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THREE ESSAYS EVALUATING CHOICES OF TEACHERS AND ADMINISTRATORS IN KENTUCKY PUBLIC SCHOOLS

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DISSERTATION

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Martin School of Public Policy and Administration at the University of Kentucky

By
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Lexington, Kentucky

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ABSTRACT OF DISSERTATION

THREE ESSAYS EVALUATING CHOICES OF TEACHERS AND ADMINISTRATORS IN KENTUCKY PUBLIC SCHOOLS

Public K-12 education is a large enterprise in the United States. Through local, state and federal sources, the U.S. allocated over $610 billion to K-12 public education in 2009 (NCES). Not only is the commitment of public funds for education substantial, the provision of K-12 education is primarily administered by the government in non-market settings through local school districts. It is this institutional environment that generates the impetus for evaluating how those in education make choices in the absence of markets.

Like traditional markets, non-market solutions often fail because the incentives facing individuals and agencies elicit choices which produce outcomes that are divergent from those which could be considered Pareto optimal. Examining these incentives and the resulting choices allows researchers to identify unintended consequences of policy and better inform policy design and reform. This dissertation endeavors to identify some of these incentives and to empirically examine their effects on the choices made by teachers and administrators.

Chapter two recognizes that teaching effectiveness may motivate teacher choice into relatively more rigorous professional development. The empirical results suggest that teachers with a past history of relative ineffectiveness are selecting into the professional development program examined. The subsequent effectiveness of the in-service training is mixed.

High stakes testing and school accountability are an increasing part of our K-12 education system. Chapter three acknowledges it is plausible that administrators may choose to place more students into class rooms of more effective teachers to maximize school performance. However, because of tenure and salary constraints they may choose to place fewer students into the class rooms of more effective teachers to reward their performance. Results overall indicate that more effective teachers have larger classes.

Chapter four examines school district budget uncertainty and its relation to contingency funds. The institutional ambiguity of the definition of contingency funds allows a significant amount of choice for administrators to determine fund size and use. This chapter finds that administrators may be less sensitive to budget uncertainty and more responsive to the desire for budget fungibility. This dissertation concludes by addressing implications and future research.

KEYWORDS: K-12 education policy; teacher quality; class size; contingency funds; choice

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December 7, 2011

Date

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All errors contained herein remain my own.

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CHAPTER 1

INTRODUCTION

An Alternative Context of Choice in Public Education

Public K-12 education is one of the largest enterprises in the United States. According to the National Center for Education Statistics (NCES), through local, state and federal sources, the U.S. allocated over $610 billion to K-12 public education in 2009. Not only is the commitment of public funds for education substantial, the U.S. education system is structured such that the provision of K-12 education is primarily administered by the government through local school districts.

Conceptually, the argument for funding and/or provision of services by the government arises because of inefficiencies in the private sector due to market failures. These inefficiencies generally fall into the categories of externalities and public goods. However, it is not readily apparent in the context of education that these market failures exist in a manner that requires government production of schooling.[1] Furthermore, one must consider that even if these market failures exist, government production generates its own set of inefficiencies. The argument for government production of any good, including education, requires an explicit comparison of the inefficiencies under both private market and government conditions.

In addressing these potential non-market failures, a substantial academic literature has emerged which focuses on market based solutions that introduce school

[1] For discussion and analysis of K-12 externalities and education as a public good see West (1967), Labaree (1997) and Stoddard (2009). While there is some evidence of K-12 education providing positive externalities there is little which would suggest that K-12 education is a public good by the strict definition of the term.

choice for consumers.[2] This is the traditional context of choice in K-12 literature. With the introduction of choice, principally through charter schools and voucher systems, advocates for market solutions argue that competition arises in the provision of education. By creating market oriented solutions, these reforms are viewed as a means to limit inefficiencies attributable to the government. While this research is valuable, it has yet to offer definitive conclusions that school choice arising from these market based reforms provides improved educational outcomes. Moreover, these reforms are not without their own unintended consequences, and there is reason to suspect that large scale implementation of these initiatives present their own challenges.[3] However, it is clear that evaluating the effects of those choices is an important academic endeavor.

Rather than evaluate choice in market based educational reforms, this dissertation builds upon the recognition that education is publically funded and provided and is a significant enterprise.[4] It is this institutional environment that generates the impetus for evaluating how those in education make choices in the absence of markets.

Like traditional markets, non-market solutions often fail because the incentives facing individuals and agencies elicit choices which produce outcomes that are divergent from those which could be considered Pareto optimal. Examining these incentives and the resulting choices allows researchers to identify unintended consequences of policy in implementation and better inform policy design and reform. There are many

[2] While the direct consumption of educational outputs is by the students, choice in this context is primarily made by parents.
[3] Lubienski (2005) provides an analysis of unintended consequences of market-based reforms. See Ladd (2002) and Barrera-Osorio et al. (2008) for a discussion of issues of large scale implementation.
[4] According to NCES, approximately 97% of all K-12 students enrolled in the public school system attend a traditional public school.

institutional elements of the K-12 school system that introduce a variety of incentives for public school teachers and administrators in the provision of educational outputs. Often, these institutional procedures create conflicting incentives so that their expected effect on the choices made by teachers and administrators is not apparent. By addressing select institutional policies and practices, the dissertation endeavors to identify some of these incentives and to empirically examine their effects on the choices made by teachers and administrators.

Organization of the Dissertation

Following this introduction, Chapters 2, 3 and 4 address various institutional policies and practices, the incentives they create, and analyses of the resulting choices of teachers and administrators in Kentucky public schools. Chapter 2 evaluates the effect of professional development activities associated with the Appalachian Math and Science Partnership (AMSP) on student achievement. In doing so, this chapter addresses the institutional requirement of professional development and its relation to teaching effectiveness. It examines whether teaching effectiveness serves as an incentive in the choice to participate, as part of the professional development requirement, in the professional development activities of AMSP. A teacher fixed effects model is estimated to generate effectiveness measures. Results indicate that less effective teachers are more likely to participate in the professional development. Then, controlling for the bias of teaching effectiveness on the decision to participate, a propensity score matching model is used to create a treatment and non-treatment group to determine the effectiveness of the professional development treatment. The results suggest that the program had a positive and statistically significant effect on student achievement in the 5th and 11th grades.

Chapter 3 evaluates the relationship between demonstrated teaching effectiveness and class size under the institutional constraints of tenure, salary schedules, and school accountability. More specifically, do these constraints provide incentives for administrators to compensate or exploit demonstrated teaching effectiveness through adjustments in class size? Using both pooled-OLS and fixed effects modeling, this chapter addresses the question of whether administrators choose to reward past teaching effectiveness with smaller classes because of tenure and salary constraints, or choose to give effective teachers larger classes in an effort to maximize school achievement and satisfy school accountability demands. Results suggest that the latter provides a greater incentive for administrator choice as teachers with higher demonstrated effectiveness have larger classes.

Chapter 4 examines the relationship between school district contingency funds and the various factors that may influence their size and use. Institutional policy requires districts to maintain a minimum contingency fund level of 2% of operating expenses and there are no institutional restrictions on the size or use of these funds. However, the contingency fund is not defined in the traditional accounting sense, as the state defines the contingency fund broadly so that it is an amalgam of what is considered a traditional contingency fund and accumulated savings. Therefore, the incentives facing the administrator are a function of not only those factors which would affect contingency funds but also those factors which determine accumulated savings. More specifically, this chapter assumes the administrator faces incentives traditionally associated with determining contingency fund size and use such as revenue and expenditure variability. However, this chapter also suggests that the administrator seeks to create budget fungibility through savings and that this incentive is constrained by various political economy factors. School district contingency funds are estimated using both fixed and between effects models to estimate the levels and changes of the contingency funds respectively. This chapter addresses those factors which establish the context of choice for the administrator in determining contingency fund size and use and in doing so seeks to answer if administrators respond to budget variability and/or the incentive to create budget fungibility. Finally, Chapter 5 concludes the dissertation and includes a review of the findings, conclusions, limitations, implications, and recommendations for future research.

CHAPTER 2

DO LESS EFFECTIVE TEACHERS CHOOSE PROFESSIONAL DEVELOPMENT: DOES IT MATTER?

Introduction

Academics and policymakers increasingly emphasize that a key to improving educational outcomes in the United States lies in enhancing the quality of teachers. After many years of research that failed to show significant and systematic effects of school level inputs such as per pupil expenditures, teacher salaries, or pupil-teacher ratios on student outcomes, recent work illustrates that the quality of teachers is a significant factor in explaining student achievement (Boyd, D., Grossman, P., Lankford, H., Loeb, S., and Wyckoff, J., 2005a; Clotfelter, C., Ladd, H., and J. Vigdor, 2007; Rivkin, Hanushek, and Kain, 2005). For those individuals already in the teaching world, one of the hallmarks of this new focus on teacher quality is professional development programs. While different methods of recruitment and training of teachers may affect the quality of future teachers, professional development programs focus on changing the quality of those teachers currently in the classroom.[5]

Unlike the growing literature on the relationship between pre-service training and student achievement (Acevedo, 2009; Aaronson, et. al., 2007; Betts et. al., 2003; Clotfelter et.al. 2006, 2007; Kane et.al. 2006), the effectiveness of professional development in influencing in-service teacher quality has received less attention. Some

[5] National Board Certification for in-service teachers is also an alternative route for enhancing teacher quality. See Goldhaber and Anthony (2007) for a description of the program and its effects on teacher quality.

work has examined teacher perceptions of their own learning from professional development activities (Garet, et. al., 2001), but Jacob and Lefgren (2004), Garet et.al (2008), and Harris and Sass (2009) are among the few who have empirically examined whether and/or to what extent professional development activities influence teacher quality exhibited through student learning. And, of importance for this study, I am unaware of any studies of in-service training of teachers concentrated in poor, rural areas of the U.S.

This paper looks at one program within the Math and Science Partnerships (MSPs), a large federally funded initiative that sponsors professional development in the K-12 science, technology, engineering, and math (STEM) areas focused in Appalachian Kentucky. The program design resembles many real-world policy interventions in that it was explicitly not designed for random implementation. Instead, school districts endorsed the program and teachers within a particular region of a state voluntarily chose to participate in the program. For the purposes of this paper, I am ultimately interested in two questions. Did the weakest teachers (i.e., those who have the greatest potential for gain from content-based professional development) choose to participate in the MSP professional development? The alternative possibilities are that teachers randomly selected into professional development, or the highest quality teachers chose the content-based professional development. Second, did the professional development add to a teacher's effectiveness? To answer these questions, I look at teacher effectiveness prior to the in-service training, and then link the teacher effectiveness to the propensity to participate in the program. Finally, I measure the program effectiveness. The results indicate that weak teachers from poor performing schools were more likely to participate in the training. Elementary and high school students showed higher achievement gains linked to the teacher training than did middle school students**.**

The Appalachian Math and Science Partnership: A Description

As part of the vision of the *No Child Left Behind Act*, the National Science Foundation launched a new initiative in 2002 to improve the quality of teaching in the STEM areas. The initiative, as envisioned at the National Science Foundation, was focused on the creation of partnerships between institutions of higher education and K-12 schools to increase the quality of K-12 STEM teachers. The National Science Foundation has allocated approximately $800 million to the new initiative since 2002 and the programs are now operating in at least 39 states.[6] The focus on teacher training has as its ultimate goal the improvement in student outcomes in the STEM subject areas.

Evaluation of the success of the MSPs has varied. There have been qualitative studies that examine whether the partnership between an institution(s) of higher education and a particular K-12 school changed teacher or student attitudes or the culture of the school. Alternatively, instruments have been developed to assess whether teachers' knowledge of the content of their STEM area increased after participation in a training program. To date, there has been little disaggregated large scale empirical

[6] James Hamos, National Science Foundation, Plenary Talk for the Appalachian Math and Science Conference, "Voices of AMSP," Lexington, KY: December, 2010. The U.S. Department of Education also sponsors programs to foster STEM professional development among teachers.

examination of whether focused STEM teacher professional development has enhanced teacher quality as exemplified by student test scores.[7]

While there are over 40 targeted and comprehensive National Science Foundation funded professional development partnerships around the country, one of the largest of the initial programs was the Appalachian Math and Science Partnership (AMSP). The AMSP initially received a five year grant of $22.5 million from the National Science Foundation and began implementation in 2002-03. AMSP began as a partnership among 38 Central and Eastern Kentucky school districts, 9 eastern Tennessee school districts, and 5 Virginia (western part of the state) school districts, the Kentucky Science and Technology Corporation, and 10 higher education institutions located in these three states although this paper focuses on Kentucky only because of data limitations.[8] This area of the country is especially interesting because of its poor, rural population and longstanding achievement gap between rural schools and those of the urban areas of the same states. A goal of AMSP was to demonstrate improved student achievement in mathematics and science in the central Appalachian region through the support of partnerships that unite the efforts of local schools with administrators and faculty at area colleges and universities.

A requirement of each MSP is STEM faculty (most commonly math and science faculty but some engineering and computer science faculty) involvement from participating institutions of higher education. In the AMSP, the higher education faculty

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[7] See Wong, Yin, Moyer-Packenham, and Scherer eds. (2008) for a special issue of the *Peabody Journal of Education* devoted to describing the design and implementation of these MSPs. They look at some of the effects of the MSPs.
[8] The partnership has now been expanded to include five West Virginia school districts. The lead institution in this initiative was the University of Kentucky.

designed and delivered training programs for K-12 teachers of math and science. The programs, for example, covered content training in algebra, geometry, statistics, physics, and biology among others although for reasons presented later, this paper will focus only on math training.[9] The training programs were offered in a variety of settings. In some cases, K-12 teachers traveled to the institution of higher education where the training was conducted; in most cases, the higher education faculty traveled to an Appalachian site accessible to K-12 teachers across multiple schools and districts. The training varied in terms of hours per session and number of sessions offered for a particular course type (i.e., biology or algebra). Some of the training occurred during the regular semester and other training took place in longer periods over the K-12 summer break. Other MSPs around the country differ in specifics but the higher education/K-12 partnership model applies to all programs. In all MSPs, it is assumed that the content expertise held by higher education faculty will translate into higher quality teaching at the K-12 level.

At the inception of the AMSP program, superintendents of Appalachian districts were invited to participate in AMSP. Superintendents' endorsed the training offered by AMSP or they did not endorse. The districts that agreed to participate are illustrated by the map in Figure 2.1. Beyond the initial agreement at the district level, there was no systematic means of selecting which teachers participated in the program. Professional development activities were announced and teachers either voluntarily chose to participate or they chose not to participate. Some teachers also participated who were

[9] In a small number of cases the program covered content pedagogy.

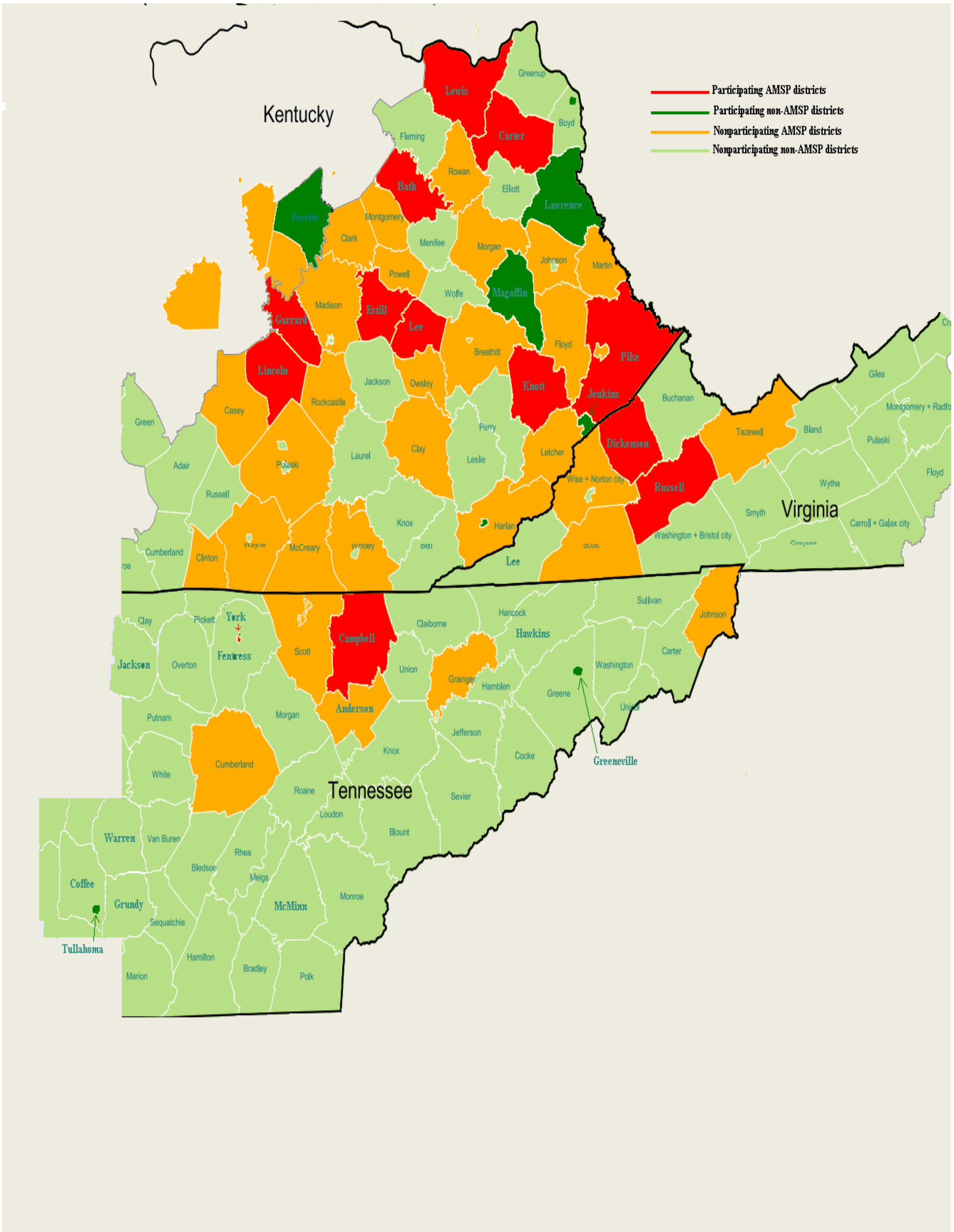

Figure 2.1: Districts Participating in AMSP Training and Providing Data

Note: Dark red and dark green districts participated in this evaluation study. Red and orange districts participated in the AMSP training.

Table 2.1: Teacher Participation Rates in AMSP and in the Sample

	AMSP Districts		Non-AMSP Districts	
School Year	**All**	**Sample**	**All**	**Sample**
2002-2003	0.018	0.010	0.001	0.007
2003-2004	0.041	0.037	0.003	0.026
2004-2005	0.067	0.051	0.008	0.035
2005-2006	0.107	0.080	0.009	0.052
2006-2007	0.080	0.071	0.005	0.048
2007-2008	0.049	0.051	0.002	0.035
2008-2009	0.020	0.019	0.001	0.013

not teaching in an AMSP district.[10] Table 2.1 illustrates the extent of teacher participation by year for districts that endorsed AMSP and those that did not. I also illustrate the participation rates for the districts that agreed to be part of the sample for this study. I discuss the data for this study in more detail below.

Note that in Kentucky, all K-12 teachers are required to participate in at least 4 days of professional development activities annually. The AMSP professional development activities satisfy annual teacher professional development training as required by the Kentucky Department of Education. The state does not systematically monitor the effectiveness of these alternative PD activities nor does it centrally collect information about the specific types of activities chosen by the teachers. Throughout this analysis, I implicitly am evaluating the AMSP effectiveness relative to the

[10] In the sample used in this paper, approximately 10 percent of the teachers who participated in professional development were not employed by AMSP districts.

collection of all other types of in-service training. Measured simply in terms of the opportunity costs of teachers for the 4 days of training, Kentucky spends over $42 million annually on professional development activities. On many margins, looking at effectiveness of training appears warranted.[11]

Teacher Quality and Professional Development

Before attempting to estimate who selects into AMSP and to examine its effectiveness, it is useful to think conceptually about whether and/or why I expect professional development activities to influence student outcomes and the circumstances under which they should be more or less effective. Recall that the goal of MSPs is to enhance the math and science content knowledge of in-service teachers and, thereby, to enhance student learning. Professional development may be best characterized as specific on-the-job training. It is a form of targeted training for particular individuals. Viewed in this way, there is reason to believe that high quality professional development over some period of time should lead to more effective teaching and, therefore, higher student outcomes just as specific on-the-job-training leads to increased productivity in various private sector industries. The literature on the effectiveness of content training at the pre-service level is mixed, however, which casts some doubt on the expected outcome for in-service professional development effects.

Beyond the expected effectiveness, there are elements of professional development programs that present challenges as I think about measuring effectiveness. As already suggested, one of these elements is the means by which teachers select into

[11] This number was calculated as a salary equivalent representing the opportunity costs of teachers' absence from the classroom.

professional development activities. Kentucky, as most states, requires teachers to participate in some sort of professional development each year as part of their continuing certification or licensure requirements. I am unaware of any state that requires that the programs prove effectiveness to be included in the list of acceptable professional development hours for the state.

This raises an interesting dilemma for a teacher. Suppose a teacher confronts a choice between “real” professional development and an activity that may provide more entertainment and/or be less taxing in terms of effort required on the part of the teacher. From a societal perspective, the welfare gains are highest from professional development if the teachers who reap the highest value-added from the training are the ones who participate in a professional development activity. But teachers who benefit most from professional development may or may not be the ones most likely to pursue content training. To illustrate, one could argue that the teachers who are weakest in terms of their own value-added for the students are the ones expected to gain the most from training. Under increasing accountability of teachers, I may also expect them to be the most motivated to improve. But these teachers may also be the least ambitious more generally as reflected by prior ineffectiveness in the classroom. Conversely, the teachers who are most motivated generally and the ones with the most effective teaching records may be the ones more likely to enroll in rigorous, content-based professional development even though the value-added in knowledge and instructional effectiveness may be least for them. Finally, there may be no relationship between a teacher’s past effectiveness, other observable characteristics, or even unobservable characteristics that influence her decision to participate in professional development activities.

Regardless of the direction of the effect, if there are systematic factors (either observed or unobserved) that influence which teachers choose to enroll in professional development, and these effects are not controlled in an empirical model, the effectiveness of the intervention itself will not be properly estimated. The remainder of this paper looks at who chose to participate in AMSP and empirically estimates its subsequent effectiveness.

Data

The remainder of this paper will provide an analysis of the AMSP using individual student-teacher observations from the school year 2000-2001 through 2007-08.[12] This time period allows two years of observations prior to the AMSP intervention and covers its entire time of activity. Although the training program includes schools across 4 states, this paper looks only at students in Kentucky.[13] Like many states to

[12] An earlier paper looked at school level data for all Kentucky public elementary and secondary schools from the school year 2002-01 through 2005-06 (Foster and Toma, 2008). That paper addressed the issue of which particular school districts agreed to participate in AMSP and the subsequent effectiveness of the participation. School level data are useful for identifying school level effects from a professional development intervention but they contain possible aggregation bias. A preferred measurement of the effectiveness of an individual teacher's participation in any professional development activity involves matching students to teachers and comparing the effectiveness of those teachers who participated to that of those teachers who did not participate while controlling for other observable and unobservable factors that may influence student outcomes.

[13] In a future paper, I will look at students in TN and VA as well. The different testing systems of the states and the different schedule of tests pose special and interesting econometric challenges for combining the data across the three states.

Table 2.2: Indicator of AMSP Participation and Years of Roster Data for Kentucky Districts

District	AMSP Participant	Years of Roster Data
Kentucky1	YES	2002-2008
Kentucky2	YES	2001-2008
Kentucky3	YES	2003-2008
Kentucky4	NO	2001-2008
Kentucky5	YES	2002-2008
Kentucky6	NO	2003-2008
Kentucky7	YES	2002-2008
Kentucky8	NO	2003-2008
Kentucky9	YES	2002-2008
Kentucky10	NO	2004-2008

date, Kentucky did not collect information that allows particular students to be matched to specific teachers over this time period. To successfully identify which students were in a particular teacher's classroom, I solicited the cooperation of local school districts in the Appalachian portion of the state.[14] I invited all Appalachian districts to provide classroom roster data regardless of whether or not the school superintendents had officially agreed for their schools to participate in the partnership program. The roster data for each school and each school year, lists the course, the teacher for the course, and all students who were enrolled in that course. My ability to match students to specific teachers over the past 8 years varies by district. Some districts retained all data from the past while others retained data for shorter periods of time. As a result, I will have a

[14] The Appalachian districts were chosen because they were the target of the AMSP PD activities. This evaluation did not accompany the AMSP but followed it – adding to the challenges of data collection.

mixed panel of data. The resulting districts in Kentucky and the years of data availability are listed in Table 2.2.[15]

Ten school districts in eastern Kentucky provided useable data for this project. The study required matching data from several state-level administrative data bases as well as class roster data from individual school districts. The data were district-based and from a variety of state agencies and none were developed with the idea of being used for evaluation purposes. Much of the matching required name and birth date or other person-specific characteristics.

Because the professional development program deals strictly with math and science, I theoretically can examine student performance in both subject areas but Kentucky's testing schedule for science poses challenges for measuring annual value-added that could be attributed to a specific teacher. Standardized math and science test tests (known as Kentucky Core Content Tests) are administered annually in all schools in Kentucky but not at all grade levels each year. From the 2000-2001 to the 2005-2006 school years, the state tests covered science in grades 4, 7, and 11 and tested math in grades 5, 8, and 11. Nationally standardized tests (the CTBS) were also administered to students in grades 3, 6, and 9 over the same years. Beginning in 2006-07, state math testing was instituted annually in grades 3-8 and retained for 11th graders as well. The years of science testing did not change. Reading was tested (state tests) in grades 4, 7, and 10 through 2006 but like math it now is tested annually through 8th grade and in the 10th grade for high school. As I describe in the model, I take advantage of all subject

[15] The payoff to the districts for providing data is a promise that I will share the results about teacher effectiveness with them. The cost to participation for the district is staff time required to extract the data.

test results regardless of which subject matter I examine. The value of using multiple past scores has been illustrated by McCaffrey et. al. (2003). Scores from these exams are used to satisfy state reporting requirements for NCLB and are used as part of the accountability standards set by the Kentucky Education Reform Act of 1991. Also like many states, the subjects tested and scaling of the tests have changed multiple times since 1991. The change in the state's test in 2007 was such that the scale of score in years prior cannot reliably be reconciled with those of 2007 and onward.[16] In addition, each grade level test involves scores with different scales. A 500 on a math test of a 5th grader was not designed to be equivalent to a 500 on the math test of an 8th grader. This means that grade levels must be examined separately for evaluation purposes. The methods of addressing the scale changes and other challenges regarding testing are presented below. Other student characteristics available for the matching are time-invariant characteristics such as gender and race. Free and reduced price lunch data vary slightly by school year.

The Kentucky Department of Education (KDE) provided the individual student demographic and test score data for this analysis. The student level data cover the years, 2000-01 to 2008-09. This includes two years of data prior to the onset of AMSP (in 2002-03) and six years post the implementation of AMSP. It is clear from the participation data in Table 2.1 that the program was phased in with the peak level of teacher participation (10 percent of all teachers) in 2005-06, a slight decline in 2006-07, and then a phase-out. The Kentucky Education Professional Standards Board (EPSB)

[16] This conclusion has been affirmed by officials of the Kentucky Department of Education.

Table 2.3: District Locale, Total Students and Number of Schools by Type of School

District	Urban-Centric Locale	Total Students 2007-2008	Primary Schools	Middle Schools	High Schools	Other Schools
Kentucky1	Rural: Distant	1,234	3	1	1	0
Kentucky2	Rural: Distant	3,119	6	2	2	0
Kentucky3	Rural: Fringe	2,196	3	1	1	0
Kentucky4	City: Large	24,134	35	12	5	3
Kentucky5	Town: Distant	2,399	3	1	1	0
Kentucky6	Town: Distant	1,606	3	1	1	0
Kentucky7	Rural: Remote	1,133	4	1	1	0
Kentucky8	Rural: Remote	2,105	6	1	1	0
Kentucky9	Rural: Distant	9,743	17	4	5	2
Kentucky10	Suburb: Mid	663	1	2	1	0
Total		48,332	81	26	19	5

Kentucky 2: missing vocational high school
Kentucky 3: missing one primary school one year, school switched to PK and K.
Kentucky 4: there are additional vocational and alternative schools for which I did not receive data.
Kentucky 5: missing 2001-2002 data for all primary schools.
Kentucky 9: name/location change 15 elementary schools over all years; name/location change 3 schools over all years
Kentucky 8: missing 2003 data for middle schools
Kentucky 10: primary available 2006-2008; middle school available 2004-2007; high school available 2004-2005, 2007-2008

provided teacher level data that also begin in the 2000-01 school year and continue to the present. The available teacher-level data are quite comprehensive but I limit myself to experience of the teacher and highest degree achieved. All other characteristics of the teachers such as Praxis scores, gender, and race are time invariant and are captured in the teacher fixed effects in the model below. I also have school level characteristics that are time varying.

Table 2.3 provides additional information about the 10 school districts I am examining. As illustrated here, these are small, rural districts with typically a single high school but multiple elementary schools.[17] Of these 10 districts, 6 districts formally participated in the partnership professional development activities beginning in 2002-03 but 4 districts did not officially participate with AMSP as a provider of professional development activities.[18] Regardless of official district level participation, teachers in all districts were permitted to enroll in the training activities and in the non-participating district, teachers crossed district lines for the training activities even though the superintendent had not formally joined AMSP. Participation rates tended to be higher in those districts whose superintendents agreed. In the non-AMSP districts for this analysis, there were 10 percent of teachers who selected to participate in the professional development activities. Table 2.4 presents summary data on teacher participation, including the total number of unique teachers involved in the in-service training by district and year. The AMSP program provided the data on teacher participation.

After receiving the data from multiple sources, I matched the data so that I observe each student who is testing in math or science in a given year and for which I can identify the teacher(s) who taught that student in those content courses. The total number of student-teacher observations for the analysis is slightly more than 700,000

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[17] Kentucky has traditionally had small, county-based school districts with additional districts for the county seats (the largest town typically) in many cases. Nine of the 10 districts in this sample are county-based. One of the advantages of this study is its focus on professional development in rural schools.

[18] As noted earlier, all Kentucky teachers are required to participate in a minimum of 4 days of PD activities annually. The quality of the data on the alternative PD types varies considerably by district and there is no state collection of these data.

Table 2.4: Number of Teachers with AMSP Professional Development in Math by District by School Year

District	AMSP Participant	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	Total teacher/years	Total Teachers	Total hours	Average hours per teacher
Kentucky1	YES	0	5	3	9	10	1	28	17	364	21.41
Kentucky2	YES	0	0	14	35	21	21	91	48	1,629	33.94
Kentucky3	YES	0	2	0	5	2	16	25	23	321	13.96
Kentucky4	NO	1	1	9	4	0	1	16	14	693	49.50
Kentucky5	YES	0	4	2	4	0	0	10	7	666	95.14
Kentucky6	NO	0	0	0	0	0	1	1	1	2	2.00
Kentucky7	YES	0	2	1	5	1	0	9	6	520	86.67
Kentucky8	NO	0	0	2	1	0	0	3	2	180	90.00
Kentucky9	YES	0	2	33	17	10	13	75	58	2,429	41.88
Kentucky10	NO	0	0	0	0	0	0	0	0	0	0.00
Total		1	16	64	80	44	53	258	176	6,804	38.66

Table 2.5: Descriptive Statistics for selective sample in 2005 for grades 5, 8, and 11

Variable	Observations	Mean	Standard Deviation	Minimum	Maximum
Free and Reduced Price Lunch	11,929	0.46	0.50	0	1
Female	11,695	0.48	0.50	0	1
Asian	11,715	0.02	0.12	0	1
Black	11,715	0.10	0.30	0	1
Hispanic	11,715	0.02	0.15	0	1
Native American	11,715	<0.00	0.01	0	1
Other	11,715	0.01	0.09	0	1
Avg. Experience (School)	11,929	12.30	2.10	5.3	17.7
Enrollment	11,929	681.94	423.17	80	2,062
Percent Masters' Degree	11,929	76.09	11.26	35	100
Percent Free and Reduced	11,929	0.51	0.212	0	.97
Expenditure per Student	11,929	5,708.21	1,208.24	3,908	12,837
Student Teacher Ratio	11,929	15.15	2.38	8	22
Student Computer Ratio	11,929	4.01	1.28	1.6	7.6
Math Index	11,929	71.52	12.35	41.97	112.69
Experience	11,929	12.085	8.973	0	34
Experience Squared	11,929	226.552	269.009	0	1,156
Highest Degree[1]	11,929	3.083	1.301	1	7

1– Highest degree coded as follows: 1=Bachelor's, 2=5th year, 3=Planned 6th year, 4=Master's, 5=Rank I, 6=Specialist, 7=Doctorate

but this includes teachers and students across all grade levels regardless of whether there are standardized tests. Table 2.5 provides descriptive statistics for the students, teachers, and schools for the 10 districts. The statistics vary somewhat by year and here I present school year 2005-06 as a representative year because it is a year in which all districts provided roster data. As stated earlier, because Kentucky tests science only in grades 4, 7, and 11, I focus on math performance in this analysis.

Model and Results

Given the changing scale of the test score data over the time period I observe and the multiple exams (state and national), the use of standardized test scores as variables (as in a standard value-added model) is somewhat problematic for estimating the effectiveness of the professional development activities. Ballou (2009) summarizes the many issues associated with scaling and the use of standardized test scores. Because changing scales make increases and decreases in scores difficult to interpret, I do not use the scores as the dependent variable. Instead, to mitigate the test score issues, I convert the Kentucky standardized exam scores to ranks. Ranks are well defined for any scale and comparable as long as the tests have validity for the same ability measure—math, science, or reading, in the present case. Students' ranks on scores have been used recently by Arcidiacono (2004; 2005) and Betebenner (2009), and they have an advantage over test scores (raw or scaled) in that no attempt is made to compare the meaning of a unit change in score. [19] The rankings, on the other hand, imply that I cannot link teacher effectiveness to a quantitative measure of student learning by using units of change in test scores. Appendix A also illustrates the results using z-scores. These results may differ as z-scores are a nonlinear transformation of scores and ranks represent a linear transformation.

Because I use ranks from the standardized exams rather than the scores, it is useful to discuss the rank data a bit further. I rank students on their performance on the state tests in math, science, and reading although I am using only the first one as a dependent variable. To compute the ranks, I grouped all students taking a particular grade-relevant exam per year. For example, all students in the sample who participated

[19] Ranks, like percentiles, reduce the importance of extremes in the data relative to the more frequently used z-scores. Percentiles would be preferred over ranks if the dependent variable was a "change" score. As will become clear in the model description, I use past ranks as control variables rather than examine the difference in two rankings for a student so either ranks or percentiles are appropriate. Ranks can be more informative than percentiles in that a student can change rank from year to year without changing percentile.

in the math exam in the eighth grade for school year 2006-07 were ranked together. I did not cross subject exam, grade levels, or years in ranking the students.

Before discussing the model and results, I address the technical aspects of selection and subsequent treatment effects that motivated the empirical methods used. In an experimental setting, where treatment was randomized, the methods I use below would not be necessary.[20] However, as is the case with many program evaluations, the decision to participate in the professional development was not likely random but, rather, a deliberate teacher choice and a function of teacher and school characteristics. In such cases, where both the decision and outcome of treatment are correlated with the covariates, the resulting estimation of the average treatment effect is most likely biased.

Accounting for this bias requires the use of a counterfactual argument. Because I cannot see both teacher j's treatment and non-treatment outcome, I cannot determine the effect of treatment. By matching teachers with similar covariates, but with different participation decisions, the effects of treatment can be estimated. With many covariates this is often unmanageable, but the use of matched propensity scores generated by a probit estimation allows teachers to be matched more easily. To illustrate, a participating teacher is matched based on her propensity score to a non-participating teacher to generate a replacement treatment and non-treatment outcome. Once all participating teachers are matched with a non-participating teacher, a teacher fixed effects estimation can be used to estimate the effect of the professional development treatment.

[20] Here I use randomization of treatment rather than the offer of treatment.

Typically the covariates are observable factors that contribute to both treatment and outcomes. In fact, if treatment and outcomes are based on unobservable factors this method does not properly control for selection bias. My approach explicitly controls for the potential influence of unobservable factors in the treatment decision and outcome by estimating teacher fixed effects and including them in the estimate of participation and the resulting propensity scores on which the teachers are matched.

For estimating purposes, I want to both look at which teachers selected into AMSP and to subsequently examine its effectiveness. In other words, I question whether teachers are randomly choosing this particular, content-focused professional development. As described above, if selection is not random, estimates of the effectiveness of the intervention must account for the selection mechanism. The model will consist of three stages.

First, the teacher's past effectiveness is estimated as follows. I estimate for each student-teacher year combination the student outcome:

(1) $R_{it} = \beta_0 + \beta_1 R_{it-1} + \beta_2 D_{it} + \beta_3 T_{ijt} + \beta_4 SC_{it} + \theta_j + c_j + u_{it}$

where R is the relative ranking of each student i in the sample on the standardized math exam in year t and the $\beta_i's$ are estimated coefficients. The grade level is not listed because math exams and year (t) are always associated with certain grade levels. The rankings are a function of the same student's rankings on the most recent prior test on math as well as the two other subject areas.[21] If the most recent test was a nationally

[21] I use all prior test scores on math, science, and reading because of the interval timing of these tests in Kentucky. Note that the lagged test score could be one to two years

standardized math test (CTBS) rather than the state test, I used ranks on that test as a control variable. A vector of variables, D, describes the demographics of student i in year t, T is a vector of student i's math teacher (j) experience and degree variables in year t, and the vector, SC, describes characteristics of the school for which the student-teacher combination is observed. The term, $\theta j,$ represents a teacher fixed effect, c_j the teacher-clustered error term, and u_{it} is the idiosyncratic error.[22] Estimation of equation (1) yields a predicted ranking, $\hat{R}_{it}$ for each student that is based on that student's own demographics, past test performance, the student's teacher, and his or her school attended. To develop a measure of teacher effectiveness, I estimated this equation for school years 2003 through 2008.[23] In the estimation, the current year as well as all preceding years are included to generate an estimate of the predicted student rank and, for my purpose, a teacher fixed effect. For example, in year t, the estimated fixed effect for a given teacher j is the average effect of the unobservable characteristics of teacher j from 2000-01 through year t.

This estimate of teacher effectiveness is then substituted into the equation (2) below in year t+1 in which I estimate a probit equation for teacher participation in

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earlier depending on the subject tested. Of great interest, the correlation coefficients on student ranks are remarkably similar across the 3 subject areas. For example, 8th grade math ranks across the panel have a correlation coefficient of 0.56 with the prior math test, 0.54 with the most recent reading exam, and 0.58 with the lagged science exam. Recall, that through 2006, math was tested in grades 5, 8, and 11. After 2006, the test is annual. See McCafferty et. al. (2003) for discussion of the value of using as many past test results as available in value-added models.

[22] I do not cluster the error term on schools because there is little mobility of teachers across schools in this panel; that is, a given teacher is usually at one school only.

[23] The equations are estimated for these years only because these are the years in which a teacher could decide to participate in the PD.

AMSP.[24] In particular, I estimate the probability of teacher j choosing to participate in the professional development activities in year t as:

(2) $PD_{jt} = \alpha_1 T_{jt} + \alpha_2 SC_{it} + \alpha_3 \hat{\theta}_{jt-n} + \varepsilon$

where PD is a binary variable indicating whether a teacher chose to participate in the professional development activities of a given year or did not.[25] The independent variables includes a vector of time-varying teacher characteristics; a vector of school level characteristics in each year t including the lagged school's performance level; and $\hat{\theta}$ is the constructed measure of the teacher's past effectiveness in the classroom. I include this as a means of testing whether the teacher's own effectiveness in the classroom motivates her to choose the content-based professional development and, if so, whether the motivation is in a positive or negative way.

Table 2.6 presents the results from estimating the student rank (equation 1) for students in grades 5, 8, and 11 over the 2000-01 to 2007-08 data. The results are consistent with expectations predicted by the literature on student outcomes. The lagged math ranks for the student are important both statistically and in magnitude in explaining the student's current rank at all grade levels. Higher ranks on the previous math test imply a higher rank on the current exam. Also statistically significant at the .01 level are

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[24] An alternative approach would include the use of an instrumental variables model to predict participation. Unfortunately, I have no instrument that explains participation that also potentially does not explain student performance.

[25] I model the participation decision as a yes or no. In reality, the teacher could choose among activities with varying hours. The propensity scores generated from this probit estimate are correlated at the .01 level with the number of hours of participation. The hours of participation were clustered and not normally distributed.

Table 2.6: Student Achievement with Teacher Fixed Effects (00-08)

Independent Variables	Grade 5		Grade 8		Grade 11	
Math Rank Lagged	0.369	***	0.476	***	0.433	***
	(0.009)		(0.011)		(0.014)	
Science Rank Lagged	0.224	***	0.224	***	0.274	***
	(0.009)		(0.007)		(0.008)	
Reading Rank Lagged	0.255	***	0.193	***	0.099	***
	(0.010)		(0.009)		(0.009)	
Student Characteristics						
Free and Reduced Price (FRP) Lunch	-246.370	***	-188.627	***	-65.668	***
	(20.510)		(17.516)		(13.003)	
Female	-34.783	**	-54.732	***	-58.272	***
	(15.957)		(12.029)		(10,737)	
Asian	460.173	***	586.069	***	386.307	***
	(56.740)		(47.091)		(47.426)	
Black	-292.138	***	-318.987	***	-263.128	***
	(26.667)		(22.748)		(19.276)	
Hispanic	-124.143	***	-178.853	***	-233.565	***
	(44.062)		(39.535)		(45.952)	
Native American	239.453		-558.093	**	-477.576	**
	(264.329)		(228.737)		(200.553)	
Other	-39.347		115.232	**	-48.399	
	(73.329)		(58.761)		(61.212)	
School Characteristics						
Class Size	2.794	**	0.221		-1.243	
	(1.327)		(1.298)		(1.426)	
Average Experience	-7.567		-10.725		16.886	**
	(12.236)		(9.957)		(8.422)	
Enrollment	0.086		0.102	*	0.047	
	(0.89)		(0.056)		(0.044)	
Percent Master's	-0.657		2.347	**	-3.478	***
	(0.820)		(1.034)		(0.994)	
Percent of FRP Students	92.872		8.342		-237.259	
	(63.310)		(62.673)		(59.490)	
Expenditure per Student	0.006		0.029	*	0.014	
	(0.015)		(0.015)		(0.020)	
Student-Teacher Ratio	-0.792		-15.621	*	-10.018	
	(10.123)		(9.422)		(6.855)	
Student-Computer Ratio	-3.466		6.842		-1.284	
	(9.185)		(7.257)		(4.528)	
Math Index	0.829		2.904	***	3.150	**
	(0.883)		(0.875)		(1.278)	
Teacher Characteristics						
Highest Degree Obtained	-35.181		14.578		34.481	*
	(31.330)		(21.546)		(18.059)	
Experience 4-7 Years	-223.132	**	-110.904		96.746	**
	(105.680)		(72.339)		(42.324)	
Experience 8-12 Years	-196.710	**	-112.714		33.986	
	(98.659)		(81.555)		(53.861)	
Experience 13-17 Years	-332.442	***	-96.951		63.302	
	(124.589)		(99.846)		(64.209)	
Experience 18 Years and Higher	-436.147	***	-70.630		74.983	
	(144.120)		(100.205)		(73.347)	
N	22859		27952		18009	
F-Test	481.99	***	977.68	***	545.29	***

Note: Coefficients with robust standard errors in parentheses are presented in the table.
*indicates 0.10 level of significance ** indicates 0.05 level of significance, *** indicates 0.01 level of significance

past reading and science scores although as expected, the magnitudes of the coefficients are less than with the math scores.

In interpreting the remaining independent variables, note that the dependent variable, RANK, is constructed with the lowest ranking student receiving the number one rank. In addition to the lagged test ranks that are significant across all past subject tests and grade levels, student characteristics also significantly influence rank across grade levels. Free and reduced price lunch students perform at lower levels than full price lunch students. In all three grades, Asian students significantly outperform White students (the omitted category) and Black, Hispanic, and Native American students significantly underperform (rank) relative to White students. These results are particularly striking given the low percentages of minority students in the schools in this sample. See again the descriptive statistics in Table 2.5.

School level characteristics are less consistent in their contribution to student rankings across grade levels. At grade 5, class size is significant but has the opposite sign than expected. Larger classes are associated with a higher average student rank. In 8^{th} grade, larger schools are associated with higher ranks as are the percent of teachers holding a master's degree and expenditures per pupil. Of particular interest, the school level math index score is significant indicating that the overall performance of the school as measured by a state index score, significantly affects the performance of the student. This is consistent with many findings in the literature. By grade 11, it appears that a higher level of experience for the school's teachers contributes positively to student rank and now the percent of teachers with a master's degree has switched signs is contributes negatively to student ranks. Again, the school's performance in math affects the individual student ranks on average.

Finally, I look at the teachers paired to the students that I am examining and the effect of observable characteristics on student rank. At grade 5, teacher experience matters for student rank but not in the way typically found in the literature.[26] All categories of experience for teachers point to lower ranks for experienced teachers than for those teachers in the first 3 years of experience. This is not true at the 8th and 11th grades. Now experience is either insignificant or for 11th grade teachers, 4-7 years of experience improves student rankings over that of teachers with less than 4 years of experience.

For my purpose, the primary intention for estimating the above student ranks is to capture the teacher fixed effects.[27] At each of the three grade levels, the teacher fixed effects are explaining a significant portion of the variance in rank performance. Teacher fixed effects explain 35 percent of the variance in 5th grade student ranks, 28 percent of the variance in 8th grade ranks they explain 35 percent of the variance in ranks of 11th graders. These results are consistent with the findings of Rivkin, Hanushek, and Kain (2005), and corroborated by others, that teachers matter in ways that are not easily observable.

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[26] This finding does not hold when I enter experience as a quadratic term rather than in categorical form. The signs are as expected although generally insignificant with the latter form.

[27] I use the net teacher fixed effect, or the unobservable effect rather than the gross effect because the unobservable portion better captures the motivation to participate that I am seeking to capture.

Table 2.7: Predicted Teacher Participation

Independent Variables	Coefficient		Standard Error
Teacher Characteristics			
Lagged Effectiveness	-0.007	**	0.000
Max Degree Held	0.130	***	0.035
Experience	-0.011		0.016
Experience Squared	0.000		0.001
School Characteristics			
Average Experience	0.085	***	0.018
Enrollment	0.000	***	0.000
Percent Master's	-0.012	***	0.003
Percent of FRP Students	0.010	***	0.002
Expenditure per Student	0.000	***	0.000
Student-Computer Ratio	0.022		0.024
Math Index	-0.008	***	0.002
N	3,970		
Log Likelihood	-567.317	***	

*indicates 0.10 level of significance ** indicates 0.05 level of significance, *** indicates 0.01 level of significance

Using the measure of past teacher effectiveness constructed from these fixed effects, I present the results from estimating the probability that a teacher will choose to participate in AMSP professional development in any given year in Table 2.7. The variable of greatest interest for my purpose is the lagged fixed effect, or past teacher effectiveness. The coefficient on the lagged effectiveness variable is significant in explaining a teacher's choice to participate in professional development. The negative sign implies that teachers with lower past effectiveness as reflected in student ranks are more likely to choose to participate in AMSP professional development.[28] Viewed from this perspective alone, it appears that voluntary selection of teachers into AMSP was not

[28] Recall again that ranks are in ascending order with one being bottom-performing.

random. In particular, weaker teachers are the ones who tended to choose to participate in AMSP professional development. Note that school level characteristics are also significant in explaining an individual teacher's selection into the professional development.

Other variables also help explain the probability of participating. Teachers who have higher education levels are more likely to participate in the AMSP in-service training. Of particular interest and not surprising is the fact that school level variables explain a great deal of the individual probability of participating. Teachers from schools in which the average level of experience is higher are more likely to participate. Teachers from larger schools are less likely to participate and teachers from schools with a higher percentage with master's degrees are less likely to participate. As expected because of the nature of this program, teachers from schools with a higher percent of students with free and reduced price lunch are more likely to participate and those with higher expenditures per pupil are less likely to participate. Finally, the quality of the school level output as reflected in the math index score of the school influence participation probabilities. Teachers from better schools are less likely to participate. Taken together, the significant, negative teacher fixed effects and the school characteristics suggest that weaker teachers and those from lower quality schools are the ones most likely to participate in AMSP. [29]

[29] I also ran the probit model using teacher effectiveness measured in deciles. The results support those reported here. Teachers in the lower decile ranks (3 and 4) were more likely to participate while those in the 10^{th} decile (highest and best) were significantly less likely to participate in the professional development activities.

With these probit estimates, I next construct propensity scores for a given teacher's propensity to enroll in professional development in a given year.[30] I use the teacher propensity scores to create a sample of teachers for which I can estimate the effectiveness of the professional development intervention. The sample is based on matching each AMSP participant to a non-participant using the nearest neighbor matching procedure from the estimated probit model. This improves the sample by enhancing the ability of the sample to have the property of "overlap" (Wooldridge (2010, pp. 910-911): "…estimating the average treatment effect will require being able to observe both control and treated units for every outcome on [the data].[31] The kernel densities of the propensity scores (see Figure 2.2) show that there is considerable non-overlap in both tails for participants (treatment) and non-participants (control), and the matching reduces the sample to equal groups of teachers (not equal groups of students) with extremely similar propensity scores.[32] Therefore, this smaller sample should be more reliable in estimating the effect of AMSP than the entire sample of teachers.

The results above provide evidence that teacher selection into the professional development activities of AMSP was not random. While I offered no prior expectation about the direction of bias influencing selection, it appears that weaker teachers did select into the professional development. Finally, I am in a position to examine the final question posed for this paper. Did the AMSP professional development intervention

[30] As mentioned previously, the propensity score allows me to estimate the effects of the covariates on the probability of participation so that participating and non-participating teachers can be matched to create a treatment and non-treatment counterfactual.
[31] This assumption is typically called the overlap assumption. Overlap means that, for any setting of the covariates in the assumed population, there is a chance of seeing units in both the control and treatment groups." The use of propensity scores is described in detail on pages 909-915 of Wooldridge (2010).
[32] The propensity scores were matched to the thousandths.

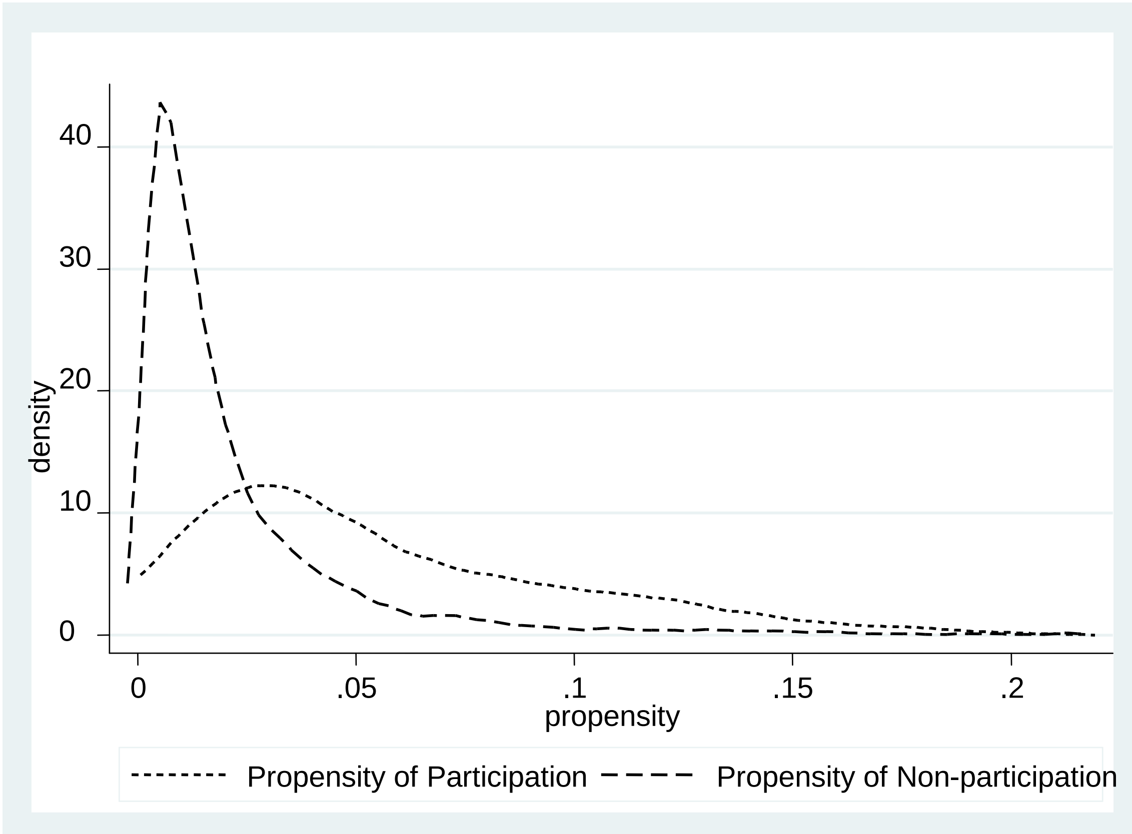

Figure 2.2: Kernel Density of Participating and Non-participating Teachers

have an effect on the math teachers' effectiveness as reflected in the ranks of their students? To answer this question, I ran a teacher fixed effect model on the following equation:

(3) $R_{it} = \beta_0 + \beta_1 R_{it-1} + \beta_2 D_{it} + \beta_3 T_{jt} + \beta_4 SC_{it} + \beta_5 AMSP_{jt} + \varepsilon_{it}$

where all variables are described as in equation 1 but with the addition of the AMSP variable. AMSP is a binary variable that captures whether the teacher participated in the AMSP professional development in a given year or not and reflects the sample construction defined above.

The results from estimating the effects of AMSP on student rank performance are presented in Table 2.8. Teacher participation in the content-based AMSP professional development had a significant effect on 5th and 11th grades' student rank performance. Using the propensity-derived sample of teachers and matching to their students over the entire time period observed, the students of those teachers who participated in the AMSP training outperformed in rank those students whose teachers who did not participate. In the 8th grade, however, the results do not hold. At these grade levels, the AMSP participation results in no significant difference for those students whose teachers participated and those who did not participate. It is unclear why the payoffs do not appear for 8th grade teachers.

Other control variables again behave generally as expected. Most notably, the students' own rank on tests in prior years continues to be significant in explaining current ranks as do other student and school characteristics. Particularly interesting, the school quality variable as capture in the math index score is now insignificant in explaining student ranks at the 5th and 8th grade levels although it continues to help explain 11th grade ranks. Given the strong role of school quality in explaining participation propensity, the insignificance of the index score is perhaps not surprising. Other than the participation variable, there are few teacher characteristics that contribute to student ranks in these estimates. Teachers who hold higher degrees continue to positively influence 5th grade ranks but not 8th or 11th grade ranks. One category of teacher experience, 4 to 7 years, appears to be less effective than the least experienced teachers but all others are insignificant.

Table 2.8: Student Achievement: Censored With AMSP Participation Propensities

Independent Variables	Grade 5		Grade 8		Grade 11	
Math Rank Lagged	0.416	***	0.517	***	0.382	***
	(0.018)		(0.013)		(0.018)	
Science Rank Lagged	0.178	***	0.207	***	0.259	***
	(0.018)		(0.013)		(0.017)	
Reading Rank Lagged	0.253	***	0.171	***	0.135	***
	(0.019)		(0.013)		(0.018)	
Student Characteristics						
Free and Reduced Price (FRP) Lunch	-221.907	***	-114.847	***	0.947	
	(34.822)		(24.237)		(28.304)	
Female	-49.193		-75.317	***	-39.273	
	(31.653)		(23.549)		(27.936)	
Non-white	-164.302	*	-144.373	**	0.000	*
	(84.096)		(72.977)		(94.432)	
Class size	1.683		2.247		4.390	
	(2.125)		(2.972)		(2.875)	
School Characteristics						
Average Experience	-490.503	***	-100.032	***	28.343	
	(117.126)		(42.307)		(46.866)	
Enrollment	3.365	*	0.556		-5.799	***
	(1.760)		(0.931)		(1.842)	
Percent Master's	14.678	***	-0.005		0.858	
	(4.484)		(2.415)		(3.609)	
Percent of FRP Students	252.479		-444.412	***	155.044	
	(179.601)		(154.500)		(159.462)	
Expenditure per Student	-0.086		0.261	*	0.152	**
	(0.064)		(0.136)		(0.076)	
Student-Teacher Ratio	194.655	***	-32.196		220.401	***
	(63.139)		(37.296)		(74.473)	
Student-Computer Ratio	59.538		23.464		-118.509	***
	(79.274)		(32.195)		(41.502)	
Math Index	2.868		2.846		37.551	***
	(7.832)		(6.628)		(7.068)	
Teacher Characteristics						
Participation in AMSP PD	215.019	*	-44.736		157.560	***
	(125.206)		(69.408)		(70.926)	
Highest Degree Obtained	447.020	**	80.725		-192.241	
	(210.544)		(54.166)		(600.938)	
Experience 4-7 Years	-1110.156	*	-154.100	*	932.595	
	(597.908)		(86.678)		(1,820.060)	
Experience 8-12 Years	-719.150		-140.509		983.457	
	(848.763)		(143.228)		(1,875.215)	
Experience 13-17 Years	-712.986		-84.059		845.810	
	(1,083.843)		(218.908)		(1,879,568)	
Experience 18 Years and Higher	-222.000					
	(1,208.937)					
N	3,221		5,087		2,119	
F-Test	121.70	***	304.31	***	105.18	***

Note: Coefficients with robust standard errors in parentheses are presented in the table.
*indicates 0.10 level of significance ** indicates 0.05 level of significance, *** indicates 0.01 level of significance

Finally, as a comparison of my results, I estimated a teacher fixed effects model using the full sample of observations of teachers and students. Table 2.9 reports the results using the observed AMSP participation on the full sample of teacher-student observations with teacher fixed effects. The results of that model indicate that the in-service training had positive results on teacher effectiveness for 11^{th} grade students but not middle or elementary level students.

Taken together, the results from this analysis suggest that the AMSP program targeted weaker teachers because weaker teachers are affiliated with weaker schools. Looking at similar teachers and contrasting those who participated with those that did not, the results suggest the program did have positive effects for the students of elementary and high school teachers. I am left with a puzzle. Why did content training increase effectiveness for these two levels but not middle school teachers? On surface, it seems that pre-service training in content subjects would have been more likely for middle and high school teachers than for elementary teachers. A next step would be to gather additional data on pre-service coursework or math aptitude for the teachers to see if there is some relationship to pre-service training and in-service training gains.

Concluding Comments

This paper addresses an important topic for an understudied and chronically underachieving group of students. Improving teacher quality in poor, rural schools is an important issue not just for schools in central Appalachia. Among the 10 states with the highest rates of poverty, 57 percent of the school districts and 36 percent of students are

Table 2.9: Student Achievement with Teacher Fixed Effects and Participation (Actual)

Independent Variables	Grade 5		Grade 8		Grade 11	
Math Rank Lagged	0.369	***	0.476	***	0.433	***
	(0.009)		(0.011)		(0.014)	
Science Rank Lagged	0.224	***	0.224	***	0.274	***
	(0.009)		(0.007)		(0.008)	
Reading Rank Lagged	0.255	***	0.193	***	0.099	***
	(0.010)		(0.009)		(0.009)	
Student Characteristics						
Free and Reduced Price (FRP)	-246.398	***	-189.319	***	-65.892	***
	(20.505)		(17.336)		(12.925)	
Female	-34.805	**	-54.798	***	-58.294	***
	(15.970)		(12.056)		(10.707)	
Asian	460.242	***	585.340	***	386.516	***
	(56.735)		(47.085)		(47.441)	
Black	-292.162	***	-318.763	***	-262.862	***
	(26.669)		(22.737)		(19.257)	
Hispanic	-124.199	***	-178.535	***	-233.661	***
	(44.060)		(39.607)		(46.011)	
Native American	240.467		-560.013	**	-478.218	**
	(264.506)		(229.273)		(201.035)	
Other	-39.374		115.547	**	-48.552	
	(73.328)		(58.733)		(61.238)	
School Characteristics						
Class Size	2.771	**	0.077		-1.085	
	(1.303)		(1.285)		(1.446)	
Average Experience	-7.759		-9.906		17.268	**
	(12.100)		(9.899)		(8.221)	
Enrollment	0.087		0.107	*	0.054	
	(0.089)		(0.056)		(0.045)	
Percent Master's	-0.631		2.485	**	-3.329	***
	(0.830)		(1.051)		(0.995)	
Percent of FRP Students	94.541		22.008		-218.719	***
	(646.107)		(64.384)		(62.105)	
Expenditure per Student	0.007		0.028	*	0.014	
	(0.015)		(0.015)		(0.019)	
Student-Teacher Ratio	-0.909		-16.678	*	-11.526	
	(10.129)		(9.607)		(7.151)	
Student-Computer Ratio	-3.483		5.498		-1.235	
	(9.163)		(6.954)		(4.442)	
Math Index	0.828		2.957	***	3.222	**
	(0.885)		(0.882)		(1.286)	
Teacher Characteristics						
Participation in AMSP PD	14.348		43.663		79.274	**
	(37.569)		(54.654)		(39.796)	
Highest Degree Obtained	-34.667		13.053		34.686	*
	(31.500)		(19.596)		(17.912)	
Experience 4-7 Years	-223.719	**	-117.065		93.877	***
	(105.393)		(73.497)		(41.389)	
Experience 8-12 Years	-197.157	**	-117.580		25.328	
	(98.298)		(82.189)		(50.653)	
Experience 13-17 Years	-332.487	***	-112.060		48.836	
	(124.566)		(99.183)		(62.116)	
Experience 18 Years and Higher	-435.132	***	-84.856		63.351	
	(144.455)		(99.015)		(72.064)	
N	22,861		27,952		18,009	
F-Test	478.93	***	942.55	***	542.60	***

Note: Coefficients with robust standard errors in parentheses are presented in the table.
*indicates 0.10 level of significance ** indicates 0.05 level of significance, *** indicates 0.01 level of significance

located in rural areas. The unique problems that these schools face in bridging the achievement gap, especially in terms of teacher quality, are worthy of study. Because many teachers attend college in the region in which they teach (Boyd et. al. 2005b), there is reason to believe that the pre-service training of many rural teachers may be weaker than that of their counterparts in more urban areas of the same states. A policy question is whether in-service training can compensate for the pre-service differences in training that may exist.

I argue that correctly evaluating an in-service program requires accounting for teacher selection into the professional development activities. By looking at the teacher's own past effectiveness, I find that this particular program, through targeting poor performing districts, succeeded in attracting the weakest teachers into the professional development activities. Significant effects from the professional development subsequently were found at both the elementary and high school levels. Why it did not succeed at the middle school level is an additional question to be addressed. This is the beginning of a research agenda to assess whether professional development can compensate for weak pre-service training. This paper does not provide the definitive answer but provides a road map for future evaluations. More research is necessary.

CHAPTER 3

REWARD OR PUNISHMENT? CLASS SIZE AND TEACHER QUALITY.

Introduction

A major focus in both education research and in education policy currently is on teacher quality. Recent research has emphasized the importance of quality teachers in explaining student achievement (Darling-Hammond 2000; Guarino, Santibanez, and Daley 2006; Rivkin, Hanushek, and Kain 2005; Rowan, Correnti, and Miller 2002; Sanders and Rivers 1996). This finding is so critical that it became one of the focal points for the No Child Left Behind legislation (NCLB) enacted in 2001 and continues to be a driver of the emphasis on data collection in the federal Race to the Top competition. Indeed, researchers, policymakers, and families appear not to question the common sense finding that teachers matter in student outcomes.

While most agree anecdotally that teachers matter, a challenge remains from a research perspective. Studies attempting to identify the characteristics of teachers that define "quality" are beset by mixed results.[33] While new teachers are generally identified as relative weak teachers, other characteristics are less straightforward (Clotfelter et al. 2007; Harris and Sass 2007).[34] Degree held by the teacher, salary earned, gender and ethnicity, and other measured characteristics seem to generate few consistent effects when measuring teacher effectiveness. Generally, evidence shows that teachers do have

[33] I assume teacher quality to be the impact teachers have on student outcomes.
[34] In this context, new teachers can be considered to be those with less than three to five years of experience.

differential effects on student learning but the task of explaining why some teachers perform better than others remains open.

The lack of measurable characteristics to define teacher quality has been viewed as an argument against teacher performance evaluations and differential compensation for teachers. The concern has been that subjectivity and bias on the part of principals and superintendents will mean that administrators' favorite teachers are rewarded and their disliked teachers will be penalized unfairly in such a schema. As a result, tenure and salary schedules remain an important part of teacher compensation packages and constrain the ability of the administrator to reward or punish differential performance.

This paper argues that schools, either through pressure from parents, or independent behavior of principals, *do* recognize that teachers are not equally effective. Indeed, I argue that current class size reflects past teacher performance. Using a unique data set of teachers matched to students over an eight year period, I can measure teacher effectiveness in terms of student performance. I then consider whether prior teacher effectiveness influences current class size. The results show that class size is influenced by prior teacher effectiveness, particularly in lower levels of schooling where there is greater substitutability between teachers based on content knowledge.

Class Size as a Policy Instrument

Before discussing the research concerning class size and its potential implications for policy, it is important to differentiate between class size and pupil-teacher ratios. While some may consider these two measurements to be similar, they are in fact quite different. Pupil-teacher ratios give a comprehensive view of the human resources committed to students' learning within a school. However, these expenditures may not be directly related to classroom interaction and may include teachers who spend time in administrative roles or other support positions (Ehrenberg et al. 2001). While class size does not give a sense of the overall level of resources committed to students, it does account for the most important resource, the teacher, and how the teacher's impact may be constrained by the number of students with whom they interact. In an effort to identify this relationship and how the number of students in a class may influence individual student performance, numerous studies have looked at class size.[35] The Tennessee STAR experiments are the most prominent of findings in this research area (Nye 2000; Finn, Gerber, Achilles, and Boyd-Zaharias 2001; Krueger 2003). Like the effects of other school resources such as expenditure per student and teacher salaries, the results are mixed, although significant reductions in class size do appear to increase student performance on standardized exams. For example, a reduction in class size of about ten students would lead to gains in student achievement comparable to what could be achieved through the improvement of teacher quality by one standard deviation (Nye, Hedges, & Konstantopoulos, 2001). These results are contingent upon the controlled environment of the Tennessee STAR experiment and would require a significant commitment of resources.

Therefore, because districts often cannot commit the resources necessary to affect student achievement through class size reductions, perhaps more important for research is to establish whether decision makers determine class sizes based upon other factors, particularly those associated with the teacher. Accordingly, for the purpose of this paper,

[35] See Hanushek 1997; Hanushek 1999; Krueger 1999.

I am not directly interested in whether class size influences student performance. Rather, I want to address whether class size is a policy instrument of principals and school administrators more generally. The remainder of this section of the paper provides a conceptual framework for thinking about class size as a reward and/or punishment variable for effective and ineffective teaching.

As stated above, virtually all stakeholders agree that teacher quality is an important input into the education production process. The importance of enhanced teacher quality has grown in recent years with federal and state laws that have increased school accountability. High stakes testing is now a significant part of the K-12 educational system (Airasian 1988; Dorn 1998; Bracey 2000). Given this environment, principals of schools face increased pressure to produce results and view teachers as a significant way to improve the school performance measures. Because principals face constraints such as tenure and salary schedules, they may have few alternatives in recognizing effective teaching other than how they choose to allocate students into teachers' classrooms. Therefore, I suggest that the inability of administrators to exit ineffective teachers, or compensate according to performance, leaves them with little recourse but how they choose to place students into teachers' classrooms. This allocation can be done based on many factors such as the ability of student and teacher, and/or class size. This paper will focus on class size.

From the perspective of an administrator of a school, class size is a policy instrument that can be used to reward or punish behavior and, ultimately, to potentially influence school performance. To be able to do this, the administrator must possess information that may not be readily available to researchers. Specifically, I assume the administrator can observe quality variance in teachers. This variance may be independent of measurable variables but it is known to the administrator. It may be signaled via parents, via students, via other teachers, or via direct classroom observations. The method of signaling quality variance is not critical. For the purpose of this argument, it is important that the administrator can judge the relative effectiveness of a teacher within the school.

Assuming teacher effectiveness can be observed, the administrator faces two choices. On the one hand, she can place more students in the classroom of the more effective teachers. If increasing class size, in turn, reduces a teacher's marginal effectiveness, the administrator will have an incentive to increase class sizes of the relative effective teachers to the point that at the margin, a reduction in the class size of the ineffective teachers increases their marginal effectiveness. In other words, administrators have an incentive to change class size so that marginal effectiveness is equated across teachers. If there were no class size effects on teacher effectiveness and there were no binding budget or regulatory constraints, administrators would have an incentive to increase class sizes of effective teachers and reduce class sizes of ineffective teachers so that ultimately, the least effective teachers would not teach.

On the other hand, administrators may also wish to use class size as a source of compensation for teachers. Because salary schedules are typically fixed and tied to degree and experience, reducing class size may be one of the ways in which administrators can reward the more effective teachers. Under this scenario, I should observe smaller classes for the most effective teachers and larger class sizes for the least effective teachers.

A priori, it is not clear which of the above incentives is stronger from an administrator’s perspective or whether they balance one another so that there is no relationship at all between current class size and past teacher effectiveness. The next section of the paper presents an empirical framework for testing the potential relationship.

Empirical Framework for Estimating Teacher Effectiveness

If one wishes to assess whether administrators are determining class sizes based upon a teacher's effectiveness, it is essential to define and measure what is meant by effective teaching.[36] However, accomplishing this task empirically has proven quite challenging. As mentioned previously, the findings on the effects of measureable teacher characteristics on student achievement have shown mixed results. One potential explanation is that most of the divergent findings on measureable characteristics stem from the differences in empirical methods that have been employed, and especially how researchers correct for possible bias and selection issues between students, teachers and schools. Early studies suffered from a failure to account for neighborhood selection effects and how they might affect school and teacher covariates. As a result, these studies suggest that teachers and schools matter very little. Factors such as teacher experience, educational attainment and salary were found to have no statistically significant relationship with student outcomes.

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[36] Although I understand that there are many ways to define teaching effectiveness, I assume for the purpose of this paper that effective teaching is the ability to influence student test scores.

Researchers have attempted to correct for potential confoundedness between students and their teachers and schools by using value added models. These studies use prior achievement to account for family factors which may influence student achievement. Although the methodology is similar between these studies, the findings on teacher characteristics and their relation to student achievement have shown varied results (Murnane and Phillips 1981; Goldhaber and Brewer 2000; Clotfelter et al. 2007; Harris and Sass 2007; Boyd et al. 2009). Perhaps the only consistent finding is that teacher experience matters in the first few years of teaching. These teachers have a negative effect on their students' achievement as compared to those teachers that have at least three years of experience, all else equal. However, some research has found that the negative effects of new teachers can be offset by the quality of undergraduate field work. Studies assessing the further effects of a teacher's undergraduate experience and the effect of additional education such as a Master's degree have failed to establish any consistent relationship with student outcomes.

The inability to establish causal relationships between teachers and their students' outcomes goes against conventionally held societal beliefs. There are two potential factors that could cause these findings. The first is that teachers have no systematic impact on student achievement. The second is that measured and compensated characteristics do not capture teacher quality. Assuming that the latter is true, I am left to account for teacher impacts based on unobserved or unmeasured characteristics. Methodologically I am attempting to estimate the deviations from mean student achievement by teacher over time while accounting for all other factors I believe impact student outcomes. I expect that the variation in these deviations is not random between teachers, but rather fixed on their unobservable characteristics. These fixed effects are then attributed to the teacher as a measure of effectiveness. Many studies have established that these fixed effects are significant and can explain anywhere from 7% to 21% of the variation in student outcomes (Rivkin, et al., 2005). In this way, the research has established that teachers matter, but not how they matter.

The teacher fixed effect accounts for the average impact of unobservable fixed teacher characteristics on student achievement over time. For example, I assume that a teacher with a high level of motivation, which is unobserved, will have a larger positive impact on her students' achievement than a teacher with a lower level of motivation. However, I suspect that context matters for these fixed effects. Indeed, recent evidence finds that teacher fixed effects are more pronounced in smaller classes with low achievers (Konstantopoulos and Sun 2010). Consider again the teacher with a high level of motivation. I suggest that the impact of this unobserved characteristic will function differently, all else equal, in a class of 5 students as opposed to a class of 40 students. If I assume that class size is randomly determined, this assertion does not matter. However, I am explicitly assuming that class size may be related to past teaching effectiveness. If there is indeed a relationship between past effectiveness and current class size, an empirical model which uses the entire panel to generate the fixed effects would be subject to selection bias. In other words, class size would be endogenous to teacher effectiveness. To account for this change in context and the potential endogeneity between teaching effectiveness and class size, I cannot use current or future teacher effectiveness estimates. Instead, I use the panel for the years prior to the current year to generate a teacher effectiveness measure. Therefore, if I want to predict class size in year t, I use the panel from year 1 to year t-1 to generate teacher fixed effects.[37] In order to generate reliable measures of the iterated fixed effect, I use the first three years of data to estimate the first iteration, and then add an additional year for each subsequent iteration.

Data

The remainder of this paper will provide an analysis of teacher fixed effects and their relation to class size using individual student-teacher level observations from ten Kentucky school districts for the school years 2000-2001 through 2007-2008.[38] Because Kentucky lacks a system that allows students to be matched to their teachers over time, roster data was obtained directly from the school districts which are located in central and eastern Kentucky.[39] The roster data include the school year, the name and section of the math course, the teacher for that section, and all students enrolled in that section. The ability to match students to teachers varies by district over the sample period as some districts retained data for longer periods. Therefore, the data set is a mixed panel. The roster files were then matched to several state-level administrative data bases. Because Kentucky does not use common identifiers for students and teachers, much of the matching required name and birth date or other person-specific characteristics. Included in these data bases are student characteristics and testing data, teacher characteristics and credentials, as well as school level data. The matched data set used for the following analysis allows observations of each student who tested in math in a given year for which I can identify the teacher who taught his or her math class. Table 3.2 provides descriptive statistics for students, teachers and schools in the ten districts used for the analysis. The

[37] I will refer to this measure as an iterated fixed effect.
[38] The data were compiled as part of an evaluation project sponsored by NSF.
[39] Table 3.1 provides data for the districts used in this analysis.

Table 3.1: District Locale, Total Students and Number of Schools by Type of School

District	Urban-Centric Locale	Total Students 2007-2008	Primary Schools	Middle Schools	High Schools	Other Schools
Kentucky1	Rural: Distant	1,234	3	1	1	0
Kentucky2	Rural: Distant	3,119	6	2	2	0
Kentucky3	Rural: Fringe	2,196	3	1	1	0
Kentucky4	City: Large	24,134	35	12	5	3
Kentucky5	Town: Distant	2,399	3	1	1	0
Kentucky6	Town: Distant	1,606	3	1	1	0
Kentucky7	Rural: Remote	1,133	4	1	1	0
Kentucky8	Rural: Remote	2,105	6	1	1	0
Kentucky9	Rural: Distant	9,743	17	4	5	2
Kentucky10	Suburb: Mid	663	1	2	1	0
Total		48,332	81	26	19	5

Kentucky 2: missing vocational high school
Kentucky 3: missing one primary school one year, school switched to PK and K.
Kentucky 4: there are additional vocational and alternative schools for which I did not receive data.
Kentucky 5: missing 2001-2002 data for all primary schools.
Kentucky 9: name/location change 15 elementary schools over all years; name/location change 3 schools over all years
Kentucky 8: missing 2003 data for middle schools
Kentucky 10: primary available 2006-2008; middle school available 2004-2007; high school available 2004-2005, 2007-2008

statistics vary by year, therefore Table 3.2 presents the school year 2004-2005 as a representative year.

Beyond the logistical issues associated with data collection, the use of the Kentucky data also required reconciliation of multiple testing instruments because testing in Kentucky has undergone significant changes within the sample years of the data. From the 2000-2001 to the 2005-2006 school years, the state math test covered grades 5,

Table 3.2: Descriptive Statistics for a selective sample in 2005 for grades 5, 8, and 11

Variable	Observations	Mean	Standard Deviation	Minimum	Maximum
Free and Reduced Price Lunch	11,929	0.46	0.50	0	1
Female	11,695	0.48	0.50	0	1
Asian	11,715	0.02	0.12	0	1
Black	11,715	0.10	0.30	0	1
Hispanic	11,715	0.02	0.15	0	1
Native American	11,715	<0.00	0.01	0	1
Other	11,715	0.01	0.09	0	1
Avg. Experience (School)	11,929	12.30	2.10	5.3	17.7
Enrollment	11,929	681.94	423.17	80	2,062
Percent Masters' Degree	11,929	76.09	11.26	35	100
Percent Free and Reduced	11,929	0.51	0.212	0	.97
Expenditure per Student	11,929	5,708.21	1,208.24	3,908	12,837
Student Teacher Ratio	11,929	15.15	2.38	8	22
Student Computer Ratio	11,929	4.01	1.28	1.6	7.6
Math Index	11,929	71.52	12.35	41.97	112.69
Experience	11,929	12.085	8.973	0	34
Experience Squared	11,929	226.552	269.009	0	1,156
Highest Degree[1]	11,929	3.083	1.301	1	7

1 – Highest degree coded as follows: 1=Bachelor's, 2=5th year, 3=Planned 6th year, 4=Master's, 5=Rank I, 6=Specialist, 7=Doctorate

8, and 11. Nationally standardized tests (the CTBS) were also administered in math to students in grades 3, 6, and 9 over the same years. Most recently, in 2007 the state administered the state test in grades 3 through 9 and grade 11, and changed the test so that the scale of score in years prior cannot reliably be reconciled with those of 2007 and onward.[40] In addition, each grade level test involves scores with different scales. For example, a 500 on a math test of a 5th grader was not designed to be equivalent to a 500 on the math test of an 8th grader. Changes in the testing intervals and scales were also present in the state reading and science tests. From 2000-2001 through 2005-2006 the state reading test was administered in grades 4,7, and 10, and the state science test was administered in grades 4,7, and 11. Beginning in 2006-2007, the reading test was

[40] This conclusion has been affirmed by officials of the Kentucky Department of Education.

administered in grades 3 through 8 and in grade 10. Like the math test, the scales of the reading and science exams also changed in 2006-2007 so that scores cannot be reconciled. I use the reading and science tests as controls for prior achievement. [41]

Given the changing scale of the test score data over the time period I observe, the use of standardized test scores as variables (as in a standard value-added model) is somewhat problematic for estimating the effectiveness of teachers and its subsequent relationship with class size. Ballou (2009) summarizes the many issues associated with scaling and the use of standardized test scores. Because changing scales make increases and decreases in scores difficult to interpret, I do not use the scores as the dependent variable. Instead, to mitigate the test score issues, I convert the Kentucky standardized exam scores to ranks. Ranks are well defined for any scale and comparable as long as the tests have validity for the same ability measure—math, science, or reading, in the present case. Students' ranks on scores have been used recently by Arcidiacono (2004; 2005) and Betebenner (2009), and they have an advantage over test scores (raw or scaled) in that no attempt is made to compare the meaning of a unit change in score. The rankings, on the other hand, imply that I cannot link teacher effectiveness to a quantitative measure of student learning by using units of change in test scores.

Because I use ranks from the standardized exams rather than the scores, it is useful to discuss the rank data a bit further. I rank students on their performance on the

[41] I use all prior test scores on math, science, and reading because of the interval timing of these tests in Kentucky. Note that the lagged test score could be one to two years earlier depending on the subject tested. Of great interest, the correlation coefficients on student ranks are remarkably similar across the 3 subject areas. For example, 8th grade math ranks across the panel have a correlation coefficient of 0.56 with the prior math test, 0.54 with the most recent reading exam, and 0.58 with the lagged science exam. Recall, that through 2006, math was tested in grades 5, 8, and 11. After 2006, the test is annual. See McCafferty et. al. (2003) for discussion of the usage of multiple subject area tests.

state tests in math, science, and reading although I am using only the first one as a dependent variable. The summary statistics for rank are not useful, because ranks (in descending order in this example) are fixed numbers from n, the total number of students taking the test in that grade level each year, down to 1. To compute the ranks, I grouped all students taking a particular grade-relevant exam per year.[42] For example, all students in the sample who participated in the math exam in the eighth grade for school year 2006-07 were ranked together. I did not cross subject exam, grade levels, or years in ranking the students.[43]

Model and Results

Before discussing the model and results, I address the technical aspects of the estimation of class size which motivated the empirical methods used. Conceptually, I expect that class size can be influenced by three main factors, average in-class characteristics of the students, school characteristics and teacher characteristics, and can be estimated by the following equation:

$$(1) \quad C_i = \beta_0 + \beta_1 \overline{P}_i + \beta_2 S_{ik} + \beta_3 T_{ij} + \beta_4 E_{ij} + u_i$$

where C is the number of students in class i and the $\beta_i's$ are the estimated coefficients. $\overline{P}$ is a vector of the average student characteristics of class i. S describes a vector of the characteristics of the school for which class i is located. A vector of characteristics of the

[42] Ranking was conducted using the mean rank method where the mean of the sample is equal to (n+1)/2. This method assigns the same average rank to students with the same score. For example, if three students have the same score and account for the 2nd, 3rd and 4th to last ranks, they would each be given the average rank of 3.
[43] I also transformed the scaled scores into z-scores by subject and cohort. The results of the following analysis of class size using z-scores are presented in Appendix B.

teacher for class i is represented by T, and that teacher's past effectiveness is accounted for by E. While most of the explanatory variables are easily accounted for, controlling for teacher effectiveness presents some difficulty. As mentioned previously, typically measured teacher characteristics are generally found to be unrelated to effective teaching. Accordingly, to generate such a measure, a student achievement model using teacher fixed effects was estimated.

Using the individually matched student-teacher level data, student achievement was estimated in order to generate the teacher fixed effects. The model is as follows:

(2) $R_{it} = \beta_0 + \beta_1 R_{it-1} + \beta_2 P_{it} + \beta_3 T_{ijt} + \beta_4 S_{it} + \theta_j + c_j + u_{it}$

where R is the relative ranking of student i within the sample of students in the same grade that took the standardized math exam in year t and the $\beta_i's$ are the estimated coefficients. The rankings are a function of the same student's rankings on the most recent prior test in math as well as reading and science. If the most recent test was a nationally standardized math test (CTBS) rather than the state test, I used ranks on that test as a control variable. A vector of variables P, describes the characteristics of student i in year t. T is a vector of student i's math teacher's experience and degree in year t. S is a vector of school characteristics for student i in year t for which the student-teacher combination is observed. The term, $\theta j,$ represents a teacher fixed effect for teacher j, c_j is the teacher-clustered error term, and u_{it} is the idiosyncratic error.

Estimation of equation (2) yields a predicted ranking, $\hat{R}_{it}$ for each student that is based on that student's own demographics, past test performance, the student's teacher, and his or her school attended. To develop a measure of teacher effectiveness, I estimated this equation for each school year 2003 through 2008.[44] In the estimation, the current year as well as all preceding years are included to generate an estimate of the predicted student rank and, for my purpose, a teacher fixed effect. For example, in year t, the estimated fixed effect for a given teacher j is the average effect of the unobservable characteristics of teacher j from 2000-01 through year t. This measure of teacher effectiveness is then used to predict class size in year t+1.

Consistent with the theory that actors within the school may be adjusting class sizes according to variation of within school teaching effectiveness, equation (1) was re-specified as a school fixed effects model. This also allows me to account for potential heterogeneity in the pooled-OLS model as it is likely that the error term is correlated with the regressors. The model is as follows:[45]

$$(3) \quad C_{it} = \beta_0 + \beta_1 \overline{P}_{it} + \beta_2 S_{ikt} + \beta_3 T_{ijt} + \beta_4 E_{ijt-1} + \theta_k + c_k + u_{it}$$

where C is the number of students in class i in year t. $\overline{P}$ is a vector of the average student characteristics for class i in year t. S is a vector of time varying school characteristics for year t for which the class is located. Teacher characteristics for class i year t are represented by the vector T. Past teacher effectiveness for teacher j in class i year t-1 which was generated from equation (2) is denoted by E. θ_k represents the school fixed effect for school k, c_k is the school-clustered error term, and u_{it} is the idiosyncratic error.

[44] I use the first three years of data to generate reliable estimates of teacher effectiveness.
[45] Recall that those responding to teacher effectiveness through class size can include administrators, parents or students.

Given the theoretical importance of teacher effectiveness for the specification of equations (1) and (3) I will first discuss the results from equation (2), the estimation of student rankings with teacher fixed effects.[46] Consistent with those factors which influence student achievement, I include variables within the categories of student, school and teacher.[47] Considering first student level characteristics, one can see in Table 3.3 that, consistent with the findings in the literature, the previous achievement of a student in all subjects is highly predictive of current achievement in math in all grade levels. The sign is consistent with what one would expect. If a student performs relatively worse on a previous test as compared to his peers, he can expect to have a worse ranking in the current period. Students that have a lower socioeconomic family status, as indicated by whether or not they are eligible for free and reduced price lunch, have a worse ranking on the math exam than their peers. This relationship is consistent across all grade levels, although its magnitude diminishes as grade level increases. In all grades, females have a lower expected ranking than their male counterparts. In all grade levels, Asian students perform significantly better than White students, while Black and Hispanic students perform worse. Native American students perform worse relative to white students in 8th and 11th grade, while students with an ethnicity designated as other perform worse in 8th grade.

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[46] Note that the ranking of student performance is in descending order with one being the worst.
[47] Equation 2 was estimated for each panel group from the base year 2000-2001 to 200x-200x+1 where x = (3, 4, 5, 6, 7) to generate the iterated fixed effects. Table 3 displays the results from the entire panel, 2000-01 to 2007-2008.

Table 3.3: Student Achievement with Teacher Fixed Effects (00-08)

Independent Variables	Grade 5		Grade 8		Grade 11	
Math Rank Lagged	0.369	***	0.476	***	0.433	***
	(0.009)		(0.011)		(0.014)	
Science Rank Lagged	0.224	***	0.224	***	0.274	***
	(0.009)		(0.007)		(0.008)	
Reading Rank Lagged	0.255	***	0.193	***	0.099	***
	(0.010)		(0.009)		(0.009)	
Student Characteristics						
Free and Reduced Price (FRP) Lunch	-246.370	***	-188.627	***	-65.668	***
	(20.510)		(17.516)		(13.003)	
Female	-34.783	**	-54.732	***	-58.272	***
	(15.957)		(12.029)		(10,737)	
Asian	460.173	***	586.069	***	386.307	***
	(56.740)		(47.091)		(47.426)	
Black	-292.138	***	-318.987	***	-263.128	***
	(26.667)		(22.748)		(19.276)	
Hispanic	-124.143	***	-178.853	***	-233.565	***
	(44.062)		(39.535)		(45.952)	
Native American	239.453		-558.093	**	-477.576	**
	(264.329)		(228.737)		(200.553)	
Other	-39.347		115.232	**	-48.399	
	(73.329)		(58.761)		(61.212)	
School Characteristics						
Class Size	2.794	**	0.221		-1.243	
	(1.327)		(1.298)		(1.426)	
Average Experience	-7.567		-10.725		16.886	**
	(12.236)		(9.957)		(8.422)	
Enrollment	0.086		0.102	*	0.047	
	(0.89)		(0.056)		(0.044)	
Percent Master's	-0.657		2.347	**	-3.478	***
	(0.820)		(1.034)		(0.994)	
Percent of FRP Students	92.872		8.342		-237.259	
	(63.310)		(62.673)		(59.490)	
Expenditure per Student	0.006		0.029	*	0.014	
	(0.015)		(0.015)		(0.020)	
Student-Teacher Ratio	-0.792		-15.621	*	-10.018	
	(10.123)		(9.422)		(6.855)	
Student-Computer Ratio	-3.466		6.842		-1.284	
	(9.185)		(7.257)		(4.528)	
Math Index	0.829		2.904	***	3.150	**
	(0.883)		(0.875)		(1.278)	
Teacher Characteristics						
Highest Degree Obtained	-35.181		14.578		34.481	*
	(31.330)		(21.546)		(18.059)	
Experience 4-7 Years	-223.132	**	-110.904		96.746	**
	(105.680)		(72.339)		(42.324)	
Experience 8-12 Years	-196.710	**	-112.714		33.986	
	(98.659)		(81.555)		(53.861)	
Experience 13-17 Years	-332.442	***	-96.951		63.302	
	(124.589)		(99.846)		(64.209)	
Experience 18 Years and Higher	-436.147	***	-70.630		74.983	
	(144.120)		(100.205)		(73.347)	
N	22,859		27,952		18,009	
F-Test	481.99	***	977.68	***	545.29	***

Note: Coefficients with robust standard errors in parentheses are presented in the table.
*indicates 0.10 level of significance ** indicates 0.05 level of significance, *** indicates 0.01 level of significance

Certain school level characteristics are also important in explaining current student performance. A school's math index is positively associated with student achievement in the 8th and 11th grade. Class size and the average experience level of teachers in the school have a statistically significant impact on student achievement in the 5th and 11th grade respectively. School enrollment is statistically significant in the 8th grade and suggests that students in larger schools perform better than students in schools with lower enrollments. The percentage of teachers that hold a master's degree has an unfavorable impact on student achievement in 11th grade, but has a favorable impact in 8th grade. Students who attend schools with higher percentages of FRP students do not have statistically different achievement than their counterparts. Expenditure per student is only statistically significant in the 8th, implying that higher expenditures lead to better student performance. Student-teacher ratio is statistically significant in the 8th grade, suggesting that increased ratios are associated with worse performance. Student-computer ratios do not have a statistically significant influence on student achievement at any grade level.

For the purpose of this paper, the primary intention of estimating this equation was to generate the teacher fixed effects.[48] First note that the observable teacher characteristics, experience and highest degree obtained, are unrelated to student achievement in all grade levels. The teacher fixed effects, however, explain a significant portion of the variance in student achievement. The fixed effects explain a low of 32

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[48] The summary statistics for the fixed effects vary by iteration. They are reported in Table 2 for the entire panel. A teacher with a positive fixed effect has a favorable influence on their students by improving their relative ranking.

Table 3.4: Predicted Class Size (pooled-OLS)

Independent Variables	Coefficients (robust std. errors) Grade 5	Coefficients (robust std. errors) Grade 8	Coefficients (robust std. errors) Grade 11
Teacher Characteristics			
Past Effectiveness	0.0003 (0.0003)	0.0021*** (0.0008)	0.0017** (0.0008)
Experience	-0.0132 (0.0264)	0.0765* (0.0408)	-0.0018 (0.0292)
Highest Degree Obtained	-0.2318 (0.2067)	0.5119** (0.2440)	0.5391* (0.2836)
Classroom Characteristics			
Math rank lag	-0.0016 (0.0010)	0.0013 (0.0013)	0.0012 (0.0012)
Science rank lag	-0.0002 (0.0009)	-0.0017* (0.0010)	-0.0002 (0.0012)
Reading rank lag	0.0006 (0.0009)	-0.0010 (0.0014)	-0.0009 (0.0008)
Free and Reduced Price (FRP)Lunch	3.855* (2.047)	-2.070 (1.971)	-4.186* (2.306)
Asian	-1.838 (4.510)	17.155 (19.020)	-8.613 (6.583)
Black	-0.6768 (1.954)	-7.957** (3.472)	-13.036*** (2.977)
Hispanic	-11.673*** (3.558)	-0.9724 (7.690)	33.377** (16.517)
Native American	2.996 (25.041)	400.830*** (75.420)	171.800 (114.808)
Other	-4.245 (6.539)	-2.292 (13.673)	5.674 (17.910)
School Characteristics			
Expenditure per student	-0.0003*** (0.0001)	-0.0011*** (0.0002)	-0.0004 (0.0004)
Student-Teacher Ratio	-0.1456** (0.0640)	0.4770*** (0.1171)	0.1131 (0.1092)
Math Index Lag	0.0185 (0.0139)	0.0277 (0.0264)	0.0712*** (0.0258)
Appalachia	4.268*** (1.383)	5.451*** (1.913)	1.911 (1.749)
N	937	633	735
R-Squared	0.0513	0.1406	0.1062

*indicates 0.10 level of significance, **indicates 0.05 level of significance, *** indicates 0.01 level of significance

percent of the variation in 8th grade, 34 percent of the variation in 5th grade and a high of 43 percent in 11th grade. These results are consistent with the findings of Rivkin, Hanushek, and Kain (2005), and supported by others, that teachers matter in ways that are not always observable.

Using the measure of past effectiveness generated from the fixed effects model, the two class size models were then estimated. I present first, in Table 3.4, the results of class size predicted from the pooled-OLS model.[49] In interpreting these results, it is important to consider that this specification accounts for both across and within school variation. The variable of greatest interest is the lagged fixed effect, or past teacher effectiveness. In both 8th and 11th grade there is a statistically significant relationship between class size and past teacher effectiveness. More effective teaching in prior periods is associated with larger current class size, although the magnitude is small.[50] More specifically, a teacher that performs one standard deviation better than the average teacher can expect to have approximately one more student in her classroom. More experienced teachers have larger classrooms in 8th grade, while teachers with better credentials have larger classrooms in grades 8 and 11. The average number of eligible FRP students has a positive impact on class size in 5th grade but a negative impact on class size in grade 11. The average number of Black students is associated with smaller classes in grades 8 and 11. Greater percentages of Hispanic students in a class are associated with smaller classes in grade 5, but larger classes in grade 11 and higher Native American percentages are positively related to class size in grade 8. Expenditure per student is negatively related to class size in 5th and 8th grade. Student-teacher ratios are significant and negatively related to class size in 5th grade, significant and positively related to class size in 8th grade, and unrelated to class size in 11th grade. This is consistent with the notion that the two measures are conceptually different from one another as asserted earlier in the paper. The lagged performance of the school as

[49] The classroom characteristics are averages.
[50] Recall again that ranks are in descending order with one being worse-performing.

measured by their math index is significant at the high school level and suggests that schools that have better performance last year have larger classes this year. Finally, schools in Appalachia have larger classes in the 5th and 8th grades.

Although these results are suggestive, the pooled-OLS accounts for both across and within school variation. Therefore, it is important to note that they may be sensitive to the specification of the model. The results of the estimation for class size in the school fixed effects model present a somewhat different picture than those of the pooled-OLS, as this specification accounts for only the within school variation. Though this is not surprising, and is consistent with my theory that because of tenure and salary constraints within the school, all else equal, administrators determine class size according to within school variation in past teaching effectiveness.

The results of the school fixed effects estimation of class size are presented in Table 3.5. The variable of interest, past teaching effectiveness, is statistically significant in the 5th and 8th grades. The signs of the two coefficients indicate that teachers who had a positive impact on their past students' performance, in terms of improving their relative ranking, have larger class sizes in the current year. The only other significant teacher level characteristic is highest degree for 8th grade teachers, indicating that teachers with higher credentials have more students. The average classroom characteristics related to class size are the lagged reading rank, free and reduced price lunch percentage and the percentage of Native American students. In grade 8, on average, classes with better reading performance as measured by their past reading rank, have larger classes. In grades 8 and 11, classes with a higher percentage of free and reduced price lunch students are smaller. Also in grades 8 and 11, classes with higher

Table 3.5: Predicted Class Size (School Fixed Effects)

	Coefficients (robust std. errors)	Coefficients (robust std. errors)	Coefficients (robust std. errors)
Independent Variables	**Grade 5**	**Grade 8**	**Grade 11**
Teacher Characteristics			
Past Effectiveness	0.0008**	0.0015**	-0.0012
	(0.0003)	(0.0006)	(0.0012)
Experience	-0.0239	0.0464	-0.0184
	(0.0256)	(0.0409)	(0.0298)
Highest Degree Obtained	-0.0567	0.5610**	0.5384
	(0.1840)	(0.2544)	(0.4879)
Classroom Characteristics			
Math rank lag	-0.0016	0.0020	-0.0001
	(0.0010)	(0.0015)	(0.0013)
Science rank lag	0.0003	-0.0011	0.0002
	(0.0007)	(0.0014)	(0.0014)
Reading rank lag	-0.0003	-0.0028**	-0.0006
	(0.0008)	(0.0013)	(0.0007)
Free and Reduced Price	-1.528	-9.210*	-5.489*
(FRP)Lunch	(2.923)	(5.293)	(3.139)
Asian	1.286	22.415	-8.054
	(5.538)	(26.084)	(9.796)
Black	4.901	3.727	-6.053
	(3.189)	(7.697)	(4.230)
Hispanic	-4.337	5.642	39.544
	(4.779)	(11.597)	(26.783)
Native American	16.188	298.240***	142.189*
	(24.986)	(106.953)	(72.199)
Other	-3.527	7.669	15.693
	(8.761)	(14.347)	(23.495)
School Characteristics			
Expenditure per student	-0.0004***	-0.0001	0.0002
	(0.0001)	(0.0003)	(0.0005)
Student-Teacher Ratio	0.1631	0.0649	-0.0925
	(0.1062)	(0.1564)	(0.1622)
Math Index Lag	0.0449*	-0.0235	-0.0132
	(0.0237)	(0.0435)	(0.0371)
N	937	633	735
R-Squared	0.0589	0.1216	0.0837
Fraction of Variance	0.733	0.417	0.169

*indicates 0.10 level of significance, **indicates 0.05 level of significance, *** indicates 0.01 level of significance

percentages of Native American students are larger. Finally, expenditure per student and past school math performance are significant in the 5th grade. At this level, higher school per student expenditure in the current year than other years, on average, is related to smaller classes. These schools also have smaller classes if they performed relatively worse in the previous year than other years.

Because the effects of past teaching effectiveness on class size change somewhat depending on how the model is specified, it is helpful to offer a potential explanation for why I may expect to see this. The remaining part of this section presents a conceptual hypothesis of how an administrator may face additional constraints which may prevent her from determining class sizes based upon past teaching effectiveness due to a lack of alternative teachers. Certainly I am concerned with past effectiveness, but teachers also provide content specific knowledge or field expertise. So for simplicity, I can assume that teacher demand, measured by their class size, can be defined by how effective they are in the classroom, as measured by their ability to influence student outcomes, and the content knowledge demands of their area of expertise. For example, in 11th grade there is a relationship between past teacher effectiveness and current class size across the sample in the OLS model, suggesting that teachers who are better than the average teacher in the sample have classes with more students. However, it is not clear whether or not this is due to overall teacher quality and curriculum differences between schools. In other words, this may be reflective of a distributional effect as some schools may have better teachers on average as well as higher demand for the classes they teach. Consider the results of the school fixed effects model for grade 11. Past effectiveness is no longer significant in explaining the variation in class size within the school. This may be due to the fact that as grade level increases so too does the rigor of the curriculum and the level of content knowledge needed by the teacher. Accordingly, there may be only one teacher qualified to teach a certain subject. In this respect, it may be that the area of expertise and the number of students taking the course dominate the consideration of past teaching effectiveness.

Conversely, the results for the grade 5 models suggest that past effectiveness may be more important than content expertise in elementary school. Consider first the results from the OLS estimation. Class size is unrelated to past effectiveness. Once again, it is not clear that this is due to an absence of a relationship between past teacher effectiveness and class size, or simply reflective of the distribution of effective teachers across schools. What is perhaps more illuminating is that there is a significant relationship to within school differences in past teaching effectiveness and class size. In the school fixed effects model, a teacher that is more effective than her colleagues within the school has a larger class, although the magnitude is small. It can be argued that the content knowledge or expertise demands for an elementary teacher are less than that of their high school counterparts. Therefore, all teachers are qualified to teach the curriculum and there is a greater opportunity for substitutability between teachers based on past effectiveness thereby generating the significant relationship between past effectiveness and class size in the fixed effects model. These inferences are strengthened by the results of the class size estimations for grade 8. One could argue that the content knowledge demands for these teachers are greater than that of their elementary counterparts but less than that of their high school counterparts. As such there may be both distributional effects as well as within school effects between past effectiveness and class size. Similar to the results from the grade 11 OLS model, there may be teacher effectiveness and curriculum distributional differences across schools. However, the school fixed effects model suggests that there is a within school relationship between past effectiveness and class size. This suggests that at the middle school level, content knowledge is important, but it is not as exclusive and there may still be an opportunity for administrators to substitute one teacher for another based on differences in past effectiveness.

Consider finally the differences in the fraction of variance of the error term due to the fixed effect. The large percentage at the elementary level suggests that there is more that schools can do at this level to affect class size. However this ability diminishes as grade level increases so that by grade 11 the ability of schools to affect class size becomes minimal. Therefore, schools may be able to do less at the margin as school level increases. Although I cannot definitively conclude that my hypothesis is supported through the findings in this paper, the results are suggestive and provide an opportunity for future research.

Conclusions and Implications

School administrators are accountable for numerous tasks. Arguably, the most significant of these is how their schools perform. If we believe that teachers are the most important school level resource affecting this performance, then how the administrator manages this resource is critical. However, the ability of the administrator to reward or punish differential performance is limited due to tenure and salary schedule constraints. Therefore, they have an incentive to employ methods which can work under the current system. One possible strategy is the use of class size.

While there has been significant scholarly effort focusing on the effects of class size, to my knowledge there has been no research evaluating how class size can be used as an instrument of the school in recognizing teacher performance. At the outset of this paper I suggested that a priori it is not clear if class size is used as a tool to try to equalize the marginal impacts of teachers, a tool to reward teaching effectiveness or unrelated to teacher performance. The results indicate that schools, whether it be through administrators, parents, other teachers and/or students, do recognize variations in teacher performance and overall, classrooms of the more effective teachers are larger.

While this paper examined the choice of class size by the administrator, one possible extension of this research is to explore the possibility of a subsequent response by more effective teachers in the long run. Allgood and Rice (2002) found evidence that turnover rates are higher in lower income, lower achieving schools, and as Figlio (1997) finds, higher quality teachers tend to command higher salaries that affluent districts are more willing to pay. Although much needs to be done, one possible explanation is that the larger class sizes of more effective teachers in lower performing schools coupled with lower compensation may motivate exit, particularly if they can command higher salaries in other schools with teachers of similar quality.

Finally, I offer a conceptual hypothesis for the somewhat different findings of the two models used to predict class size. Conceptually, the notion of substitutability between teachers provides an alternative way to define teacher quality. At the beginning of this paper I explicitly assumed that teacher quality is defined as the impact a teacher has on student outcomes. It may be that along with this impact, the content knowledge of the teacher could also be considered. Indeed, if the content knowledge of the teacher is unmatched within the school, this should be considered as a part of the quality of the teacher. However, I cannot definitively state that this is the case, nevertheless this provides an interesting avenue for research concerning the various constraints that school administrators face and how those constraints influence their choices.

CHAPTER 4

CONTINGENCY FUNDS IN KENTUCKY: ARE SCHOOLS RESPONDING TO BUDGET UNCERTAINTY?

Introduction

Academic research focused on school finance has been primarily concerned with two issues; the effect of school resources on student achievement and the equity of access to those resources across school districts. Nestled within these two broad literatures is the role of the budgeting process. Much has been said about equity and how districts choose to expend their budgets. However, research has had little to say about how districts choose *not* to expend their budgets. More formally, why do some districts choose to save money in contingency or "rainy day" funds? If they do save money, how do they determine the fund level? Is it a function of the characteristics of their students and sponsors, or a function of the preferences of the superintendent or principal? Finally, is this efficient in the sense that it makes these school districts better able to accomplish the various wants of their sponsors over time?[51] While educational contingency funds have been a topic in the popular press, the academic literature has yet to analyze them. The focus of this analysis will address only the influencing factors of contingency funds, although it is also the intention of this research to begin a discourse on a topic that has far reaching school finance implications and many unanswered questions.

[51] In this case, sponsors are the state, parents, and general public.

Contingency Funds in Education

Much of the literature pertaining to contingency or rainy day funds in the public sector evaluates their role at the state level (Pollock & Suyderhoud, 1986; Joyce, 2001; Cornia &Nelson, 2003).[52] This research has been primarily concerned with estimating the optimal size of contingency funds for which the explicit function is managing revenue shortfalls during economic downturns.[53] Contingency funds provide needed flexibility in the budgeting process because often times revenue shortfalls are not discovered until well after the fiscal year begins and because all but one state, either by constitutional or statutory requirement, must have revenues that meet or exceed expenditures.[54] Rather than using politically unpopular and administratively costly tax increases or expenditure cuts, contingency funds provide an alternate means of addressing budgetary shortfalls. Contingency funds represent sacrificed expenditure during periods of economic growth or stability and may themselves be unpopular if citizens feel their tax burdens are too high and/or services are under provided. However, it is likely that short run adjustments using contingency funds are less costly politically than raising taxes. Given these considerations, research has found that the optimal level of state contingency funds depends uniquely on the state in question and their respective revenue and expenditure variability, suggesting that it is necessary for each state to determine their optimal contingency level independently. More specifically, states that have higher budget

[52] All but four states, Alabama, Arkansas, Montana, and Oregon have state contingency funds.
[53] The literature considers the optimal size of contingency funds as a percentage of the state's general fund.
[54] Vermont does not require a balanced budget.

variability should have larger contingency funds and vice versa. Using this standard, one would expect that contingency funds in education depend on the context of the district.

A priori, it is not clear that the optimal response of school districts to budget uncertainty should be the same as states' response. Although tax collections can vary somewhat, revenue streams are generally predictable as they are funded by property taxes and state allocations based upon ensuring a given revenue per pupil. However, the degree of predictability in local revenue varies as districts engage in property reassessment differently and property tax delinquencies can be worse in poor economic times. As part of a federalist system of government, school districts have the state as a built in insurance provider that is able to provide production smoothing given an unforeseen catastrophic event.[55] However, this does not control for unexpected revenue shortfalls which may be generated by state funding formula changes or state revenue shortfalls. Regardless, the question remains if school districts do indeed respond to budget uncertainty by establishing and maintaining a contingency fund, and if so, how that contingency fund is used.

In determining how the district will handle budget uncertainty administrators face several choices. For the purpose of this paper, Kentucky school districts, by mandate, must carry a contingency fund of at least 2% of operating expenses. Regardless of the mandate, administrators must then choose how to fund the contingency and the amount of the fund. Taxes play a large role in both of these decisions. School districts must first decide if they are going to fund their contingencies through sacrificed production or

[55] In Kentucky, the Kentucky School Boards Insurance Trust (KSBIT) is a non-profit organization that provides Kentucky school districts with insurance and risk management services.

increased taxes. It is not obvious which choice is preferred as both have disadvantages. If districts do not expend their entire budget in a given time period, they may face objections from parents, students and/or teachers. If a contingency fund is funded through increased taxes there may be resistance from taxpayers or a demand for more outputs to justify the increased burden.

Once administrators resolve how they will fund the contingency, they must choose the desired level of the contingency fund. Ideally, according to the literature on state contingency funds, the fund amount should be a function of the budget variability and the potential budget shortfall. However, large contingency funds, even if they are determined to be necessary by that rubric, may be looked upon unfavorably by taxpayers as excessive and unnecessary taxation since these funds are essentially idle taxpayer's dollars. Conversely, taxpayers may be concerned with large increases in future tax burdens or cuts in production to cover unexpected budgetary shortfalls should the contingency fund be inadequate. Tax increases are also costly to implement. Indeed, in Kentucky local revenue increases exceeding 4% must meet voter approval. Taxpayers' ability to pay and budget deficits are often related to the same economic factors. Much like states, local school district decision makers must contend with the delicate balance between current production and tax burdens while planning for possible budget shortfalls in the future.

In the case of school districts, it is not readily apparent that maintaining a contingency fund is an ideal strategy for managing budget uncertainty. Do school districts experience enough budget uncertainty to warrant contingency funds, particularly since state and federal funds are typically formula driven? Should districts hedge against uncertainty when they are part of a federalist system of government? If districts should carry a contingency fund, should it come from sacrificed consumption or increased taxes? Finally, how large should the fund be? In moving forward, the size and use of school district contingency funds will focus on two main areas: the influence of budget variability and political economy factors.[56]

I suggest that, consistent with the previous literature on state contingency funds, budget variability would be expected to influence the size and use of school district contingency funds, where contingency funds are measured as a percent of the operating budget. For the purpose of this paper, I consider budget variability to be a function of both revenue fluctuations as well as the fluctuations in demand for expenditures. I also explicitly assume that since state and federal funds are mostly formula driven, revenue variability is primarily a function of the local revenue share of the budget.[57] More specifically, districts with higher local budget shares are expected to have more budget variability, and during periods of budget shortfalls school districts will use their contingency funds to smooth production. I also consider the political constraints that may be important in determining the size and use of contingency funds. However, unlike budget variability, I offer no preconceptions as to the expected relationship between political factors and contingency fund size and use. On one hand, Niskanen (1971) suggests that because of the information advantages on the part of the bureau, in this case the superintendant or principal; the budget may be higher than the minimal level of

[56] Contingency fund use in this context refers to both expenditures from and additions to the contingency fund.
[57] There is also revenue from other sources, but this data is not included in the analysis as the percentages never exceed 2.4% and for most districts in most years the amount is zero.

resources necessary to produce their outcomes. Accordingly, there is an opportunity for school districts to satisfy the wants of their sponsors (i.e. residents/taxpayers) without committing the entirety of their given budget. Administrators can satisfy the wants of their sponsors while simultaneously placing funds into the contingency reserve for uses other than managing budget uncertainty. On the other hand, transparency may be significant enough in school district outcomes and budgets to inhibit large contingencies. In this case, the administration may be more sensitive to their political constraints and less likely to carry large contingency fund balances.

School District Contingency Funds in Kentucky

School district contingency funds are not unique to Kentucky. Indeed, Figure 4.1 demonstrates that 16 out of 19 surrounding states allow or require school districts to maintain a contingency fund. Although the particulars of each state vary somewhat in statutory limits and with how the funds may be used, the fact that they are a part of the budgeting process suggests that contingencies in these states may also be determined by budget variability as well as political economy factors. Therefore, the findings of this research should be generalizable enough to inform contingency fund analysis in these states.

Kentucky, does however, present an interesting case in which to analyze school district contingency funds. In 1990, concerned with equity of school financing, the Kentucky legislature enacted the Kentucky Education Reform Act (KERA). This

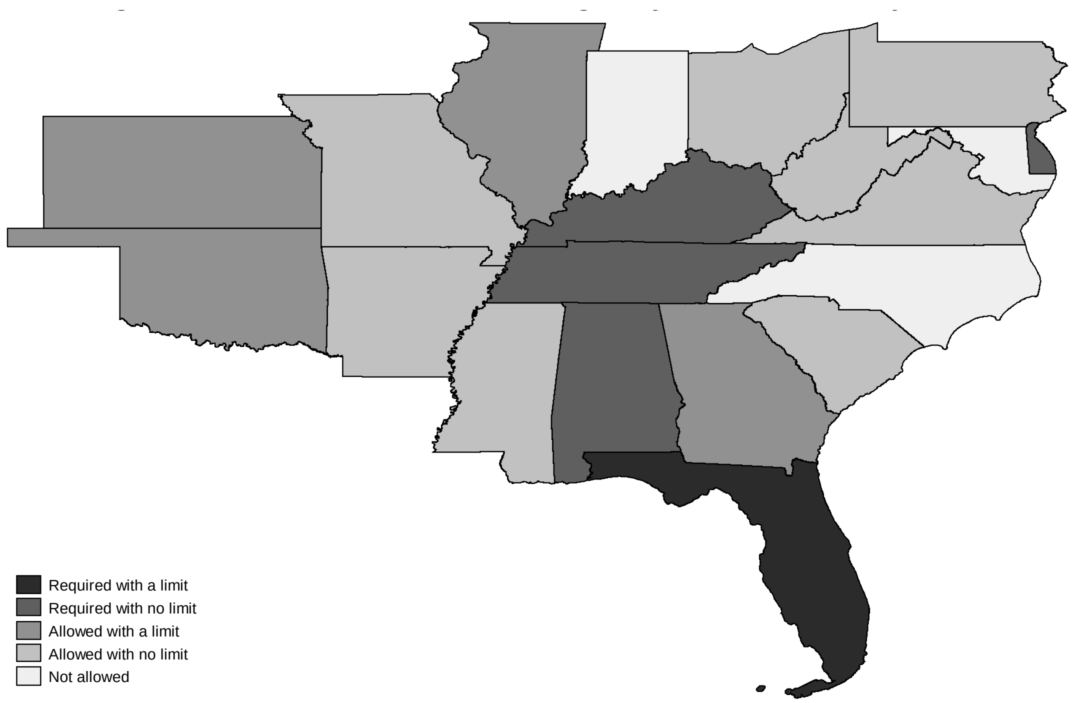

Figure 4.1: School District Contingency Fund Rules by State

legislation was in large part motivated by the disparity in per pupil spending between Appalachian and non-Appalachian districts.[58] As a result of a new state funding formula, per pupil revenues across districts moved toward financial equity (Bosworth, 2001; Weston & Sexton, 2009; Streams et al., 2011).[59] By enacting this legislation, Kentucky effectively reduced the disparity in per pupil spending by over 50%.[60] This suggests that

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[58] From 2001 through 2006 there were 74 Appalachian school districts and 102 non-Appalachian school districts. In 2007, Harrodsburg Independent merged with Mercer County School District and in 2008 Providence Independent merged with Webster County School District, reducing the number of non-Appalachian school districts to 101 and 100 respectively.

[59] Although SEEK funding equalized Tier I state funding, districts are also able to levy additional taxes under Tier II funding which is subject to local voter referendum and not matched by the state.

[60] See Streams et al (2011).

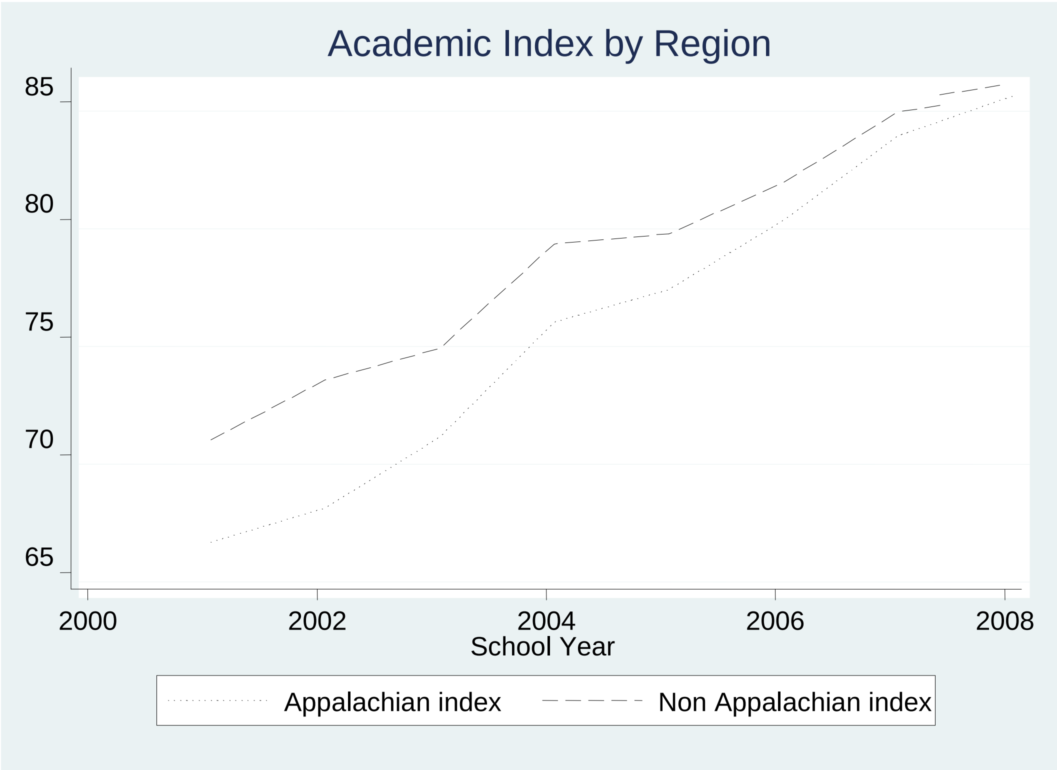

Figure 4.2: Academic Index by Region

while there may still be an "Appalachia effect" in determining contingency funds, the increased access to resources addresses the concern that some districts may not have the financial ability to maintain contingency funds. The Support Education Excellence in Kentucky (SEEK) formula as established through KERA arguably reduces budget variability across districts as it mandates a minimal level of local tax effort and also guarantees a base per pupil funding amount. KERA, however, does not mandate how districts choose to spend their revenue.

In 1999, Kentucky also established a new outcome measure to accompany the equalization in revenues. The outcome measure is a school academic index which is a weighted average of student performance at each performance level across several subjects and then averaged by district.[61] Figure 2 shows the yearly academic index comparison between Appalachian and non-Appalachian districts. As shown, considering legislative reform aimed at equalizing per pupil revenues and subsequent academic outcomes, there remains a distinct difference between the two regions although there has been recent convergence.[62] This academic index does, however, provide a metric on which district administrators can be held accountable for educational production within the district and may possibly influence the size and use of contingency funds.

Although districts in Kentucky have experienced revenue equalization, they have significant autonomy in how they decide to levy additional taxes and allocate their budgets. This generates substantial variation between districts with how they choose to produce educational outcomes. Most notably for the purpose of this research is the decision to reserve money into a contingency fund. While Kentucky has a mandated district contingency fund of 2% of yearly operating expenses, the state recommends a 10% contingency fund for school districts. The state also does not limit the maximum size of the fund nor does it regulate how the fund is used. Table 4.1 provides descriptive statistics of contingency funds in Kentucky as well as Appalachian and non-Appalachian districts. On average, contingency funds are well above the state mandated 2%

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[61] Performance levels include: novice, apprentice, and proficient/distinguished. Subject categories include: Reading, Mathematics, Science, and Writing.
[62] In 2007, Kentucky changed the scaling of the state tests. Therefore, convergence of the academic indexes may be an artifact of the scale change. See Barrett et al. (2011) for a discussion of the testing system in Kentucky.

regardless of group designation. Since contingency funds are mostly self-regulated in Kentucky, this presents an ideal scenario in which to determine the factors that influence their size and use. Unfortunately, because of the way in which Kentucky defines school district contingency funds, the ability to inform this relationship, as traditionally considered, may be limited.

In Kentucky, contingency funds are considered to be the difference between current assets and currents liabilities not appropriated to a specific expenditure in the following year or reserved for a specific purpose. In accounting terms, this is equivalent to the unrestricted portion of net assets or retained earnings. This is not the standard designation for contingency funds. Accounting standards are to assign contingencies as designated or restricted funds within the larger category of retained earnings. There is also usually some sort of procedure that must be satisfied to release them for use. Because the institutional definition of contingency funds in Kentucky is different than what is considered in the literature, I will now refer to these funds as the unrestricted fund balance. Since contingency funds are broadly defined by the state, it may be that only a portion of this fund is meant for managing budget uncertainty. This increases considerably the factors which may influence the context of choice for the administrator. While administrators may still view the unrestricted fund balance as a means to manage budget uncertainty, the institutional anomaly about fund qualifications may dramatically affect the way in which administrators view the unrestricted fund balance for uses other than to manage budget variability.

Table 4.1: Contingency Funds in Kentucky

a. Statewide

Year	Operating Budget*	Contingency Funds*	Percent of Operating Budget	Fund Use*	Percent of Operating Budget	Fund Additions*	Percent of Operating Budget
2001	44579	4696	10.53				
2002	45828	4127	9.01	806	1.76	237	0.52
2003	48858	4705	9.63	182	0.37	760	1.56
2004	55291	4972	8.99	281	0.51	549	0.99
2005	58935	5006	8.49	351	0.59	384	0.65
2006	63939	5408	8.46	356	0.56	769	1.20
2007	67689	6028	8.91	214	0.32	836	1.24
2008	71691	6776	9.45	356	0.50	1105	1.54

* 2001 Dollars. Figures are in 100,000's and are totals

b. Appalachia

Year	Operating Budget*	Contingency Funds*	Percent of Operating Budget	Fund Use*	Percent of Operating Budget	Fund Additions*	Percent of Operating Budget
2001	13869	1488	10.73				
2002	14060	1352	9.61	191	1.36	54	0.38
2003	15072	1493	9.91	64	0.43	206	1.36
2004	16828	1474	8.76	162	0.96	143	0.85
2005	17539	1376	7.84	171	0.98	73	0.42
2006	18557	1316	7.09	204	1.10	144	0.78
2007	19391	1442	7.44	109	0.56	235	1.21
2008	20276	1458	7.19	149	0.73	164	0.81

* 2001 Dollars. Figures are in 100,000's and are totals

c. non-Appalachia

Year	Operating Budget*	Contingency Funds*	Percent of Operating Budget	Fund Use*	Percent of Operating Budget	Fund Additions*	Percent of Operating Budget
2001	30709	3207	10.44				
2002	31767	2775	8.74	615	1.94	183	0.58
2003	33786	3212	9.51	118	0.35	555	1.64
2004	38463	3498	9.09	119	0.31	406	1.05
2005	41396	3630	8.77	179	0.43	311	0.75
2006	45383	4093	9.02	153	0.34	625	1.38
2007	48298	4586	9.50	105	0.22	601	1.24
2008	51415	5318	10.34	208	0.40	940	1.83

* 2001 Dollars. Figures are in 100,000's and are totals

As discussed previously, contingency funds are expected to be a function of district budget variability and the context of the district. I also explicitly assume that various political economy factors may influence the unrestricted fund balance. Therefore, the explanatory variables of interest will be grouped into these two categories. This paper argues that the unrestricted fund balance is viewed by superintendents as a means to create budget fungibility as opposed to simply smoothing productive capacity by managing budget uncertainty. In particular, the lack of restrictions on fund use implies that superintendants can use the unrestricted fund balance as a slush fund.

Data

The financial data used for this study came directly from the 2001 through 2008 annual financial reports (AFR's) from 176 school districts as reported to the Kentucky Office of Education Accountability (OEA).[63] Within the AFR's are the types of fund, the unit that the fund belongs to, the function and program on which the fund was allocated, and whether the fund was an expenditure, revenue, or balance sheet object. Of particular relevance to this study, these data allow me to determine categories and levels of educational input spending, contingency fund levels, as defined by the state, as well as contingency use or contribution. In addition to the AFR's, local levied tax rates were also obtained from OEA.

Academic index scores are also available at the school level for the academic years 2001 through 2008. These data were obtained from the Kentucky Department of Education (KDE). District level demographics and characteristics were obtained for 2001-2008 from the Common Core Data (CCD) and include: total enrollment, number of teachers, percentage of teachers with a master's degree or higher and average years of teacher experience. The data from these various sources were merged by district and year. Table 4.2 presents descriptive statistics for the data used in the following analysis.

[63] A brief description of budget categories and coding can be found in Appendix B.

Table 4.2: Descriptive Statistics[1]

Variable	State Mean	State Std Dev	Appalachia Mean	Appalachia Std Dev	Non-Appalachia Mean	Non-Appalachia Std Dev
Contingency Fund as % of Operating	11.115	14.569	9.032	5.146	12.638	18.514
Variability Measures						
Local Revenue % Change	5.246	13.683	4.319	16.513	5.922	11.139
State Revenue % Change	3.240	8.853	2.366	7.386	3.878	9.741
Federal Revenue % Change	7.475	16.194	6.235	15.585	8.380	16.576
Enrollment % Change	0.574	3.656	0.243	2.998	0.815	4.054
% Teachers with Master's or higher	56.743	34.049	58.605	34.965	55.370	33.319
Average Years of Experience	9.921	4.365	10.202	4.407	9.715	4.326
Political Economy Measures						
Academic Index	77.653	9.142	76.522	8.931	78.477	9.211
Levied Equivalent Rate	60.301	12.327	56.605	8.405	62.995	13.933
Tax Increase	0.501	0.500	0.470	0.500	0.525	0.500
% of Budget from Local Revenue	26.333	11.548	19.274	7.233	31.479	11.388
% of Budget from State Revenue	57.750	9.472	62.777	6.209	54.086	9.758
% of Budget from Federal Revenue	13.834	4.768	16.382	4.277	11.977	4.221
Building Activity (dummy)[2]	0.394	0.489	0.373	0.484	0.409	0.492
Future Building Activity (dummy)[3]	0.322	0.467	0.301	0.459	0.337	0.473

1- All dollar amounts were adjusted to 2001 dollars.
2- Coded as 1 if a school district engaged in major renovations, new construction or site acquisition in the current fiscal year.
3- Coded as 1 if a school district engaged in major renovations, new construction or site acquisition in the next fiscal year.

Variability Measures

The variability measures used in this analysis are intended to account for the contingency portion of the unrestricted fund balance. Arguably, if there is a consistent relationship between these factors and the unrestricted fund balance, it could be suggested that administrators view the unrestricted fund balances as a means to manage budget uncertainty. The variability measures account for both the fluctuations in productive capacity, the cost of providing educational services, as well as fluctuations in those factors that create demand for education production. The use of these measures is intended to account for the variability that the administration faces in the budgeting process and the impact that variability has on a given district's contingency fund portion of the unrestricted fund balance. The standard deviation of the operating budget within districts is used. It is expected that the higher the standard deviation the higher the contingency fund portion of the unrestricted fund balance. This measure allows me to control for the variability that a district experiences over time. The percentage change in the operating budget is decomposed into three parts; the percentage change in local revenue, the percentage change in state revenue, and the percentage change in federal revenue. These measures are expected to be positively related to the size of the contingency fund portion. In years of percentage increases, I expect that districts will allocate funds into the contingency to allow for production smoothing during years of percentage decreases. Consequently, in years of percentage decreases, one would expect the contingency fund share of the unrestricted balance to decrease. Conceptually, it is not apparent that the response by administrators will be the same for percentage changes in each revenue category. Since state and federal funding changes are primarily formula driven the administrator may not respond to percentage changes from these sources of revenue as they may with local revenue percentage changes. In other words, the variability in local revenue may be higher than the variability of federal and state revenue. The expected effect of the percentage change in enrollments on contingency funds is negative; however it is not clear that this relationship will be statistically significant because projected enrollments is a part of the state's calculation for the operating budget. However, if enrollment changes are unexpected then one would expect districts to use contingency funds during enrollment increases and reserve more into contingency funds during enrollment decreases. Because the number of teachers is closely tied to enrollments, the percentage change in teachers is not used. However, since teacher salaries are determined by experience and degree, the average years of experience in the district as well as the percentage of teachers with a master's degree are included to account for the effect enrollment changes may have on salary expenditures. It is expected that districts with higher experience averages and percentage of teachers with a master's degree will have larger contingency funds.

Political Economy Measures

Although the variability of the budget and of the demand for outputs is important in determining contingency levels, it may be that the contingency portion of the unrestricted fund balance is minimal. The political constraints that administrators face may also be important in explaining the context in which the unrestricted fund balance size and use are determined. A priori it is not clear how these constraints may influence the size and use of these school district fund balances. On one hand, scrutiny from various sponsors may prevent administrators from maintaining their desired unrestricted fund balance level and may also constrain fund use. Conversely, because of the budgeting process it may be easier for the administration than it is for sponsors to determine the minimal level of resources needed to produce a given output. To account for the influence of political constraints on the unrestricted fund balance size and use several variables were used. The district's academic index was included to control for academic accountability and the relationship between a district's fund balance and their educational production. While the academic index is subject to the quality and mix of educational inputs, I explicitly assume that the administration will expend more resources in educational inputs to improve their respective academic index. Therefore, I expect a district's academic index to be negatively related to the size and use of a district's unrestricted fund balance.

A district's levied equivalent rate indicates a district's local tax effort.[64] The expected relationship between the levied equivalent rate and unrestricted fund balance size and use is somewhat ambiguous. On one hand, a high level may suggest that there is strong local support for schools and citizens may desire a larger fund balance. Because of their high rates, these citizens may also be concerned about future tax increases to cover revenue shortfalls as they are more sensitive to marginal tax increases. In this case the relationship between the levied local tax rate and the fund balance would be positive. On the other hand, local citizens may look at their tax burden and expect it to closely match the school district's current output to justify said burden. In this case, the relationship between the local levied tax rate and a district's unrestricted fund balance would be statistically insignificant because districts would expend their budgets solely on current production. Closely related to the local levied tax are local tax increases. The expected relationship between district fund balances and local tax increases is negative for two reasons. First, a tax increase may signify an expected revenue shortfall and therefore funds will be used from the unrestricted balance. Second, local citizens will be resistant to increased fund balances in the presence of a higher tax burden.

The mix of revenue, as defined by the percent of the operating budget from local, state and federal sources, is also important in explaining the political context influencing the size and use of unrestricted fund balances. The level of federal spending is expected

[64] The levied equivalent rate is calculated by summing property, personal and motor vehicle tax revenue as well as any prior year permissive revenue. That total is then multiplied by last year's collection rate. That figure is then divided by the prior year's total assessment.

to be unrelated to the size and use of the fund balance as much of this funding is dedicated for specific uses. The relationship between local and state mixes and fund balances is less clear. The influence of the local percentage of revenues is ambiguous as it operates much like the local levied equivalent rate. The influence of the state percentage of revenues is also ambiguous. On one hand, since the state mandates that school districts maintain a contingency fund, as they define it, of 2% and recommends at least a 10% contingency, they may be more accepting of larger contingencies. Therefore, the relationship between state revenue percentage and unreserved fund balance size and use would be positive. Conversely, as the state commits a higher portion of a district's budget they may be less likely to accept larger contingencies as they may expect districts to increase local effort. In this context, the relationship between the state portion of revenues and the unrestricted fund balance size and use would be negative.

It is useful to consider those factors which may constrain choice in the determination of unrestricted fund balances. It is also important to consider choices for the alternative use of these fund balances. Conceptually, the unrestricted fund balance is accumulated savings over time. I have previously discussed the funds use as a tool to smooth production under budget uncertainty, but savings can also be for objectives that are unattainable through expenditure from the current budget. Of these factors, capital projects are likely the most common across school districts. While there are categories in the budget specific to capital projects, the administrator’s desire for fungibility may motivate their choice to fund certain capital through the unrestricted fund balance.

Two variables are used to evaluate the relationship between unrestricted fund balances and building projects. The first is a current year building dummy.[65] This variable is coded as one if a district engaged in major renovations, new construction or site acquisition in the current fiscal year. Because of the unrestricted size and use of these funds, it is expected that this variable will have a negative relationship with changes in the fund levels. The second is a next year building dummy. This variable is coded as one if a district engaged in major renovations, new construction or site acquisition in the next fiscal year. Because it often takes many years to accumulate the funds necessary to engage in building projects it is not clear that this variable will be related to current unrestricted fund changes.[66] However, future building projects would be expected to have a positive impact on current changes in unrestricted fund balances as districts allocate more funds into the balance in expectation of their future use for building projects.

Model and Results

For estimation, I am concerned with the factors that influence both the size of unrestricted fund balances as well as the change in fund levels. Consistent with previous literature and theory, I assume the contingency fund portion of the unrestricted balance to be a function of budget variability. Because of the institutional definition of contingency funds in Kentucky, I also consider that the unrestricted fund balances may be a function of political economy factors. In addition, I suggest that there are various district level

[65] Percentage changes in spending for building projects could not be used as there are many years in which this spending is zero.

[66] Unfortunately, because of data availability, the time horizon of future building projects could not be extended.

factors important in determining the size and change of unrestricted balances that are unobserved in the data set. Accordingly, both a district between effects model and a district fixed effects model were estimated to account for the level and change of unrestricted fund balances respectively as well as the influence of unobserved factors.

The between effects model estimating the average unrestricted balances was modeled as follows:

$$\bar{Y}_i = \beta_0 + \boldsymbol{\alpha}\overline{\boldsymbol{V}}_{\boldsymbol{i}} + \boldsymbol{\beta}\overline{\boldsymbol{P}}_{\boldsymbol{i}} + \boldsymbol{\gamma}\boldsymbol{F}_{\boldsymbol{i}} + \theta_i + \bar{\varepsilon}_i \quad (1)$$

where Y_i is the average size of district i's fund balance as a percentage of district i's operating budget. β_0 is the constant term. The term $\boldsymbol{\alpha}$ is a vector of coefficients associated with the vector $\boldsymbol{V}_{\boldsymbol{i}}$ which are average measures of district i's variability. $\boldsymbol{P}_{\boldsymbol{i}}$ is a vector of average political economy factors for district i and $\boldsymbol{\beta}$ is a vector of the associated coefficients. $\boldsymbol{F}_{\boldsymbol{i}}$ is a vector of measured time invariant characteristics of district i and $\boldsymbol{\gamma}$ is a vector of the associated coefficients. θ_i is district i's fixed effect as part of the disturbance and $\bar{\varepsilon}_i$ is the idiosyncratic error.

The fixed effects model estimating the changes or use of the unrestricted fund balance within districts was modeled as follows:

$$Y_{it} = \beta_0 + \boldsymbol{\alpha}\boldsymbol{V}_{\boldsymbol{it}} + \boldsymbol{\beta}\boldsymbol{P}_{\boldsymbol{it}} + \theta_i + \varepsilon_{it} \quad (2)$$

where Y_{it} is the size of district i's contingency fund as a percentage of district i's operating budget in year t. β_0 is the constant term. The term $\boldsymbol{\alpha}$ is a vector of coefficients associated with the vector $\boldsymbol{V}_{\boldsymbol{it}}$ which are measures of district i's variability in year t. $\boldsymbol{P}_{\boldsymbol{it}}$

is a vector of political economy factors for district i in year t and $\boldsymbol{\beta}$ is a vector of the associated coefficients. θ_i is district i's fixed effect and ε_{it} is the idiosyncratic error.

Average Unrestricted Fund Balance Results

Table 4.3 presents the results of the between effects estimation of the average levels of school district unrestricted fund balances. As a control, the average prior year unrestricted fund balance was used. The lagged fund balance is statistically significant and positive at the 1% level, suggesting that all else equal a 1% increase in the average fund balance lag results in a .919% increase in the current year's contingency fund. This result is not surprising as one would expect the average of last year's contingency fund to be highly predictive of the average current year contingency fund.[67] The average percentage change in the state percentage of the operating budget is statistically significant at the 10% level in predicting average unrestricted fund balance size, indicating that a 1% increase in the average state percent of the operating budget results in a .071% increase in the average contingency fund. This is particularly relevant if one considers the state recommendation of a 10% contingency fund. The only other variability measures statistically significant in explaining the average fund balance levels are the average teacher qualification measures. These measures control for teacher salaries mandated by district salary schedules which are closely tied to experience and degree level. Teacher salaries represent the largest expenditure item for a district and the significance of these variables is expected given a potential budget shortfall. However,

[67] The lagged value is statistically different from zero at the 99.9% level, suggesting that it does not account for all of the variation in current unrestricted fund balances.

Table 4.3: Predicted Unrestricted Fund Balance

Independent Variables	Between Effects Model		Fixed Effects Model	
	Coefficient	Standard Error	Coefficient	Standard Error
Variability Measures				
Unrestricted Fund Balance Lag	0.919***	0.006	0.364***	0.023
Operating Budget Std, Dev.	3.410	16.210	--	--
Local Revenue % Change	0.014	0.024	-0.005	0.014
State Revenue % Change	0.071*	0.040	-0.032	0.023
Federal Revenue % Change	0.004	0.017	0.009	0.012
Enrollment % Change	-0.027	0.060	-0.006	0.046
Average Years of Experience	0.237***	0.079	0.006	0.131
% Teachers With Masters or higher	-0.044**	0.019	0.004	0.020
Political Economy Measures				
Academic Index	-0.010	0.014	-0.068**	0.034
Levied Equivalent Rate	-0.005	0.007	0.164***	0.055
Tax Increase	-0.445	0.427	-0.948***	0.328
% of Budget from Local Revenue[1]	0.014	0.023	0.327**	0.145
% of Budget from State Revenue	0.003	0.026	0.195	0.122
Appalachian District	-0.469***	0.184	--	--
Fayette/Jefferson	-0.102	0.794	--	--
Current Building Activity	-0.217	1.148	-1.043***	0.407
Future Building Activity	-0.329	1.328	0.002	0.421
N(Groups)	1220(176)		1220(176)	
F Statistic	1743.29		97.60	

* significant at the 10% level ** significant at the 5% level *** significant at the 1% level

1 - Percent of the budget from federal revenue is the reference group.

the different sign on experience and the percentage of teachers with a Masters degree is difficult to explain. The only political economy measure statistically significant in explaining average fund balance levels is the Appalachia indicator. The Appalachia indicator is statistically significant at the 1% level and suggests that districts in Appalachia, on average, have fund balances .469% less than their non-Appalachian counterparts.

Unrestricted Fund Use Results

Table 4.3 presents the results of the fixed effects estimation of unrestricted fund use. [68] As in the between effects estimation, the lag of a district's unrestricted fund balance was used as a control. The lag is statistically significant at the 1% level and indicates that, all else equal, an increase of 1% from a district's average fund balance level results in a .364% increase in the current fund balance. There are no other variability measures significant in explaining the changes in unrestricted fund balances.

There are several political economy measures which are significant in explaining unrestricted fund use. A district's average academic index is statistically significant at the 5% level and suggests that a one point increase in the academic index from the mean results in a .068% decrease in a district's current unrestricted fund balance. A district's levied equivalent rate is statistically significant at the 1% level. Districts which increase their levied equivalent rate one percent above their mean increase their current year's fund balance by .164%. Districts which enact a tax increase in the current year decrease their unrestricted fund balance by .948%. This is statistically significant at the 1% level and is in the expected direction. Finally, districts that increase their local revenue mix by 1% from the mean increase their current year fund balance by .327%. This result is significant at the 5% level.

It was previously suggested that administrators may view the unrestricted fund balance as a way to create budget fungibility. One possible use of the fund is for capital

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[68] Previous research has also shown that general economic conditions, captured by year dummies, are also important in explaining contingency funds. The model was also specified using year dummies. None of the years were significant in explaining changes in unrestricted fund balances.

projects. The results of the estimation suggest that if a district engages in new building activity in the current year, it is related to a 1.043% decrease in the unrestricted fund balance, and is significant at the 1% level. In other words, current year new building activity is negatively related to the difference between a district's current year fund balance and the district's mean fund balance. Considering the intended use of the contingency fund − as a means for managing budget variability − this relationship is noteworthy as building projects are not considered to be a component of budget uncertainty.

To better understand the context of these choices by school district administrators, I reviewed state policies regarding contingency funds and capital projects. Prior to 2001, Kentucky had a statutorily mandated cap on contingency funds of 10% of operating expenses. Any funds accumulated in the unrestricted fund balance which exceeded the 10% mandate were restricted to the School Facilities Construction Commission and were no longer considered to be part of the unrestricted balance. This meant that districts were restricted in the priority of the building projects they could undertake. Priority 1-3 needs include renovating or constructing new school buildings. Priority 4 needs include athletic facilities, new construction or renovation for the central office and bus garages. More specifically, if a district had priority 1, 2 or 3 needs, they would have to be met before priority 4 projects could be funded. The 10% contingency mandate cap was eliminated in 2001 effectively making the funds unrestricted in their use no matter the size of the balance. This suggests that administrators can now circumvent priority 1, 2 and 3 building needs by allocating funds into the unrestricted fund and engage in building projects as they see fit. Because of the unrestricted size of these funds and the absence of restrictions on its use, there is cause to suspect that administrators may use contingency funds as a means to create budget fungibility by circumventing other budgeting constraints.

It is not clear that this is or is not an ideal approach to addressing building needs. On one hand, districts may not have the bonding capacity to debt finance and the use of the unrestricted fund balance allows these districts to save for future building needs. On the other hand, the used of the fund balance to save for future building projects allows the administration to bypass state priority building needs. This issue is further complicated if one considers the alignment of the cost of building projects and the accrued benefits of those projects. One could argue that if building needs are debt financed the benefits of those projects will be accrued by those currently bearing the costs within the district, either by increased tax burdens or sacrificed consumption of educational inputs. If the building projects are self financed, this alignment is not apparent. This is particularly relevant as the time period of savings increases.

Conclusions and Implications

School finance literature has long been focused on equity and the effects of increased educational inputs. However, research has failed to address how schools manage budget uncertainty. Through data collected from Kentucky school districts, this paper has provided an analysis of the factors that influence the size and use of unrestricted fund balances funds through between and fixed effects models respectively. Consistent with previous research evaluating contingency funds at the state level and theory, both variability and political economy measures were used. Results overall indicate that budget variability, through both revenue and expenditure categories, has little influence on changes in unrestricted fund balances within districts but does explain some of the variation across districts. Conversely, the political economy measures explain little of the variation in fund levels, but do influence the within district variation of unrestricted fund balances.

It was not the intention of this research to provide insight into the optimal level of contingency funds for districts as a means to manage budget uncertainty. However, because of the institutional definition of contingency funds in Kentucky, the results suggest that administrators may view contingency funds as a method to bypass other institutional constraints. Furthermore, the broad definition of contingency funds by the state suggests that the portion of the fund intended to manage budget uncertainty may be minimal, which allows for a significant amount of budget fungibility for the administrator and significantly decreases the transparency of the budgeting process. As of 2008, there was almost 700 million dollars in district contingency funds in Kentucky. It is not clear that budget uncertainty is significant enough within districts to warrant these contingencies as this is a significant amount of idle resources. While there is some variability in district operating budgets, they are relatively predictable as revenue from state and federal sources is primarily formula driven. Furthermore, the variability in local revenue is unrelated to contingency fund levels and use.

Although beyond the scope of this research, the institutional ambiguity of district contingency funds in Kentucky suggests that there may be better alternatives to managing budget uncertainty in education. It may be that budget uncertainty could be better handled at the state level by risk pooling. In this context, there could be a state run educational contingency fund. Districts could then apply for funds based upon whatever rules the state determines. Future research should focus on the efficiency implications of having state run educational contingencies versus district level contingency funds for managing budget uncertainty.

CHAPTER 5

SUMMARY, CONCLUSIONS, AND RESEARCH PROSPECTS

Dissertation Summary

Public K-12 education is a significant endeavor in the U.S. This institutional environment creates a variety of incentives which influence choices of public school teachers and administrators in the provision of educational outputs. Often, institutional policies and procedures create conflicting incentives so that their actual effect on the choices made by teachers and administrators is not apparent. This dissertation is comprised of three essays which address various institutional policies and practices, the incentives they create, and the resulting choices of teachers and administrators.

Chapter 2 analyzed the relationship between teaching effectiveness and the decision to participate in content-based professional development. Institutional policy in Kentucky requires that teachers engage in four days of professional development activity. There is no requirement as to the type of program or for programs to demonstrate effectiveness. Ideally, professional development policy would be designed to create incentives for participation to those that would benefit most from effective programs. In examining the design of the AMSP program, it is not evident that these incentives were in place. However, upon analysis, it was shown that less effective teachers engaged in the professional development activities at a higher rate than their more effective counterparts. Controlling for the choice to participate based upon teaching effectiveness; it was then shown that the program was effective in promoting student achievement for 5th and 11th grades.

Chapter 3 addressed the choice of class size by administrators in response to teaching effectiveness. A priori, because of competing incentives created by various institutional constraints, the relationship was not clear. On one hand, because of tenure and salary schedule constraints, administrators may view class size reductions as a method to reward teaching effectiveness. On the other hand, because of increased school accountability, administrators may increase class sizes of more effective teachers to improve overall school performance. Using an estimated measure of teaching effectiveness, it was shown that more effective teachers have larger classes. This suggests that school accountability provides greater incentives for administrators in their choice of class sizes.

Chapter 4 presented an analysis of contingency funds in Kentucky public school districts. Kentucky provides a unique context in which to analyze these funds as the institutional ambiguity of their definition provides districts significant autonomy with how they choose to fund and use their contingencies. While this limits the extent that the analysis can provide insight into contingency funds as customarily defined, it does provide an interesting context to evaluate choice. Using both between and fixed effects models to estimate levels and changes respectively, it was shown that school district contingency funds have little relation to variability measures. Instead, it appears as though administrators view contingency funds as a means to create budget fungibility. More specifically, is the use of these funds for building projects. While this chapter cannot speak as to the efficiency of this practice, it does raise an interesting question about the nature of contingency funds and the incentives it creates for administrators in the budgeting process and the resulting transparency of budgetary practices.

Policy Implications

The findings of this dissertation inform both general education policy as well as policy regarding the specific institutional settings evaluated. In general, more effective education policy is attainable if policy makers recognize several key elements of choice in the non-market provision of educational outputs. It is often difficult to foresee the incentives that various institutional policies and practices create. Often, the incentives created for those implementing policy generate outcomes which are misaligned with the intended outcomes. To assess this alignment, a framework of evaluation of institutional practices should be developed to first assess what it desired from a given initiative, and second, to evaluate the incentives for those implementing policies to determine any unintended consequences of the choices those incentives elicit. In doing so, policy development can be better informed.

The goal of professional development is to provide an opportunity for in-service teachers to improve or maintain their effectiveness in the classroom. However, the way in which these programs are implemented dramatically affects the ability of professional development to achieve this goal. Merely requiring a certain number of days of professional development does not guarantee that participation will enhance teacher effectiveness and in turn student achievement. Furthermore, if there are no institutional standards requiring programs to demonstrate effectiveness, teachers could be participating in ineffective programs. Finally, there is no systematic allocation of professional development activities based on need or teaching effectiveness. These institutional characteristics provide little guidance for the effective delivery of professional development and potentially limit its ability to improve the quality of in-service teachers.

The debate on class size focuses on its impact on student outcomes. This dissertation evaluated class size in a different context; as a policy instrument to either reward teaching performance or affect overall school performance. It was shown that class sizes of more effective teachers are larger relative to their less effective counterparts. From a policy perspective, the short run implication is promising; administrators recognize differentials in performance and respond in a manner that promotes student achievement. Although beyond the scope of the research, one potential long run policy implication is that more effective teachers may respond to this practice by choosing to sort into schools with higher compensation or higher average teacher quality, thereby reducing the average teacher quality of their former schools.

Many states have institutional policies concerning educational contingency funds, yet they have received little attention in the academic literature. Contingency funds, as traditionally defined, are restricted funds and are used to manage budget uncertainty. This research cautions that contingency funds may not have the same institutional definition in education. The findings suggest that how these funds are defined may have a considerable influence on how they are viewed and used by school administrators. The implications for policy begin at addressing the need for institutions to establish a clear definition of the purpose of contingency funds. Policy makers can then determine institutional rules and procedures that promote the intended function of the contingency fund. An analysis of implementation can then inform if the incentives created by the institutional constraints elicit administrator choices which are aligned with intended policy. The evidence in Kentucky suggests that the ambiguity in the institutional definition of contingency funds may lead to a wide variance in administrator choice. The ambiguity also suggests that I cannot say if administrator choices are aligned with the desired institutional function as this function is not specified.

Limitations and Future Research

It was the intent of this dissertation to present an alternative view of choice in K-12 education. I suggest that the foundation of education policy should be the advancement of student outcomes. The public contribution to those outcomes is only attainable through the millions of individuals that provide educational services, and more importantly the choices they make. Because of the nature of the data used, the key limitation of this study is the generalizability of the results to the entire population or alternative subset of students, teachers, and schools. Much of the data used in this dissertation accounted for a subset of students, teachers, and schools, which may be very different from their respective populations. While the results are suggestive, the evaluation of choice in the institutional contexts addressed should continue by using different subsets of the population.

A second important limitation concerns the use of the value added modeling in the second and third chapters. A major component of value added modeling is the use of student achievement measures, typically test scores, over time. The data used allowed me to view student achievement over time in multiple subjects, but the testing system in Kentucky presented two main obstacles. The first obstacle was the change in the testing scale for each subject over the observed time period. To reconcile scores from the different scales I transformed the scaled scores into ranks and z-scores. However, the compression of the scale in 2007 and 2008 significantly reduced the variation in student achievement. The second obstacle was the testing intervals of the CATS tests from 2000 through 2006. In an effort to reduce the intervals between testing years, CTBS achievement tests were used in math and reading as controls. The CTBS test was not administered in science. The use of the CTBS tests required the explicit assumption that the tests measured a student's ability in math and reading in a way that was systematically comparable to the CATS tests over time. The data available in non-experimental settings is seldom without complications, but it is important to note these caveats. Again, while the results are suggestive, the evaluation of choice in the institutional contexts addressed would benefit from value added modeling under different testing schemes.

The dissertation also provides future research questions specific to the institutional environments considered. Conceptually, the use of professional development is an effort to improve the human capital of teachers and their ability to promote student achievement. While the evaluation of particular programs is important, there is an opportunity to evaluate professional development in a two broader, perhaps more significant, contexts. The first is an evaluation of the societal costs and benefits associated with professional development. Given the large scale use of professional development across states, it is reasonable to question if we are affecting student outcomes commensurate with the costs of administering professional development. The second is an assessment of professional development as an alternative to traditional teacher training programs. By definition, teachers engaging in professional development have spent time in the classroom. Accordingly, they may have a better understanding of how to employ the methods learned than a student who does not have that frame of reference.

The use of class size as a policy tool to affect overall school performance presents two avenues for future research. As discussed previously, the first could address the possible response of teachers in the long run. The second opportunity for research would be to determine if this practice occurs in the private education market. Administrators in private schools are not typically constrained by tenure and salary schedules. However, administrators may still have resource or institutional constraints that restrain their ability to attach pecuniary awards to differentials in teaching effectiveness. It would be useful to assess if private school administrators respond with adjustments in class size to affect overall school performance.

The institutional definition of contingency funds in Kentucky limited the ability of the analysis to inform how school districts respond to budget uncertainty. An obvious extension of the analysis is to identify a state that defines educational contingency funds in a manner consistent with the traditional definition. The resulting analysis could then inform how schools respond to budget uncertainty and how they determine their optimal level.

Appendix A: Chapter 3 Results with Z-Scores

Table A.1: Student Achievement with Teacher Fixed Effects (00-08, z-scores)

Independent Variables	Grade 5		Grade 8		Grade 11	
Math Z-score Lagged	0.316	***	0.354	***	0.428	***
	(0.014)		(0.011)		(0.012)	
Science Z-score Lagged	0.257	***	0.286	***	0.118	***
	(0.012)		(0.012)		(0.013)	
Reading Z-score Lagged	0.225	***	0.208	***	0.361	***
	(0.011)		(0.010)		(0.010)	
Student Characteristics						
Free and Reduced Price (FRP) Lunch	-0.251	***	-0.214	***	-0.125	***
	(0.015)		(0.019)		(0.016)	
Female	-0.008		-0.010		-0.080	***
	(0.013)		(0.011)		(0.012)	
Asian	0.433	***	0.496	***	0.324	***
	(0.069)		(0.046)		(0.058)	
Black	-0.24	***	-0.283	***	-0.368	***
	(0.023)		(0.022)		(0.025)	
Hispanic	-0.156	***	-0.167	***	-0.336	***
	(0.039)		(0.038)		(0.058)	
Indian	0.173		-0.413	***	-0.446	***
	(0.245)		(0.156)		(0.168)	
Other	-0.066		0.063		-0.112	
	(0.057)		(0.053)		(0.079)	
School Characteristics						
Class Size	0.003	**	0.000		-0.001	
	(0.001)		(0.001)		(0.001)	
Average Experience	-0.004		-0.015	**	-0.018	**
	(0.009)		(0.007)		(0.009)	
Enrollment	0.000		0.000	**	0.000	***
	(0.000)		(0.000)		(0.000)	
Percent Master's	0.001		0.002	***	0.000	
	(0.001)		(0.001)		(0.001)	
Percent of FRP Students	0.029		0.071		-0.049	
	(0.054)		(0.050)		(0.055)	
Expenditure per Student	0.000		0.000	**	0.000	
	(0.000)		(0.000)		(0.000)	
Student-Teacher Ratio	-0.007		-0.012	*	0.026	***
	(0.007)		(0.007)		(0.007)	
Student-Computer Ratio	-0.004		0.011		0.004	
	(0.007)		(0.007)		(0.005)	
Math Index	0.001	*	0.002	**	0.003	***
	(0.001)		(0.001)		(0.001)	
Teacher Characteristics						
Highest Degree Obtained	-0.025		0.025		-0.004	
	(0.018)		(0.020)		(0.021)	
Experience 4-7 Years	-0.139	*	-0.129	**	0.071	
	(0.083)		(0.056)		(0.052)	
Experience 8-12 Years	-0.155	*	-0.180	***	-0.058	
	(0.080)		(0.063)		(0.062)	
Experience 13-17 Years	-0.302	***	-0.224	***	-0.065	
	(0.108)		(0.073)		(0.076)	
Experience 18 Years and Higher	-0.351	***	-0.289	***	-0.097	
	(0.119)		(0.077)		(0.083)	
N	22859		27952		18009	
F-Test	(282.48)	***	(411.54)	***	(270.81)	***

Note: Coefficients with robust standard errors in parentheses are presented in the table.
*indicates 0.10 level of significance ** indicates 0.05 level of significance, *** indicates 0.01 level of significance

Table A.2: Student Achievement Censored With AMSP Participation Propensity (z-scores

Independent Variables	Grade 5		Grade 8		Grade 11	
Math Z-score Lagged	0.305	***	0.348	***	0.436	***
	(0.022)		(0.015)		(0.023)	
Science Z-score Lagged	0.167	***	0.209	***	0.328	***
	(0.022)		(0.016)		(0.021)	
Reading Z-score Lagged	0.274	***	0.305	***	0.150	***
	(0.024)		(0.017)		(0.032)	
Student Characteristics						
Free and Reduced Price (FRP) Lunch	-0.238	***	-0.113	***	-0.104	***
	(0.030)		(0.020)		(0.029)	
Female	-0.025		-0.016		-0.040	
	(0.027)		(0.019)		(0.028)	
Non-white	-0.148	**	-0.104	*	-0.213	**
	(0.073)		(0.054)		(0.088)	
Class size	0.001		-0.001		0.001	
	(0.002)		(0.003)		(0.003)	
School Characteristics						
Average Experience	0.025		-0.113	***	0.000	
	(0.045)		(0.040)		(0.049)	
Enrollment	0.000		-0.002		0.000	
	(0.000)		(0.002)		(0.000)	
Percent Master's	0.002		0.000		0.006	*
	(0.006)		(0.003)		(0.003)	
Percent of FRP Students	-0.790	***	-0.083		-0.030	
	(0.195)		(0.176)		(0.129)	
Expenditure per Student	0.000	***	0.000	**	0.000	
	(0.000)		(0.000)		(0.000)	
Student-Teacher Ratio	0.037		0.102	**	-0.029	
	(0.026)		(0.047)		(0.040)	
Student-Computer Ratio	-0.188		0.000		-0.021	
	(0.125)		(0.033)		(0.034)	
Math Index	0.025	**	-0.004		0.018	***
	(0.010)		(0.007)		(0.005)	
Teacher Characteristics						
Participation in AMSP PD	-0.050		-0.039		0.186	**
	(0.202)		(0.095)		(0.090)	
Highest Degree Obtained	-0.133		0.104	*	0.015	
	(0.092)		(0.059)		(0.089)	
Experience 4-7 Years	0.088		-0.179	**		
	(0.255)		(0.083)			
Experience 8-12 Years			-0.296	**	0.046	
			(0.148)		(0.115)	
Experience 13-17 Years	-0.198		-0.269			
	(0.654)		(0.258)			
Experience 18 Years and Higher						
N	3004		4627		2153	
F-Test	(74.56)	***	(193.09)	***	(79.35)	***

Note: Coefficients with robust standard errors in parentheses are presented in the table.
*indicates 0.10 level of significance ** indicates 0.05 level of significance, *** indicates 0.01 level of significance

Table A.3: Student Achievement - Teacher Fixed Effects and Participation (Actual, z-scores)

Independent Variables	Grade 5		Grade 8		Grade 11	
Math Z-score Lagged	0.316	***	0.353	***	0.429	***
	(0.014)		(0.011)		(0.012)	
Science Z-score Lagged	0.257	***	0.286	***	0.117	***
	(0.012)		(0.012)		(0.013)	
Reading Z-score Lagged	0.225	***	0.208	***	0.361	***
	(0.011)		(0.010)		(0.010)	
Student Characteristics						
Free and Reduced Price (FRP) Lunch	-0.252	***	-0.215	***	-0.125	***
	(0.015)		(0.019)		(0.016)	
Female	-0.008		-0.010		-0.080	***
	(0.013)		(0.011)		(0.012)	
Asian	0.433	***	0.496	***	0.325	***
	(0.069)		(0.046)		(0.058)	
Black	-0.240	***	-0.283	***	-0.367	***
	(0.023)		(0.022)		(0.025)	
Hispanic	-0.156	***	-0.167	***	-0.337	***
	(0.039)		(0.038)		(0.058)	
Indian	0.176		-0.415	***	-0.445	***
	(0.246)		(0.156)		(0.168)	
Other	-0.066		0.063		-0.112	
	(0.057)		(0.053)		(0.079)	
School Characteristics						
Class Size	0.003	**	0.000		-0.001	
	(0.001)		(0.001)		(0.001)	
Average Experience	-0.005		-0.015	*	-0.017	**
	(0.009)		(0.008)		(0.008)	
Enrollment	0.000		0.000	**	0.000	***
	(0.000)		(0.000)		(0.000)	
Percent Master's	0.001		0.003	***	0.000	
	(0.001)		(0.001)		(0.001)	
Percent of FRP Students	0.035		0.080		-0.035	
	(0.053)		(0.054)		(0.057)	
Expenditure per Student	0.000		0.000	**	0.000	
	(0.000)		(0.000)		(0.000)	
Student-Teacher Ratio	-0.007		-0.013	*	0.025	***
	(0.007)		(0.007)		(0.007)	
Student-Computer Ratio	-0.004		0.010		0.004	
	(0.007)		(0.007)		(0.005)	
Math Index	0.001	*	0.002	***	0.003	***
	(0.001)		(0.001)		(0.001)	
Teacher Characteristics						
Participation in AMSP PD	0.053	**	0.031		0.062	
	(0.027)		(0.050)		(0.062)	
Highest Degree Obtained	-0.023		0.025		-0.004	
	(0.018)		(0.019)		(0.021)	
Experience 4-7 Years	-0.141	*	-0.134	**	0.069	
	(0.082)		(0.057)		(0.052)	
Experience 8-12 Years	-0.156	**	-0.183	***	-0.064	
	(0.079)		(0.064)		(0.063)	
Experience 13-17 Years	-0.302	***	-0.234	***	-0.076	
	(0.109)		(0.076)		(0.077)	
Experience 18 Years and Higher	-0.347	***	-0.299	***	-0.105	
	(0.120)		(0.079)		(0.085)	
N	22859		27952		18009	
F-Test	(281.90)	***	(405.60)	***	(260.38)	***

Note: Coefficients with robust standard errors in parentheses are presented in the table.
*indicates 0.10 level of significance ** indicates 0.05 level of significance, *** indicates 0.01 level of significance

Appendix B: Chapter 4 Results with Z-Scores

Table B.1: Predicted Student Z-scores with Teacher Fixed Effects (00-08)

	Coefficients (robust std. errors)	Coefficients (robust std. errors)	Coefficients (robust std. errors)
Independent Variables	**Grade 5**	**Grade 8**	**Grade 11**
Teacher Characteristics			
Experience	-0.035*** (0.014)	-0.020 (0.016)	0.003 (0.010)
Experience Squared	0.0007* (0.0004)	0.0002 (0.0004)	-0.0002 (0.0003)
Highest Degree Obtained	-0.021 (0.024)	0.018 (0.019)	-0.009 (0.020)
Student Characteristics			
Math z-score lag	0.315*** (0.014)	0.353*** (0.011)	0.428*** (0.012)
Science z-score lag	0.258*** (0.012)	0.285*** (0.012)	0.118*** (0.013)
Reading z-score lag	0.226*** (0.012)	0.209*** (0.010)	0.361*** (0.010)
Free and Reduced Price (FRP)Lunch	-0.252*** (0.016)	-0.215*** (0.019)	-0.125*** (0.016)
Female	-0.007 (0.013)	-0.010 (0.011)	-0.080*** (0.012)
Asian	0.433*** (0.068)	0.497*** (0.045)	0.321*** (0.057)
Black	-0.239*** (0.023)	-0.283*** (0.022)	-0.369*** (0.026)
Hispanic	-0.153*** (0.039)	-0.169*** (0.038)	-0.337*** (0.058)
Native American	0.167 (0.243)	-0.404*** (0.152)	-0.448*** (0.167)
Other	-0.061 (0.057)	0.063 (0.053)	-0.114 (0.079)
School Characteristics			
Class Size	0.003 (0.002)	-0.0005 (0.001)	-0.001 (0.001)
Average Experience	-0.005 (0.008)	-0.015** (0.007)	-0.017** (0.008)
Enrollment	0.0001* 0.00006	0.0001** (0.00006)	-0.0002*** (0.00005)
Percent Master's	0.0004 (0.0006)	0.002*** (0.0008)	-0.00006 (0.0009)
Percent of FRP students	-0.019** (0.008)	0.056 (0.048)	-0.042*** (0.009)
Expenditure per student	0.00001* (0.00001)	0.00003** (0.00001)	0.00001 (0.00001)
Student-Teacher Ratio	-0.007 (0.007)	-0.012 (0.007)	0.026*** (0.007)
Student-Computer Ratio	-0.004 (0.006)	0.010 (0.007)	0.003 (0.005)
Math Index	0.001** (0.0007)	0.0017*** (0.0007)	0.003*** (0.001)
N	22859	27952	18009
Fraction of Variance	0.392	0.366	0.387

*indicates 0.10 level of significance, **indicates 0.05 level of significance, *** indicates 0.01 level of significance

Table B.2: Predicted Class Size (pooled-OLS, z-scores)

	Coefficients (robust std. errors)	Coefficients (robust std. errors)	Coefficients (robust std. errors)
Independent Variables	**Grade 5**	**Grade 8**	**Grade 11**
Teacher Characteristics			
Past Effectiveness	0.527 (0.493)	0.953*** (0.239)	1.239*** (0.3429)
Experience	-0.021 (0.026)	0.0303 (0.0402)	-0.0399 (0.0299)
Highest Degree Obtained	-0.318 (0.285)	0.5023** (0.2369)	0.4991** (0.2391)
Classroom Characteristics			
Math rank lag	-0.7921* (0.4544)	0.7262 (0.5861)	1.0424* (0.5542)
Science rank lag	-0.1136 (0.1882)	-1.0032** (0.4962)	-0.2535 (0.5673)
Reading rank lag	0.3940 (0.4238)	-0.5832 (0.6436)	-0.5642 (0.3483)
Free and Reduced Price (FRP)Lunch	3.254** (1.429)	-1.276 (1.675)	-3.766** (1.811)
Asian	-1.935 (4.510)	16.805 (14.020)	-5.030 (5.054)
Black	-0.976 (1.954)	-7.972*** (3.889)	-12.136*** (2.502)
Hispanic	-11.073*** (2.849)	1.101 (5.654)	30.075*** (6.568)
Native American	2.003 (25.041)	420.315*** (160.462)	187.195* (107.925)
Other	-3.845 (6.239)	-4.242 (9.477)	4.860 (12.203)
School Characteristics			
Expenditure per student	-0.0004*** (0.0001)	-0.0010*** (0.0002)	-0.0003 (0.0004)
Student-Teacher Ratio	0.1295** (0.0556)	0.4233*** (0.1122)	0.1286 (0.1139)
Math Index Lag	0.0135 (0.0108)	-0.010 (0.0169)	0.0617** (0.0279)
Appalachia	3.968*** (1.383)	4.753*** (1.913)	1.681 (1.449)
N	937	633	735
R-Squared	0.0569	0.1243	0.1153

*indicates 0.10 level of significance, **indicates 0.05 level of significance, *** indicates 0.01 level of significance

Table B.3: Predicted Class Size (School Fixed Effects, z-scores)

	Coefficients (robust std. errors)	Coefficients (robust std. errors)	Coefficients (robust std. errors)
Independent Variables	**Grade 5**	**Grade 8**	**Grade 11**
Teacher Characteristics			
Past Effectiveness	0.6631*** (0.2430)	0.8463** (0.2812)	1.375 (0.8192)
Experience	-0.0379 (0.0246)	0.0161 (0.0403)	-0.0530 (0.0356)
Highest Degree Obtained	-0.0981 (0.1709)	0.5498** (0.2515)	0.4738 (0.4591)
Classroom Characteristics			
Math rank lag	-0.8971 (0.5872)	0.9321 (0.8621)	0.3215 (0.7539)
Science rank lag	0.2045 (0.3854)	-0.3858 (0.7384)	-0.0227 (0.6493)
Reading rank lag	-0.1853 (0.3549)	-1.217* (0.6899)	-0.3962 (0.3791)
Free and Reduced Price (FRP)Lunch	-2.297 (2.851)	-8.382 (5.211)	-5.485* (3.128)
Asian	-0.1324 (5.295)	21.917 (25.157)	-3.811 (9.625)
Black	4.701* (2.819)	3.902 (7.309)	-2.973 (4.129)
Hispanic	-4.206 (4.578)	7.712 (12.397)	38.574* (22.256)
Native American	6.174 (24.366)	310.094*** (103.396)	150.473* (72.841)
Other	-2.871 (8.667)	3.755 (14.598)	15.085 (21.399)
School Characteristics			
Expenditure per student	-0.0005*** (0.0002)	0.0003 (0.0003)	0.0002 (0.0006)
Student-Teacher Ratio	0.1501 (0.0996)	-0.1034 (0.1339)	-0.0253 (0.1717)
Math Index Lag	0.0406** (0.0197)	-0.0387* (0.0218)	-0.0224 (0.0482)
N	937	633	735
R-Squared	0.0678	0.1104	0.0982
Fraction of Variance	0.734	0.434	0.187

*indicates 0.10 level of significance, **indicates 0.05 level of significance, *** indicates 0.01 level of significance

Appendix C: Kentucky Budget Codes[1]

Fund

Category	Description
1	General Fund
2	Special Revenue Fund
310	Capital Outlay Fund
360	Construction Fund
51	Food Service Fund
7XXX	Trust and Agency Funds

Unit

000	District Wide
001	Central Office
002-899	School Numbers

Function

1XXX	Instruction
21XX	Student Support
22XX	Instructional Support
23XX	District Admin
24XX	School Admin
25XX	Business Support
26XX	Plant Operation
27XX	Student Transportation
3XXX	Non-Instructional
4XXX	Facilities Acquisition
5XXX	Other

Program

1XX	Regular Programs
2XX	Special Programs
3XX	Vocational Programs
4XX	Other Instructional Programs

Expenditure Object

01XX	Salaries/Personnel Services
02XX	Employee Benefits
03XX	Professional/Technical Serv
04XX	Property Services
05XX	Other Services
06XX	Supplies and Materials
07XX	Property
08XX	Other Expenditures
09XX	Other Uses of Funds

Appendix C cont.

Revenue Objects

0999	Balance Carry Forward
1XXX	Revenue from Local Sources
3XXX	Revenue from State Sources
4XXX	Revenue from Federal Sources
5XXX	Other Receipts

Balance Sheet Objects

6XXX	Assets
7XXX	Liabilities
8XXX	Fund Balances

1 - Provided to present an idea of the data available and is not a comprehensive list

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EDUCATION

- Ph.D. in Public Policy and Administration, Martin School of Public Policy and Administration, University of Kentucky. Dissertation Committee: Dr. Eugenia Toma (chair), Dr. Joshua Cowen, Dr. J.S. Butler, Dr. Thomas Ahn, Dr. Merl Hackbart, Dec. 2011 (expected)
- Dissertation title: Three Essays Evaluating Teachers' and Administrators' Choices in Public Education
- Master of Arts in Economics, Georgia State University, 2007
- Bachelor of Arts in Economics, Eastern Kentucky University, 2003

RESEARCH AND TEACHING INTERESTS

Research interests include: Economics of K-12 education policy, quantitative research methods, political economy, and public budgeting and finance.

Teaching interests include: Economics of K-12 education policy, microeconomic theory and application, quantitative research methods, policy analysis, political economy, and public economics.

CONFERENCE PAPERS AND PRESENTATIONS

"Teacher Participation in Professional Development." Presented at the annual meeting of the Southeastern Conference for Public Administration. Wilmington, NC: October 2010

"Student Outcomes and Teacher Professional Development" with Eugenia Toma (presenting), John Foster, and J.S. Butler. Presented at the annual meeting of the American Education Finance Association. Richmond, VA: March 2010

"Do Bad Teachers Choose Professional Development: Does it Matter?" with J.S. Butler, and Eugenia Toma. Presented at the 36th Annual Conference of The Association for Education Finance and Policy. Seattle, WA: March 2011

"Do Bad Teachers Choose Professional Development: Does it Matter?" with J.S. Butler, and Eugenia Toma. Presented at the II WORKSHOP ON ECONOMICS OF EDUCATION: Evaluation of Educational Policies. Barcelona, Spain: September 2011.

"Contingency Funds in Education: Are Schools Responding to Budget Uncertainty?" Presented at the Annual Conference of The Association for Public Policy Analysis & Management. Washington DC: November 2011.

WORKING PAPERS

- "Do Bad Teachers Choose Professional Development: Does it Matter?" under review
- "Student Outcomes and Teacher Professional Development" with Eugenia Toma, John Foster, and J.S. Butler.
- "Reward or Punishment? Class Size and Teacher Quality."
- "The Clustered Voting Model: A New Theory of the Election Process for a Changing Political Climate"
- "Contingency Funds in Education: Are Schools Responding to Budget Uncertainty?"

PROFESSIONAL EXPERIENCE

- Post Doctorate Researcher, University of North Carolina (begins January 2012)
- Adjunct Instructor, ECO-230: Principles of Microeconomics, and ECO-231: Principles of Macroeconomics Eastern Kentucky University (Spring 2009 to Present)
- Graduate Research Assistant, National Science Foundation Grant DUE-0830716: "Research, Evaluation, and Technical Assistance: Student Outcome Effects of the Appalachian Math and Science Partnership." Eugenia Toma, Principal Investigator (May 2009 to Present)
- Instructor, Martin School Math Camp, for incoming Ph.D. students. (Fall 2010)
- Visiting Instructor, ECO-230: Principles of Microeconomics, and ECO-231: Principles of Macroeconomics Eastern Kentucky University (Fall 2007 to Spring2008)

ACADEMIC AWARDS AND HONORS

- Academic Excellence Fellowship (August 2008 to May 2009)

PROFESSIONAL MEMBERSHIPS

- Association for Public Policy Analysis and Management
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