exclude the teachers in the large cities of St. Louis and Kansas City the Missouri natality of teachers is 20 percentage points higher.

A strong preference for employment in a small geographical area is certainly a potential factor in low responsiveness of quit rates to salary differentials. A further barrier to movement between districts is the nature of salary schedules for Missouri school districts. Salary level is typically determined by years of seniority with the particular district (along with education level). While some districts may grant full credit for teaching experience in another district, the most common practice is to credit no more than five years of teaching experience toward seniority steps. Thus, a teacher with ten years experience in district A might suffer a substantial pay cut if he were to move to district B.[5]

Another possible source of market power is the nature of teacher pensions. Many school districts, including those in Missouri in the late 1980's, offer defined benefit pension plans that vest after some term of employment (5 years for almost all Missouri districts). However, these

[5] Of course, a teacher with high levels of experience at a very low pay district might receive a higher salary at a high pay district, even with the incomplete experience credit.

pensions accrue in a highly non-linear way based on years of experience and age. Simulations in Podgursky and Ehlert (2007) show that pension wealth for Missouri teachers accumulates very rapidly during certain years of a teacher's career (sometimes exceeding annual salary in present value), and this situation would clearly deter moving to another employer that did not share the same pension plan. On the other hand, with the exceptions of the large districts of St. Louis and Kansas City that operate their own separate pension plans,[6] all public school teachers in Missouri belong to the same pension plan. However, any salary penalty due to incomplete credit for teaching experience could be magnified by the pension system, even for movements between employers within the system, since benefits are based on some measure of average salary. Thus, changing to a different employer could induce a significant financial loss to a Missouri schoolteacher.

If pension lock or incomplete credit for experience plays a role in the low responsiveness of teachers to salary differentials, the responsiveness should vary by teacher experience. Table 7, which examines supply elasticity heterogeneity across a few teacher characteristics, provides evidence that this is indeed the case. Since the table is designed to explore differences due to individual teacher characteristics, it represents the results of a series of individual level two-stage least squares regressions of a separation dummy on the teacher's actual salary as well as personal and district characteristics. The base salary and salary slope are used as excluded instruments. This methodology differs somewhat from our baseline which looks at adjusted district averages and produces slightly smaller average coefficients for the whole sample. However, the coefficient estimates together with specific separation rates for teachers with a particular characteristic allow us to produce supply elasticity estimates that may be comparable in a relative sense across groups.

[6] Podgursky and Ehlert (2007, p.2).

The first panel of the table shows that teachers with less than ten years of tenure in a district are four times more sensitive to wage differences than their colleagues with between ten and twenty years of tenure. The disparity of results is somewhat smaller when overall experience is considered suggesting that the tenure with the current district is likely the driving force behind this effect rather than age or general experience. To further emphasize this point, panel C shows that there are comparatively small differences in responsiveness between teachers with different degree levels, conditional on experience.

Panel D of Table 7 looks at differences in wage responsiveness by teacher sex. It finds that male teachers are approximately fifty percent more responsive to wage changes in terms of separations. In our data sample we find that men teaching in Missouri school districts are paid slightly more than a six percent premium relative to women with equivalent experience and education (see Table A1). Manning (2003) and more recently Hirsch, Schank and Schnabel (2008) suggest that some of the observed pay differential between men and women may be due to different labor supply elasticities to the employer. Ransom and Oaxacca (2008) show that the equality of marginal costs across inputs for profit maximizing firms implies a direct relationship between the log wage gender gap and differing labor supply elasticities to a firm:

$$(8) \qquad \ln(w_m) - \ln(w_f) = \ln\left(1 + 1/\varepsilon_{Nw}^{m}\right) - \ln\left(1 + 1/\varepsilon_{Nw}^{f}\right).$$

While it is possible that school districts are not equating marginal costs across various groups of teachers, if we proceed with the assumption that this approximates their behavior, the gender supply elasticites of Table 7 suggest we should expect to see a log wage gap of eight percent favoring men in the Missouri teacher labor market, remarkably close to actual six percent gap. Thus, employer monopsony power provides a plausible explanation for the magnitude of the observed gender wage differential for public school teachers in Missouri.

VI. Conclusions

Newer models of many-firm monopsony help motivate the notion that the dynamic movement of labor markets may not be frictionless. This framework provides a potential new approach for estimating the elasticity of labor supply to the firm. In this paper we estimate the labor supply elasticity to public school districts in Missouri. Because of the likely presence of measurement error and bias due to unmeasured teacher characteristics, we adopt an instrumental variables strategy using published salary schedules of the districts to create instruments. Although the IV and OLS results are quite different, both indicate that the process by which teachers and districts are matched results in a substantial amount of wage-setting power for school districts.

In fact, our instrumental variables estimates imply a labor supply elasticity to the firm of about 3.7. This suggests that labor market frictions give employers enough power to reduce wages somewhere in the neighborhood of 27 percent when compared with a world of perfectly informed and mobile workers, in the absence of institutions or factors that might limit a district's ability to exercise its monopsony power. Our results also support the idea that certain institutional features of the teacher labor market, such as existing pension plans, serve to limit the mobility of teachers. Furthermore, our estimates suggest that the wage disparity between male and female teachers in Missouri can be explained by differing elasticities to the firm.

This research shows that in one well-defined labor market, that of school teachers in Missouri, employers enjoy a substantial amount of monopsony power in spite of the presence of many competitors. Further research is needed to understand how these results apply to firms more generally.

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Table 1: Descriptive Statistics – Individual Teachers

Variable	Mean (std dev.)
Separation (=1 if left 1988 job)	0.098 (0.297)
FTE Salary	25,856 (6,863.102)
FTE	0.992 (0.060)
Female	0.749 (0.434)
BA/BS Degree	0.564 (0.496)
MA Degree	0.405 (0.491)
Specialist Degree	0.017 (0.129)
Doctorate Degree	0.004 (0.062)
Years Teaching Experience	13.525 (8.620)
Years Tenure with District	10.627 (7.988)
Number of Pupils in District	10,012 (13,151)
Kansas City MSA	0.198 (0.399)
St. Louis MSA	0.318 (0.466)
St. Joseph MSA	0.021 (0.143)
Springfield MSA	0.049 (0.216)
Columbia MSA	0.020 (0.141)
Joplin MSA	0.028 (0.165)

N= 49,357

Table 2: Descriptive Statistics – District Averages

Variable	All districts (n=540)	Base Salary Districts (n=451)
Separation Rate	0.143 (0.114)	0.136 (0.098)
District Base Salary	--	16,141.76 (1,966.18)
Average Salary Slope	--	322.78 (176.47)
FTE Salary	21,125 (3,894)	21,627 (3,926)
Log Salary	9.935 (0.162)	9.958 (0.160)
Number of Pupils in District	1,485 (3,478.877)	1,599 (3,113)
Number of Teachers	91.419 (227.009)	96.8 (189.7)
District Population Density	0.257 (0.912)	0.288 (0.937)
District Fraction Rural	0.796 (0.337)	0.763 (0.352)
Log of Median HH Income	9.964 (0.278)	9.977 (0.281)
Fraction Free Lunch Eligible	0.285 (0.156)	0.273 (0.152)
Fraction IEP	0.122 (0.054)	0.119 (0.048)
Fraction Black Students	0.039 (0.114)	0.043 (0.118)
Fraction Hispanic Students	0.003 (0.009)	0.003 (0.007)
Per-Pupil Expenditures	4,242.370 (1,120.514)	4,134.634 (1,046.272)
Kansas City MSA	0.085 (0.279)	0.093 (0.291)
St. Louis MSA	0.104 (0.305)	0.118 (0.322)
St. Joseph MSA	0.015 (0.121)	0.016 (0.124)
Springfield MSA	0.035 (0.184)	0.033 (0.180)

Columbia MSA	0.022 (0.148)	0.024 (0.154)
Joplin MSA	0.011 (0.105)	0.011 (0.105)

Table 3: First stage estimates of the total and base salary relationship.

	(1)	(2)	(3)	(4)
A. Instruments				
Log Base Contract Salary	0.440	0.363	0.506	0.491
	(0.048)**	(0.036)**	(0.047)**	(0.048)**
Average slope of salary schedule			0.203	0.199
			(0.035)**	(0.032)**
Joint F-statistic for instruments = 0			57.10	59.39
B. Other Controls				
District Population Density	0.002	0.009	-0.000	-0.001
	(0.005)	(0.005)	(0.004)	(0.004)
District Percent Rural	-0.068	-0.100	-0.050	-0.049
	(0.016)**	(0.013)**	(0.014)**	(0.013)**
Log of Median HH Income	0.157	0.052	0.128	0.092
	(0.016)**	(0.017)**	(0.019)**	(0.018)**
Fraction Free Lunch Eligible	0.002	0.028	-0.004	-0.008
	(0.030)	(0.024)	(0.030)	(0.030)
Fraction IEP	-0.138	-0.241	-0.055	-0.149
	(0.097)	(0.081)**	(0.096)	(0.090)
Fraction Black Students	0.038	-0.026	0.032	0.013
	(0.027)	(0.030)	(0.028)	(0.025)
Fraction Hispanic Students	0.221	0.678	0.501	0.476
	(0.392)	(0.615)	(0.388)	(0.450)
Per-Pupil Expenditures (x1000)	0.001	0.007	0.002	0.001
	(0.003)	(0.003)*	(0.003)	(0.003)
Kansas City SMSA		0.039		0.045
		(0.012)**		(0.013)**
St. Louis SMSA		0.058		0.032
		(0.016)**		(0.014)*
St. Joseph SMSA		0.012		0.032
		(0.013)		(0.018)
Springfield SMSA		0.029		0.013
		(0.017)		(0.012)
Joplin SMSA		-0.012		-0.019
		(0.016)		(0.010)
Columbia SMSA		0.046		0.066
		(0.025)		(0.020)**
R-squared	0.78	0.88	0.89	0.90
n	451	451	438	438

The dependent variable is district average of the natural logarithm of teacher salary. All regressions weighted by the number of teachers in the district. Robust standard errors in parentheses. * significant at 5%; ** significant at 1%.

Table 4: OLS Estimates of the Labor Supply Elasticity to Missouri School Districts

	All districts			Districts with base salary data		
	(1)	(2)	(3)	(4)	(5)	(6)
Log Salary	-0.114	-0.119	-0.112	-0.116	-0.125	-0.118
	(0.027)**	(0.027)**	(0.031)**	(0.030)**	(0.030)**	(0.033)**
Implied Labor Supply ε	1.594	1.664	1.566	1.706	1.838	1.735
District Population Density	0.007	0.003	0.005	0.008	0.004	0.005
	(0.002)**	(0.002)	(0.003)	(0.002)**	(0.002)	(0.003)
District Percent Rural	0.009	0.016	0.018	0.015	0.020	0.021
	(0.008)	(0.009)	(0.009)*	(0.008)	(0.009)*	(0.009)*
Log of Median HH Income	0.015	0.029	0.034	0.015	0.028	0.031
	(0.009)	(0.011)*	(0.014)*	(0.009)	(0.012)*	(0.014)*
Fraction Free Lunch Elig.		0.023	0.023		0.018	0.017
		(0.023)	(0.023)		(0.025)	(0.025)
Fraction IEP		0.073	0.072		0.058	0.057
		(0.061)	(0.061)		(0.062)	(0.063)
Fraction Black Students		0.016	0.016		0.019	0.020
		(0.016)	(0.016)		(0.016)	(0.016)
Fraction Hispanic Students		0.405	0.349		0.172	0.118
		(0.250)	(0.281)		(0.240)	(0.258)
Per-Pupil Expenditures (x1000)		0.002	0.002		0.003	0.003
		(0.002)	(0.002)		(0.002)	(0.002)
SMSA fe	No	No	Yes	No	No	Yes
R-squared	0.30	0.32	0.33	0.32	0.34	0.34
n	540	540	540	451	451	451

Dependent variable is a district separation rate which has been regression adjusted to reflect differences in individual level teacher characteristics. All regressions weighted by the number of FTE teachers in the district. Robust standard errors in parentheses.* significant at 5%; ** significant at 1%. Joint F-tests fail to reject the hypothesis that the collective SMSA fixed effects equal zero.

Table 5: 2SLS Estimates of the Labor Supply Elasticity to Missouri School Districts

Instruments	Natural Log of base salary			Natural Log of base salary, salary slope		
	(1)	(2)	(3)	(4)	(5)	(6)
Log Salary	-0.211	-0.243	-0.251	-0.226	-0.242	-0.248
	(0.064)**	(0.069)**	(0.079)**	(0.050)**	(0.053)**	(0.063)**
Implied Labor Supply ε	3.103	3.574	3.691	3.424	3.667	3.758
District Population Density	0.009	0.003	0.004	0.009	0.003	0.003
	(0.002)**	(0.002)	(0.003)	(0.002)**	(0.003)	(0.002)
District Percent Rural	0.005	0.009	0.010	0.002	0.009	0.009
	(0.010)	(0.011)	(0.011)	(0.010)	(0.010)	(0.010)
Log of Median HH Income	0.035	0.051	0.049	0.039	0.052	0.048
	(0.015)*	(0.017)**	(0.018)**	(0.013)**	(0.016)**	(0.017)**
Fraction Free Lunch Eligible		0.016	0.012		0.017	0.013
		(0.026)	(0.027)		(0.025)	(0.025)
Fraction IEP		0.025	0.019		0.010	0.002
		(0.067)	(0.070)		(0.066)	(0.069)
Fraction Black Students		0.029	0.027		0.027	0.024
		(0.017)	(0.017)		(0.017)	(0.017)
Fraction Hispanic Students		0.249	0.257		0.343	0.354
		(0.246)	(0.272)		(0.241)	(0.266)
Per-Pupil Expenditures		0.003	0.003		0.003	0.003
(x1000)		(0.002)	(0.002)		(0.002)	(0.002)
SMSA fe	No	No	Yes	No	No	Yes
R-squared	0.31	0.32	0.32	0.30	0.32	0.32
N	451	451	451	438	438	438

Dependent variable is the district separation rate. All regressions weighted by the number of FTE teachers in the district. Robust standard errors in parentheses. Elasticities are figured using the relevant separation rate for that sample 0.136 for columns (1)-(3) and 0.132 for columns (4)-(6). * significant at 5%; ** significant at 1%

Table 6: Labor Supply Elasticity – rural specification checks

	(1)	(2)	(3)	(4)
Log Salary	-0.243	-0.226	-0.231	-0.317
	(0.069)**	(0.094)*	(0.101)*	(0.154)*
Average separation rate	0.136	0.150	0.155	0.167
Implied Labor Supply ε	3.574	3.013	2.981	3.796
Sample	baseline	no KC or StL MSA	Non-metro	Totally rural
N=	451	356	318	283

Dependent variable is the district separation rate. Regressions are analogous to Table 5, column (2). Robust standard errors reported in parentheses. Column (2) omits all districts within the St Louis and Kansas City MSA's. Column (3) includes in the sample only districts outside metro areas and column (4) includes districts located entirely in rural areas. * significant at 5%; ** significant at 1%

Table 7: Labor Supply elasticities by teacher characteristic

A. Teacher Tenure with district		
	Less than 10 years	4.77
	10 – 20 years	1.04
B. Teacher Overall Experience		
	Less than 10 years	4.22
	10 – 20 years	1.24
C. Teacher Education		
	Bachelors only	3.44
	Advanced degree	3.17
D. Teacher Sex		
	Male	4.45
	Female	3.02

Each separation elasticity is computed using the results from an individual level regression (for those teachers with the indicated characteristic) of a separation dummy on the teachers log salary with salary schedule base and slope as instruments. Individual characteristic controls as well as the district level controls of Table 5 column (2) are included. A group specific elasticity can then be computed using that groups average separation rate.

Figure 1
Missouri School Districts by Enrollment Levels

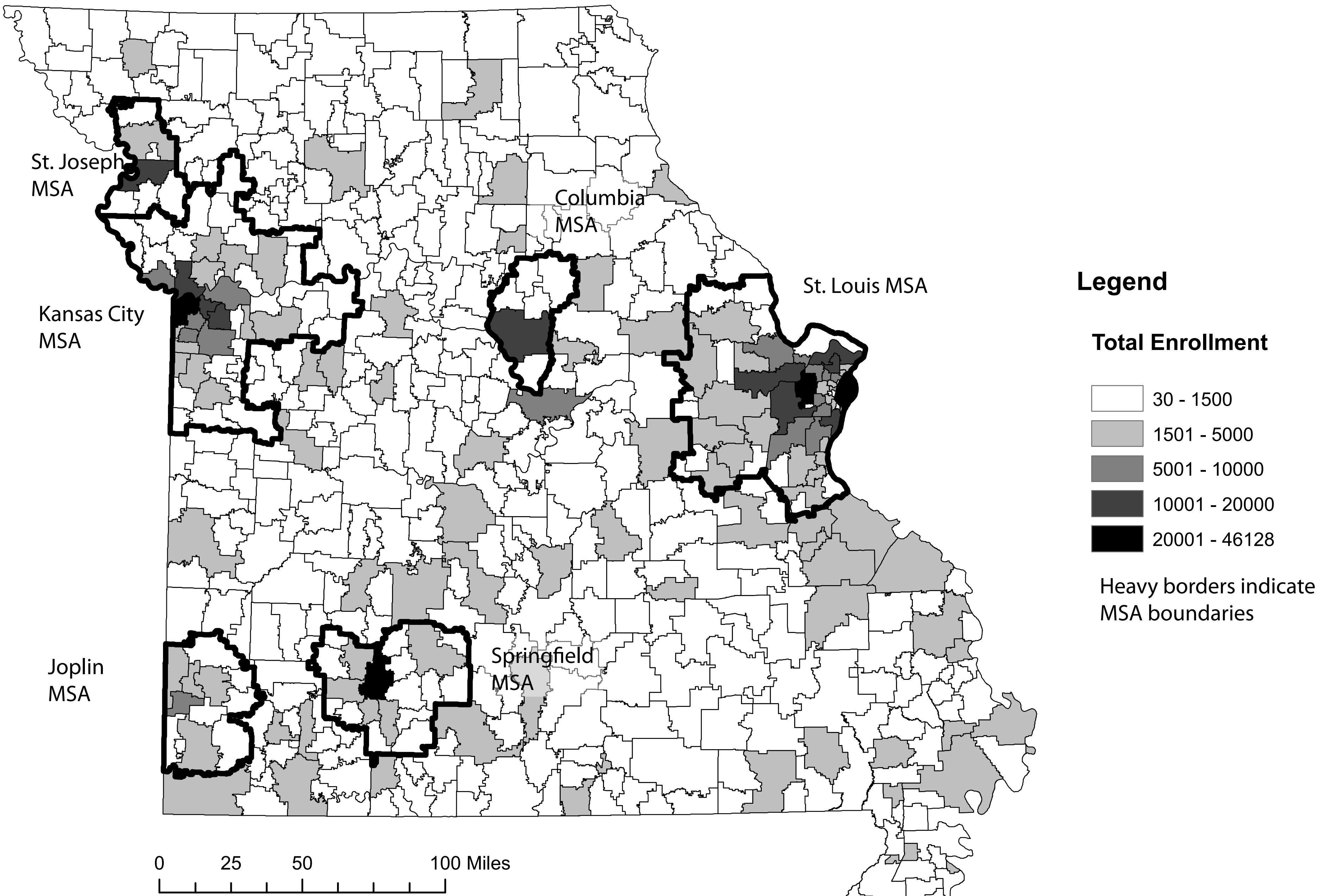


Figure 2
Base Salary, 1988-89 by Disitrict

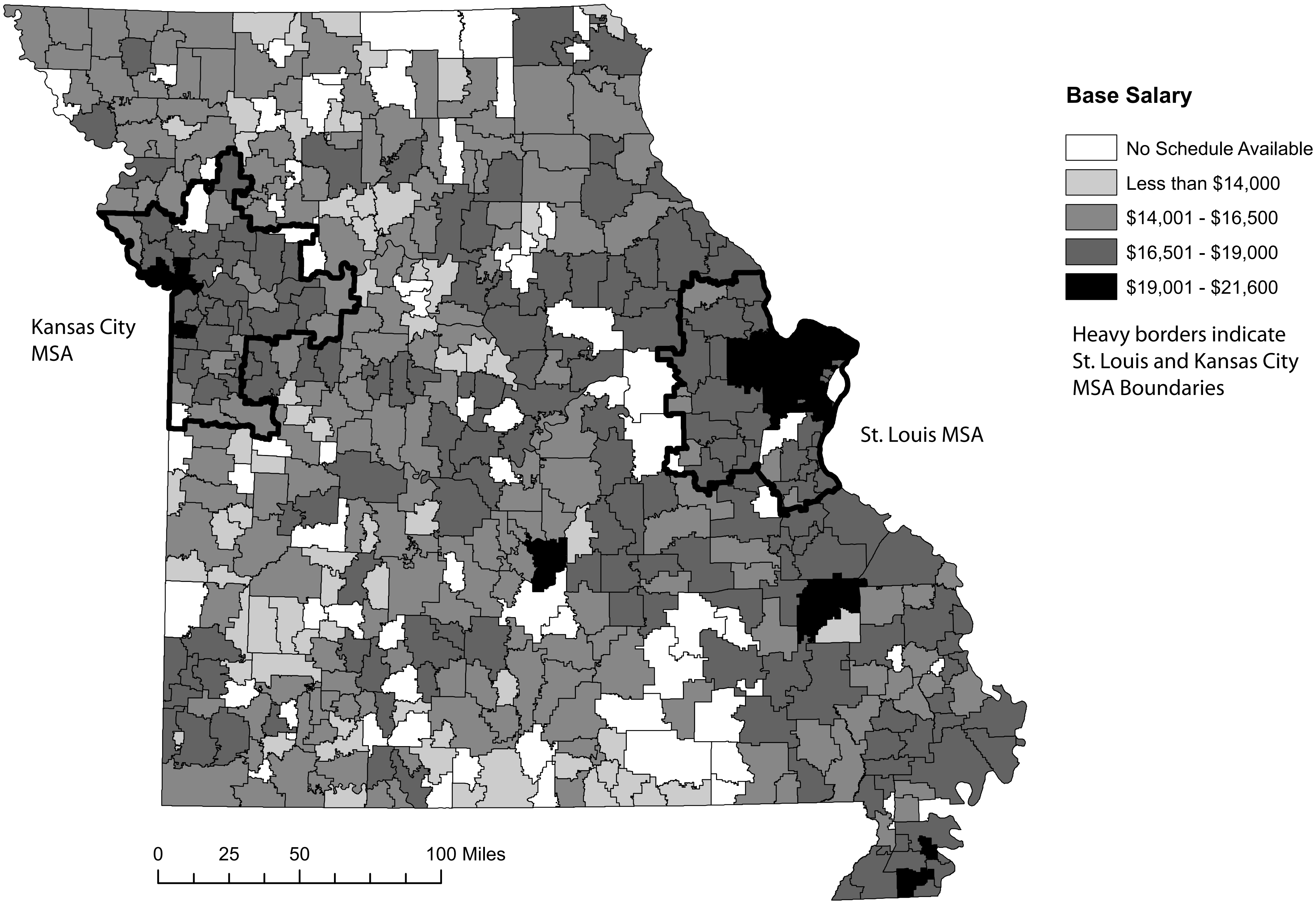
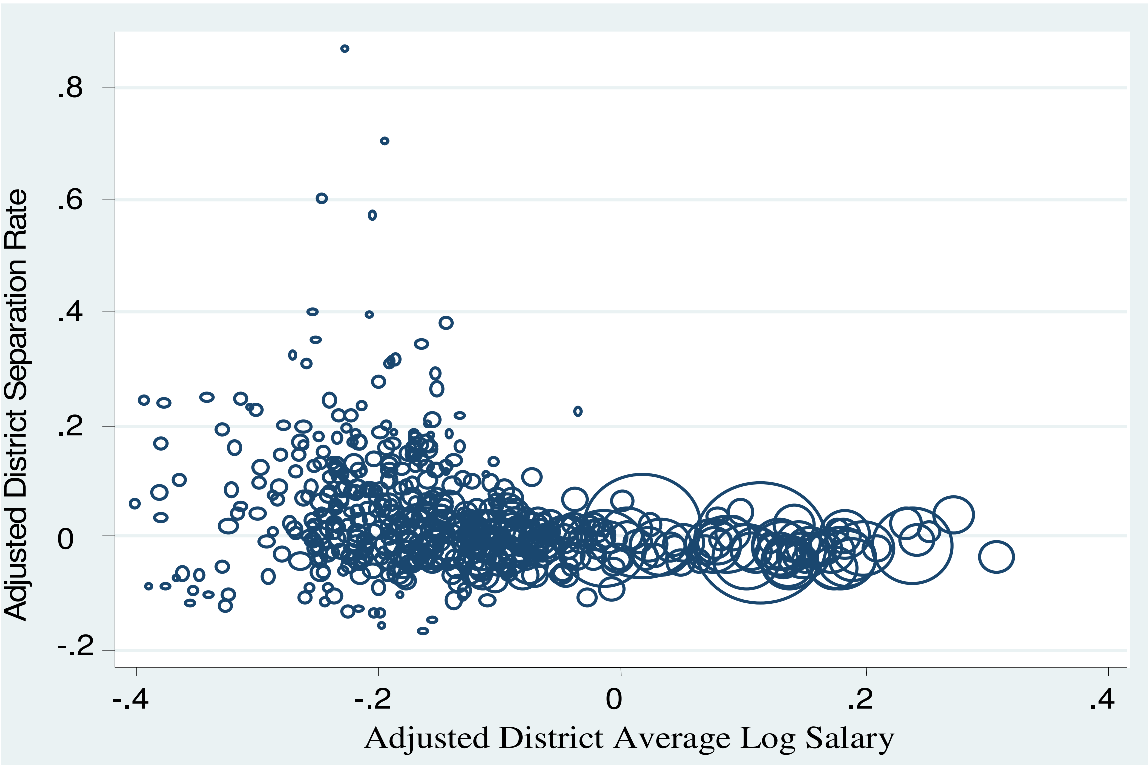


Figure 3

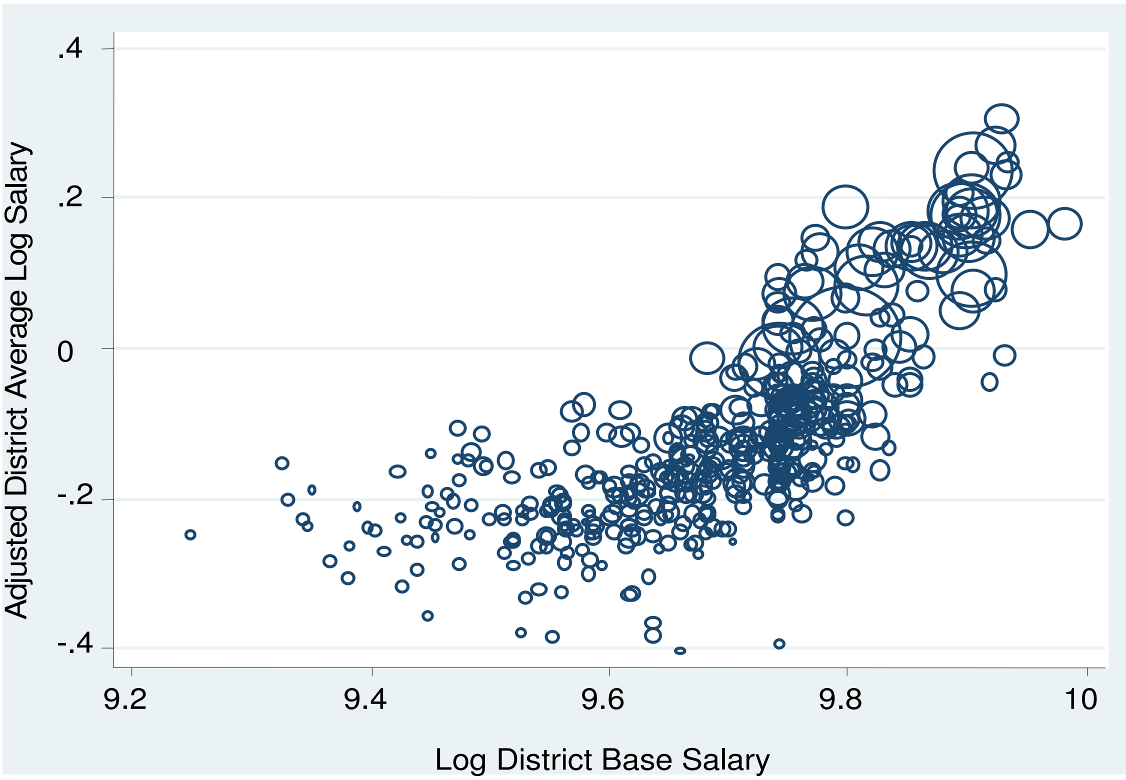
Relationship of District Separation Rate and Average Salary



Notes: Size of the circle is proportional to the number of teachers in the district. Both variables are district averaged residuals from individual level regressions on teacher characteristics.

Figure 4

Relationship of District Base Salary and Actual Average Salary



Notes: The size of the circle is proportional to the number of teachers in the district. Adjusted District Average Log Salary represents district averaged residuals from individual level regressions on teacher characteristics.

Appendix Table A1: Individual determinants of teacher outcomes

	Employment Separation	Log Salary
	(1)	(2)
Teaching Experience	-0.011	0.020
	(0.001)**	(0.000)**
Experience^2 (x100)	0.036	-0.037
	(0.002)**	(0.001)**
Tenure with District	-0.010	0.010
	(0.001)**	(0.000)**
Tenure^2 (x 100)	0.025	-0.012
	(0.003)**	(0.001)**
Female	-0.015	-0.061
	(0.003)**	(0.001)**
MA Degree	0.017	0.116
	(0.003)**	(0.001)**
Specialist Degree	0.019	0.137
	(0.011)	(0.004)**
Doctoral Degree	0.050	0.193
	(0.021)*	(0.008)**
Number of district fe	540	540
R-squared	0.03	0.64

Standard errors in parentheses. N = 49,357. All regressions also include district fixed effects. * significant at 5%; ** significant at 1%.