AN ANALYSIS OF THE NO CHILD LEFT BEHIND ACT USING GRADUAL SWITCHING REGRESSIONS

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AN ANALYSIS OF THE NO CHILD LEFT BEHIND ACT USING GRADUAL SWITCHING REGRESSIONS

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Martin Dunbar Smith, son of Wilburn A. Smith Jr. and Ellyn Smith of Montgomery, AL, was born on February 13, 1985. He graduated from The Montgomery Academy in May 2003. He attended Auburn University for his undergraduate career, and graduated with a degree in Agricultural Economics and Business in May 2008. He continued on at Auburn University for a Master of Science in Agricultural Economics in the Fall of 2008. He married Rachel Danielle Kichler, daughter of Leonard and Susan Kichler, on May 31, 2008.

THESIS ABSTRACT

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Using a rich panel data set, this paper conducts unique analysis on the structural and overall effects of the No Child Left Behind Act on the sixty-seven county school systems in Alabama. A system of equations is specified to test the effects of NCLB on education production, quality, and cost. Gradual change to the new policy regime is modeled using both linear and non-linear specifications. Wald tests firmly reject the null hypothesis that NCLB had no effect on the rural education market. However, the effects appear to be confined to structural change, as the intercept shifters across the equations were jointly zero. A key and robust finding is that the county school system in Alabama exhibits constant returns to scale.

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I. INTRODUCTION

Often hailed as one of the most significant pieces of legislation introduced by President George W. Bush, the No Child Left Behind Act of 2001 (NCLB) was a nation-wide attempt to combat the problem of substandard primary and secondary school test scores across the United States of America. The act contained a variety of economic “carrots” designed to provide positive incentives for schools to improve their testing proficiency rates, as well as a number of economic “sticks” to address the issue underachieving schools. These incentives included the promise of better facilities and environments to schools achieving the NCLB’s objectives, but they also threatened underachieving schools with the loss of jobs and governmental intervention (Executive Summary). The NCLB act provides a unique opportunity for social research. This paper will test the effectiveness of NCLB in achieving improved test scores for Alabama school systems over a period of 9 years using a system of equations modified by the gradual switching regressions technique.

In addition to examining the effect of the No Child Left Behind Act on school systems in Alabama, this paper will also attempt to answer the question of the rate of returns to scale within the state. A search of this topic did not find the question addressed in the Alabama educational economic literature. The rate of returns to scale of Alabama school systems, but also the manner in which the NCLB may have affected the returns to scale will be explored in this study. While this normally would be a difficult procedure, the method in which it was analyzed in this paper will present an analysis unique to the field of educational economics.

While many papers have attempted to discern the overall impact of the No Child Left Behind Act on educational system components, such as test score quality and cost, very few have examined the educational system with the intent of looking for structural effects as well. While it is easy to add a dummy variable representing a policy to an equation, such a technique only evaluates whether or not the level of the entire equation changed. This paper implements a gradual switching regression technique utilized by Bacon and Watts (1971), Tsurumi (1983), Ohtani and Katayama (1986), and Moschini and Meilke (1989) to analyze possible intra equation effects of the NCLB act. A thorough search of the educational economic literature revealed that this technique has never been used to evaluate educational economic policy, indicating that many of the structural effects of the NCLB act may have yet to be evaluated. The most recent work by Moschini and Meilke titled “Modeling the Pattern of Structural Change in U.S. Meat Demand” used a gradual switching regression framework the identify specific changes that occurred in U.S. meat demand so that the industry might tailor marketing and production to the new climate. First using likelihood ratio tests to make global statements regarding the structural inconsistencies in U.S. meat demand, they moved on to identify specific structural shifts in the market (Moschini and Meilke).The question of structural changes occurring due to the NCLB act will be addressed in the same manner.

Specifically, this paper will examine the effect (if any) of the No Child Left Behind Act on the 67 county school systems of the state of Alabama. While the intent of this paper is to focus primarily on the effect of the NCLB on rural school systems, it should be noted that some counties in Alabama have separate schools systems for the large cities within the county. For example, in Lee County, a relatively small county in East Alabama containing 32 schools, there are separate school systems for the city of Auburn, the city of Opelika, and the county itself. However in Montgomery County, one of the state's larger counties, there is only one school system encompassing both the rural and urban schools (ALSDE).

The data used for this analysis was time-series and cross-sectional, covering the 67 county systems using annual data for the period 1999 to 2007. Data were converted to natural logarithms (excluding dummy variables) in order to produce elasticities from the coefficient estimates. For the estimates, a system of equations was used, including a production function based on Robert Solow's 1956 growth model (Solow), a cost function derived from the Solow model, and a reduced form quality equilibrium test score derived from Kinnucan, Zheng, and Brehmer (2004 work entitled "State Aid and Student Performance, a Supply-Demand Analysis").

For this analysis, this paper will consist of 5 sections. The first section is an introduction to NCLB and a general overview of the problem. The second section is a review of current and pertinent literature. Third is a section detailing the data and model specification used. Section four presents the regression results, and finally the fifth presents conclusions and recommendations.

II. REVIEW OF LITERATURE

A vast literature regarding educational determinants, effective resource allocation, and the No Child Left Behind Act can be found with a simple search on the internet, so it is important to highlight some of the more significant pieces as they relate to the analysis presented in this paper. Beginning with works relevant to the formation of the system of equations, this section will then proceed to review a selection of articles crucial to the understanding of the current educational economics literature.

As was mentioned in the introduction, this paper will attempt to estimate a system of equations in order to analyze the effect of the No Child Left Behind Act on various aspects of the educational system. The first equation in the system is a production function modeled after the one Solow proposed in his 1956 article "A Contribution to the Theory of Economic Growth". Solow proposed a model of long run growth, appearing in its initial form as equation (1).

(1) $Y = F(K,L)$

This simple production function models output (Y) as a function of capital (K) and labor (L). In the extensions section of the same article, Solow modifies the equation to reflect neutral technological change, indicated by equation (2)(Solow).

(2) $Y=A(t)F(K,L)$

With the addition of the technological change parameter A(t), the production function's isoquants are allowed to shift in and out without changing the structure of the function itself. This “increasing scale factor” (Solow) will be represented in this paper by the various county attributes which affect the given system’s Average Daily Admissions per school

The next work with significance to both this paper and the field in general is Kinnucan, Zheng, and Brehmer’s article “State Aid and Student Performance: A Supply-Demand Analysis.” In this piece, the authors use a supply-demand framework to specify a six-equation model in order to examine the relationship between governmental aid and pupils’ academic performance (Kinnucan et al). Using econometric techniques, the authors analyzed the effect of government aid on student performance and they also examined alternative determinants of student performance using variables such as income, poverty, property value, and parental education levels. The authors’ work concluded with several key findings, including statistical evidence from their data which indicated that increases in state aid led to a reduction in local funding (Kinnucan et al). Additionally, Kinnucan, Zheng, and Brehmer posited in their concluding comments that the same results of increasing state aid might also be achieved by the expansion of programs aimed at reducing county poverty or increasing average family income. The parsimonious demand and supply equations for educational quality estimated by Kinnucan, Zheng, and Brehmer serve as the basis for the equilibrium reduced form equation for test score quality used in this paper.

Another author whose work vastly contributes to an understanding of the state of the field of educational economics is Eric A. Hanushek. Specifically, Hanushek has produced several key works identifying problems in the area of academic achievement production functions. In his 2004 article “What if There Are No ‘Best Practices’?”, Hanushek indicates that there may be several obstacles preventing robust factor estimates from being obtained. One possibility he alludes to is the notion that "the achievement process is a complicated interactive one such that simple linear additive formulations break down" (Hanushek 2004). He illustrates this same point in his 1986 article "The Economics of Schooling: Production and Efficiency in Public Schools" where he creates tables indicating the wide ranging results for some of the more commonly appearing variables in the literature (Hanushek 1986). One such table is Table 1.0, included below.

Table 1. Summary of estimated effects from 147 education production function studies

School Input	Number of studies	Significant Positive	Significant Negative	Insignificant
Teacher-pupil ratio	112	9	14	89
Teacher education	106	6	5	95
Teacher experience	109	33	7	69
Teacher Salary	60	9	1	50
Expenditures per pupil	65	13	3	49

Source: Hanushek (1986)

One can quickly see the wide ranging sets of results for some of the more common variables. Not only were many of the variables found to be statistically insignificant well over 50% of the time, but some of the estimates that actually were statistically significant turned out to have inconsistent signs. In a 2005 article by Rivkin, Hanushek, and Kain, the authors indicate that some of the blame for inconsistent and conflicting research regarding academic achievement may lie with incomplete or improperly measured data sets (Rivkin et al). Finally, in a 2003 article, "The Failure of Input-Based Schooling Policies", Hanushek notes the massive importance that governments across the globe have placed on pouring resources into schools while achieving little success from these policies (Hanushek 2003). As one will discover upon reading in the model specification and results sections, this paper attempts to circumvent some of the problems noted by Hanushek.

One of the key techniques making this paper unique in the field of educational economics is the utilization of the gradual switching regressions technique as implemented by Bacon and Watts (1971), Tsurumi (1983), Ohtani and Katayama (1986), and Moschini and Meilke (1989), in analyzing the No Child Left Behind Act. Gradual switching regressions is a revolutionary technique affecting the manner in which one analyzes the effect of a change in policy or regime. After determining a basic structural specification, the following substitution is then made:

$$(3) \qquad \beta_k = \beta_k + \beta_k'\lambda_t$$

β_k represents all coefficients in a given function with K number of variables. β_k' represents the variable shift coefficient while λ_t serves as time path vector reflecting the following values:

$$(4.1) \qquad \lambda_t = 0 \;\; | \;\; t=0 \ldots t_1$$

$$(4.2) \qquad \lambda_t = (t-t_1)/(t_2-t_1) \;\; | \;\; t=(t_1+1) \ldots (t_2-1)$$

$$(4.3) \qquad \lambda_t = 1 \;\; | \;\; t= t_2 \ldots T$$

The variable t represents the current time while t_1 represents the starting point of a policies' implementation, and t_2 represents the point in time that the policy has reached one hundred percent implementation. As is readily apparent and was mentioned by

Moschini and Meilke, if $t_2 = t_1 + 1$, then the policy implementation is abrupt and the time path vector assumes the appearance of a standard dummy variable attached to each shift coefficient. Whereas a standard dummy variable appearing a single instance in a function only indicates whether or not there has been an overall change in the rate of production given a set level of inputs, gradual switching regressions allows the structure of the equation in question to change despite the output remaining the same. Thus, if a given policy affected the ratio of inputs, but not the level of output in a production function, a standard dummy variable would appear insignificant while the gradual switching regressions' shift coefficients would illuminate the effect. Using this technique, this paper is equipped to discover any structural changes occurring in the system of equations as a result of the No Child Left Behind Act.

In 1990, Ohtani, Kakimoto, and Abe used the aforementioned transition path but allowed it to shift as a polynomial of time in their article "A Gradual Switching Regression Model with a Flexible Transition Path." In this paper, the author tested various polynomials and selected the optimal one comparing Akaike's information criterion and Schwarz's criterion values. This paper will follow the technique as it was used by Konno and Fukushige (2002) in that it will test convex and concave time path vectors. However, this paper will not test for the *optimal* non-linear function. Rather, the aim of this paper will be to find the optimal t_1 and t_2 values in conjunction with the optimal functional shift form, be that a step up (abrupt), linear, concave, or convex function. The convex and concave vectors are formed by manipulating equation 4.2 into equation (5):

$$(5) \qquad \lambda_t = (t-t_1)/(t_2-t_1)^{\mathbf{Z}} \;\; | \;\; t=(t_1+1) \ldots (t_2-1)$$

In equation (5), the Z variable assumes the value of 0.5 to test a concave time path, 1 to test a linear time path, and 2 to test a convex time path.

Literature should also be examined regarding the No Child Left Behind Act itself in order to give the reader a sense of the policy actually being tested. According to the Department of Education Executive Summary (2002), the No Child Left Behind Act's (NCLB) overarching aim is to improve standardized test scores in the United States for primary school students and to specifically close the education gap between certain minority groups (Kim and Sunderman). The NLCB sets the commendable goal of 100% of students in grades three through eight reaching "proficient" levels of academic achievement in standardized testing within 12 years of the bill being signed into law (2014, as the 2001 act was actually signed into law in 2002). Part of the "teeth" of NCLB is the section regarding adequate yearly progress (AYP). According to the 2002 article by Linn, Baker, and Betebenner titled "Accountability Systems: Implications of Requirements of the No Child Left Behind Act of 2001," the definition of AYP was initially set by the House and Senate to mean an increase in percentage proficiency of at least one point per year. While this was later changed to allow states to set their own AYP rates it brings a particularly problem to light; states have different definitions of what it means to be"proficient". As mentioned by Linn et al, Louisiana, Mississippi, and Texas reported proficiency rates on the Grade 8 mathematics assessment as 7%, 38%, and 92% respectively in 2001. Given the initial required AYP rate of 1% a year, a state could meet AYP each year, yet not meet the overall goal of 100% unless its proficiency rate was already at 88% or higher (Linn et al). Therefore, not only is it a problem that states are allowed to possess different definitions of proficient, but they are allowed to define different AYP rates, making it virtually impossible to meet the 2014 goal of 100% proficiency (barring a change of standards).

However, despite the ambiguity regarding the AYP rates and proficiency levels, it certainly behooves a state and school district to meet AYP. The second section of the NCLB Executive Summary (2002) states:

> School districts and schools that fail to make adequate yearly progress (AYP) toward statewide proficiency goals will, over time, be subject to improvement, corrective action, and restructuring measures aimed at getting them back on course to meet State standards. Schools that meet or exceed AYP objectives or close achievement gaps will be eligible for State Academic Achievement Awards.

Thus, the NCLB has significant funding and job implications at the municipal and county levels. The "restructuring" of a school due to failure to meet AYP could mean the loss of jobs. Because of the significant positive incentives to meet or exceed AYP and the negative incentives discouraging failure, this paper has the potential to illuminate important shifts in various aspects of the educational system. In addition, this paper will be able to conjecture as to the effectiveness of the NCLB in meeting its stated goal of 100% proficiency in 2014.

Finally, a 2001 article, "Response to Skrla et al. The illusion of educational equity in Texas: a commentary on 'accountability for equity'", Walt Haney examines possible explanations of the "Texas Miracle" (Haney). The "Texas Miracle" was a phenomenon that occurred in the late 1990's regarding a near miraculous jump in the level of standardized achievement test proficiency within that state. Haney explained that such a jump could have occurred due to several reasons, but specifically focused on the manner in which the percentage of correct questions required to achieve proficiency was changed (Haney). He also points at that the change in percentage was made without sound academic explanation, indicating that it was indeed an unfounded manipulation of the system. While this did not affect the actual numerical results of the score, it did affect the levels of proficiency as reported in compliance with the NCLB act.

III. DATA AND THE MODELS

As was explained in the introduction, the purpose of this paper is to ascertain some of the effects of the No Child Left Behind Act (NCLB) using a system of equations and the gradual switching regressions technique. This paper is not an attempt to explain every single aspect of the educational system, nor is it an attempt to verify previous analysis of the NCLB. Rather, it is an exploratory effort to analyze the effects of the NCLB on some of the more critical components of the educational system, while at the same time obtaining robust coefficient estimates. To that end, the system of equations was estimated in the most parsimonious manner possible, leaving out some of the more popular variables in education literature.

Data Summary

Prior to an examination of the actual system of equations, it is useful to view a table of summary statistics in order to understand trends in the data that may be appear in estimation. As the NCLB act was first implemented in 2002 (Executive Summary), the data is split in two halves; 1999 – 2002 and 2003 – 2007. The results are displayed below in table 2.0. The first variable, Q, exhibits a very interesting trend over the split. While the standard deviations of the data remain relatively unchanged, the test score quality experiences a 3 point decrease on average from the first period to the second. Additionally, the per school expenditure experiences a significant increase, though it is largely explained by the near doubling of the maximum per school expenditure. Though

Table 2.0

Variable definitions and descriptive statistics (Upper number is for 1999-2002 (*nobs* = 268); lower number is for 2003-2007 (*nobs* = 335). Dollar amounts are expressed in constant 1982-84 dollars.)

Variable	Definition	Mean	SD	Min	Max
Q	Eighth-grade SAT test score, national percentile[a]	48 45	7.9 8.3	24 24	67 67
P_G	Total education expenditures, dollars per pupil	3,801 4,318	426 845	3,053 3,185	5,891 10,222
TSR	Student-teacher ratio	15.6 14.3	0.78 1.53	13.4 9.5	18.1 17.6
TPAY	Teacher salary, dollars per year	22,463 19,899	818 2,479	20,262 13,199	26,090 25,781
ENROL	Average daily attendance in county system, per school	454 443	127 126	209 225	770 824
INC	Median family income, dollars	17,556 17,179	3,726 3,682	10,258 9,895	34,524 33,095
RACE	Nonwhite student enrollment, percent	38.4 39.1	31 30.9	0.1 0.3	100 100
POV	Poverty rate, percent	22.6 24.8	5.9 7.2	7.3 7.4	41.8 43.3
UNEMP	Unemployment rate, percent	5.8 5	2 1.7	1.5 2.3	13 11.3
RURAL	Rural county, dummy variable	0.74 0.72	0.44 0.45	0 0	1 1

many of the other variable remained relatively unchanged, the other interesting finding yielded by the summary statistics is the drop in deflated TPAY over the two periods. All of these signs indicate a decrease in test score quality coupled with an increase in cost as time progresses over the 9 year set. Specific definitions of data manipulation and sources can be found in appendix A.

Production Function

The first equation estimated in the system is a slightly modified version of Robert Solow's 1956 growth model. This equation was previously mentioned in the literature review as equation (1). Much of the previous educational economics literature regarding test scores has viewed academic achievement as an output of a production function. Table 1.0 from Hanushek's 1986 article was a study of 147 production functions where some variation of academic achievement served as the output variable. With one goal being an elucidation of the effects of NCLB on the educational system, it is felt that a more accurate use of the production function was one that examined the actual unit of school output, namely enrollment (Enrol). Thus, the ENROL variable as used as the dependent variable in our production function is defined to be average daily admissions per school within the county level school system. Average daily admission is the term used to label the 30 day, K-12 attendance average which is used on a system by system basis to quantify yearly enrollment (ALSDE). All appropriate variables have been divided by the number of schools contained within the county system in order to obtain a per school average for each variable. This is the best method for a variety of reasons. First, it allows for the system of equations to make statements regarding the school as a firm, which is the proper implementation of Solow's 1956 growth model. Second, it should be noted that test scores as reported in the Alabama State Department of Education Annual Reports (ALSDE) are averages for the county and city systems. Finally, the NCLB's rewards and corrective actions are based on a per school basis (Executive Summary), not on a per pupil basis. Thus, a larger unit of analysis would not capture as much detail while a smaller unit of analysis would misconstrue reaction to the NCLB as being on a per pupil basis rather than per firm basis.

Next, variable selection was requisite for the two components of a production function, namely capital and labor. The capital variable is a particularly difficult one to define given the aggregated nature in which school expenditures are reported. Thus, this paper chose to define capital as being non-instructionally related expenditure, to clearly differentiate it from the educational labor variable. Solow, in his 1956 piece, does not refer to capital using the current financial definition of the word capital, but instead noted that “Output is produced with the help of two factors of production, capital and labor” (Solow). The sum of all non-instructional expenditures was gathered for each county system and divided by the number of schools within that system to generate a non-instructional expenditure variable (NIE). The NIE variable was then deflated using consumer price indexes (CPI) from the Bureau of Labor and Statistics (BLS CPI), using 1982 – 1984 as a base value of 100. All financial calculations from this point on will be deflated in the same manner.

The second important factor of production utilized in Solow’s growth model is labor, a much easier variable to identify and implement. While it can be argued that all laborers at the school level can have an effect on the number of students produced by a school, this paper believes that the obvious choice for this variable is number of full time equivalent teachers. This statistic was gathered on a county system basis from the National Center for Education Statistics (NCES) Common Core of Data (CCD), and was then divided by the number of schools within the system to produce an average number of full time equivalent teachers per school (NCES). This variable (TEACH) was then utilized as the "L" in Solow's growth model.

The other important aspect of Solow's growth model is found in the previously mentioned extension, which is the addition of a technological shift function A(t). This paper felt that the most crucial variables with which to analyze base levels of technology were average standardized test scores (TS) and poverty level within the county (POV). For this paper, eighth grade standardized test scores were selected as the measure of TS, taking the average of the county systems' scores for reading, mathematics, and language garnered from the ALSDE annual reports. The POV variable was gathered using national census data and the government census website's SAIPE function, generating values for the percentage of children aged 5-17 per county in families in poverty (Census Bureau).

A lagged dependent variable was also added to the equation in order to test it as a form of partial adjustment model in which the system attempts to adjust each year toward an optimal equilibrium level (King and Thomas). Furthermore, the use of a lagged dependent variable allows this paper to examine the amount of memory within the system regarding enrollment per school. Thus, the final growth model with new variables replacing Solow's original ones results in the specification of equation (6.1)

(6.1) $ENROL = F(NIE,TEACH)A(TS,POV,ENROL^{-1})$

Prior to estimation, the natural logarithm was taken of all data excepting dummy variables in order to obtain elasticities with the final coefficient estimates. In order to examine some of the cross-sectional and time-series effects of the panel data set, a time trend variable was added to all three equations as was a set of district dummy variables. According to the ALSDE website, the state of Alabama is divided into seven different school districts containing all 67 counties (ALSDE). District 5 was withheld as a control variable. Thus a final double log model with a time trend and district dummy variables is represented in equation (6.2):

$$(6.2) \quad \ln(Enrol) = \alpha_0 + \alpha_1 \ln(NIE) + \alpha_2 \ln(Teach) + \alpha_3 \ln(TS) + \alpha_4 \ln(POV) + \alpha_5 \ln(Enrol^{-1}) + \alpha_{6\text{-}11}(D1\text{-}D7) + \alpha_{12}(t) + \varepsilon$$

Cost Function

The second equation in the system of equations is the cost function. Using standard economic theory, the cost function can be derived from Solow's production function to yield equation (7). The mathematical procedure behind this derivation can be found in appendix B of this paper.

$$(7.1) \quad C = (r,w,Q,t)$$

This function contains the same output label as the dependent variable of equation (6.2), namely Enrol, as well as the same vector of variables "t" located in the technological shift function. However, the equation differs exogenously with the appearance of the variables r and w, which represent the input factor prices of NIE and TEACH respectively. For the sake of this paper, the price of NIE will be represented by the percentage of non-instructional expenditure (PNIE) per school relative to its total expenditure. This is an accurate representation of the price of NIE because a higher value of PNIE indicates that a larger portion of the given system's budget is being consumed by NIE, versus a different system in which NIE is the same, but PNIE is lower due to a larger budget. PNIE was gathered from the ALSDE annual report by dividing the non-instructional system expenditures by the total expenditures for that system (ALSDE).

The input factor price used in the cost function relative to labor is average instructional expenditure per teacher (TPAY). This variable was generated by taking the sum of each county system's yearly instructional and instructional support expenditures (found in the ALSDE annual reports) and dividing them by the total number of full time equivalent teachers within that county (ALSDE). Those familiar with Alabama's educational system might object to this characterization on the grounds that teacher's salary In Alabama has been determined by a pre-set pay matrix since the late 1990's (ALSDE). However, the identification of the cost of labor as this paper's definition of TPAY is superior for three reasons. First, while Alabama teacher pay is set by a pay matrix based on degree achieved and number of years in service, the pay matrix does not account for temporary incentives used to hire teachers to different systems. Second, while this paper used the number of full time equivalent teachers as a definition for labor, instructional and instructional support expenditures also encompass the number of temporary and substitute teachers hired to bolster a given systems instructional labor pool. These may be viewed as a subsidy, in that the full time equivalent laborers have their labor load reduced while not having their pay cut. Therefore, the expenditures on additional resources and temporary laborers should be added to the full time equivalent teachers' average pay in order to reflect the additional benefit. Finally, using this definition gives the variable the necessary variation required to generate testable hypotheses, which otherwise would have been ignored by a procedure considering teacher pay to be strictly defined by the pay matrix. The numbers generated by this variable were also deflated using the same method as the financial variables in the production function.

The endogenous variable representing cost in this function is average per school expenditure per county system (PG). This variable was acquired by taking the sum of the State Funding, Federal Funding, Local Funding, and Other Funding values in the ALSDE annual reports and dividing the sum by the number of schools within that system (ALSDE). As with other financial variables, the cost variable was deflated using BLS CPI's (BLS CPI), resulting in the final computed variable PG. In the same manner as the production function, the cost function followed the partial adjustment model framework by added a lagged dependent variable, PG^{-1}. After computing the natural logarithm of all non-dummy variables as well as inserting a time trend and a set of district dummy variables, the final cost function equation can be written as equation (7.2).

$$(7.2) \quad \ln(PG) = \beta_0 + \beta_1 \ln(PNIE) + \beta_2 \ln(Tpay) + \beta_3 \ln(TS) + \beta_4 \ln(POV) + \beta_5 \ln(Enrol) + \beta_6 \ln(PG^{-1}) + \beta_{7\text{-}12}(D1\text{-}D7) + \beta_{13}(t) + \varepsilon$$

This specification yields several interesting results and testable hypotheses which will be explored in the results section of this paper. It should be noted that the coefficient of the production function endogenous variable found in the cost function will denote the short run returns to scale in elasticity form. A cursory exploration of the literature indicates that this statistic has never been discovered in reference to the Alabama county school systems. Additionally, upon obtaining the short run returns to scale, the following restriction may be tested to examine long run returns to scale:

$$(8) \quad 1.0 = \beta_5/(1- \beta_6)$$

In theory, the long run returns to scale of the firm should result in a one to one ratio of production increases to cost increases. An additional testable hypothesis per the mathematical theory found in appendix 1 would be the notion that the coefficient of output in the cost function is equal and opposite in sign to the sum of the coefficients of the technological shift parameters carried from the production function. Equation (9), if true, would indicate that county school systems are operating as cost minimizing firms.

(9) $\beta_5 = \beta_3 + \beta_4 + \beta_{7\text{-}12} + \beta_{13}$

These theories will be examined using Wald coefficient tests upon the estimation of the final system of equations.

Test Score Equilibrium

The test score equilibrium is largely based on the theory and technique of Kinnucan, Zheng, and Brehmer's 2002 article "State Aid and Student Performance: A Supply-Demand Analysis". Initially, the test score equation was specified as the demand function equation (10), reflecting the counties' demand for a certain test score quality, TS, as indicated by a vector of demand variables X and a price for that quality of test score, P.

(10) $TS_d = d(P,X)$

Using the supply equation for test scores, equation (11), and a definitional equation for price, equation (12), the equilibrium price was then computed by setting the supply and demand equations' values for TS equal to each other. Substituting the equilibrium price back into either test score equation then yielded the equilibrium test score, equation (13), which is a reduced form function of the exogenous variables found in equations (10) and (11).

(11) $TS_s = s(P,Z)$

(12) $P = C/Q$

(13) $TS = f(X,Z)$

By using a reduced form equation to indicate the test score resulting from equilibrium, this paper captures both the supply of test score quality by the system as well as the demand for test score quality by the citizens of the respective counties.

For the purpose of this paper, the endogenous test score variable (TS) is defined as the average of eighth grade students' scores in reading, language, and mathematics by county system. The grades used to measure school system AYP are 3 through 8 (Executive Summary 2002), and I selected the last grade used in the AYP evaluation was selected as the level at which to examine the test score equilibrium.

The variable vectors X and Z were established using the same theory and reasoning as Kinnucan et al, with the supply variables being teacher student ratio (TSR), average teacher pay (TPAY), a rural county dummy (Rural), and the same poverty variable used in the production and cost functions (POV). The demand variables used were average county income (INC), county unemployment levels (UNEMP), and a racial demographic variable (RACE).

The TSR variable is a statistic obtained from the NCES CCD, reported specifically as the number of pupils per teacher within the specific county system (NCES). The rural county dummy variable is a standard dummy variable denoting the different overall classifications of the counties as being "rural" or "urban" counties as defined by the University of Alabama's Center for Business and Economic Research (University of Alabama). The TPAY and POV variables appearing in the supply vector maintain the same definitions as used in the cost and production functions.

Again, using the same selections as Kinnucan et al, the first demand vector variable is income. The INC variable was generated using the United States' government census website's SAIPE function to estimate median family income per county per year (Census Bureau). This variable was then deflated in the same manner as the previously mentioned financial variables. The second demand vector variable used is unemployment. This variable was obtained via the BLS website (BLS LAES), recording values for county level, annual unemployment. The final demand vector variable used by Kinnucan et al was a percentage non-white racial demographic variable. Until 2007, these statistics were reported by the ALSDE annual reports for each county and city school system (ALSDE). Due to the small level of variance over the previous 8 years, the final year was estimated using a weighted average. However, one must remember that this variable continues to be very important, especially with regards to the NCLB act. Not only must each overall system make appropriate AYP gains towards 100% proficiency, but the specific demographic groups identified by the NCLB legislation must make appropriate AYP as well (Kim and Sunderman).

Thus, with the demand and supply variable vectors identified, the final linear equation will be estimated as equation (14) following the addition of cross sectional dummies and a trend variable. As with the production function and cost functions, a lagged dependent variable has been added to maintain the partial adjustment model framework.

$$(14) \quad \ln(TS) = \gamma_0 + \gamma_1 \ln(Race) + \gamma_2 \ln(Inc) + \gamma_3 \ln(Unemp) + \gamma_4 \ln(TSR) + \gamma_5 \ln(Tpay) + \gamma_6 (Rural) + \gamma_7 \ln(Pov) + \gamma_8 \ln(TS^{-1}) + \gamma_{9\text{-}14}(D1\text{-}D7) + \gamma_{15}(t) + \varepsilon$$

Gradual Switching Regressions

As was previously mentioned in the introduction and literature review, the heart of this paper's analytical power regarding the No Child Left Behind Act is the use of linear and non linear gradual switching regressions. However, one must first find the optimal time path vector to use for each equation prior to estimating a final set of results. The equations (6.2), (7.2), and (14) that were previously specified in this section were then subjected to a substitution using equation (3) that was explained in the literature review section. This gives each constant and variable its own corresponding shift coefficient, though all shift terms in each equation are multiplied by the same time path vector. Using these new equations, the system was then tested for the optimal time path vector for each equation.

To find the optimal time path vector, all possible combinations of t_1 and t_2 were tested beginning in 2001, when the bill was first passed (Executive Summary). Though it could be argued that schools could begin altering their educational systems in anticipation of the passage of the bill, it was deemed unlikely due to the tendency of the data to prefer the latter time points. Each possible t_2 value was tested in conjunction with each possible t_1 value until the year 2008. It should be noted that the year 2008 is beyond the scope of the available data set, which allows for the data to indicate that the full effect of the NCLB has not yet been achieved. The different possible vectors of λ_t, as defined by equations (4) and (5), are listed in appendix C. The different combinations resulted in 84 testable time path vectors. The explanatory power of the different time paths was then compared by ranking the resulting R^2 values for each regression. The rankings produced from these tests are available in appendix D. The rankings resulted in optimal t_1 and t_2

values of 5 and 7 respectively for the production function, using the non-linear convex time path. These values indicated that the NCLB began to have an effect on the production function in 2003, reached 25% of that effect by 2004, and had taken its full effect by the end of 2005. However, the rankings resulted in optimal t_1 and t_2 values of 6 and 7 for both the cost function and the test score quality equilibrium. These values indicate that the full system adjustment caused by the NCLB occurred from 2004 to 2005. These values correspond with the 2002 article by Linn, Baker, and Betebenner which noted that the NCLB act would have achieved full legislative implementation by the end of the following year (Linn et al). It can then be observed that while the effects of the NCLB on the production function were felt at an accelerating rate over the course of 2 years beginning in 2003, the effects on the cost function and test score equilibrium took the form of a standard dummy variable between the years 2004 and 2005. By testing the multitude of different combinations of time path vectors, this paper allowed the data set to indicate the proper time at which the impact of the NCLB act was felt, rather than assigning such a time capriciously.

Using the newly found optimal time path vectors for the respective equations, the constant shift and slope shift coefficients were subjected to a series of Wald tests, the results of which are found in table 3.0. The execution of these Wald coefficient tests allowed several very important statements to be made. The first test, restricting the all constant and slope shift coefficients to zero, was rejected at the 1% level. This rejection allows the blanket statement to be made that the NCLB act definitely created statistically significant changes in the structure of the education system. The next two tests specifically tested all of the slope shift coefficients and all of the constant shift coefficients in two separate groups.

Table 3.0 Restriction = Zero	Test Stastistic	Value	DoF	Probability
All Shift Coefficients	Chi-square	180.473	22	0
All Slope Coefficients	Chi-square	88.13429	19	0
All Constant Terms	Chi-square	7.148532	3	0.0673
Production Slopes	Chi-square	40.91271	5	0
Cost Slopes	Chi-square	29.94037	6	0
TS Slopes	Chi-square	17.28121	8	0.0273
Production Constant	Chi-square	0.710104	1	0.3994
Cost Constant	Chi-square	5.941915	1	0.0148
TS Constant	Chi-square	0.496513	1	0.481

While the restriction of the slope shift coefficients to zero was rejected at the 1% level, the constant shift coefficients failed to reject at the 5% level, indicating that some of the equations might not have experienced an overall shift, but only a structural shift. The slope shift coefficients were then jointly tested for each individual equation, and all rejected the restriction to 0 at the 5% level or better, indicating definite evidence of statistically significant structural change. However, of the constant term coefficients, only the cost function rejected the restriction at the 5% level. This indicates that while there was an overall shift in the behavior of the cost function due to reaction to the NCLB act, there was only structural change within the production and test score functions (which presumably would not have been recognized with the use of a standard dummy variable). With the knowledge that the constant shift coefficients for the production function and test score equilibrium function failed to reject the restriction to zero, they were then dropped from the final system of equations.

Next tested was the system of equations for insignificant and jointly insignificant slope coefficients. One of the difficulties of using the gradual switching regressions technique is that its initial implementation effectively doubles the number of variables in each equation. Thus, a high degree of multicollinearity and insignificant t values begin to occur. Testing the insignificant slope shift coefficients for joint significance yielded interesting results, located in table 4.0. While only one slope shift coefficient was insignificant in the production function, there were several insignificant slope shift coefficients in the cost function and test score equilibrium function. The joint Wald coefficient tests of these sets of slope shift coefficients resulted in a failure to reject either restriction at the 5% level. Thus, with these coefficients resulting in insignificant values on both the individual and the joint levels, they were dropped from the final equation.

Table 4.0

Restriction to zero	Test Stastistic	Value	DoF	Probability
Insignificant Production Slope Shifters	Chi-square	4.827597	4	0.3054
Insignificant Test Score Slope Shifters	Chi-square	4.324057	6	0.6329

Utilizing the Wald test results to created the most parsimonious system of equations possible, the final system of equations was specified as equations (15), (16), and (17).

(15) $\ln(Enrol) = \alpha_0 + \alpha_1 \ln(NIE) + \alpha_1' \lambda_{nlv15} \ln(NIE) + \alpha_2 \ln(Teach) + \alpha_2' \lambda_{nlv15} \ln(Teach) + \alpha_3 \ln(TS) + \alpha_4 \ln(POV) + \alpha_4' \lambda_{nlv15} \ln(POV) + \alpha_5 \ln(Enrol^{-1}) + \alpha_{6\text{-}11}(D1\text{-}D7) + \alpha_{12}(t) + \alpha_{12}' \lambda_{nlv15} (t) + \varepsilon$

(16) $\ln(PG) = \beta_0 + \beta_0' \lambda_{nlv19} + \beta_1 \ln(PNIE) + \beta_2 \ln(Tpay) + \beta_2' \lambda_{nlv19} \ln(Tpay) + \beta_3 \ln(TS) + \beta_4 \ln(POV) + \beta_5 \ln(Enrol) + \beta_6 \ln(PG^{-1}) + \beta_{7\text{-}12}(D1\text{-}D7) + \beta_{13}(t) + \beta_{13}' \lambda\, \lambda_{nlv19} \ln(t) + \varepsilon$

(17) $\ln(TS) = \gamma_0 + \gamma_1 \ln(Race) + \gamma_2 \ln(Inc) + \gamma_3 \ln(Unemp) + \gamma_3' \lambda_{nlv19} \ln(Unemp) + \gamma_4 \ln(TSR) + \gamma_5 \ln(Tpay) + \gamma_6(Rural) + \gamma_7 \ln(Pov) + \gamma_8 \ln(TS^{-1}) + \gamma_{9\text{-}14}(D1\text{-}D7) + \gamma_{15}(t) + \gamma_{15}' \lambda_{nlv19} \ln(t) + \varepsilon$

A quick point should be mentioned regarding these final three specifications. The differing values of λ_t (λ_{nlv15} and λ_{nlv19}) indicate the differing optimal time paths for the production function versus the cost function and test score equilibrium.

IV. RESULTS

Equations (15), (16), and (17) that were specified in the data and models section were then estimated using Eviews standard version 6.0 in a variety of different specifications. The system of equations was estimated using ordinary least squares, seemingly unrelated regressions, and three stages least squares to test for the systems sensitivity to different methods of estimation. As mentioned in the data and models section, the natural logarithm of the data was taken for the first set of estimations. The system was estimated an additional three times using the same respective estimation techniques, but after having taking the first difference of the logged data. Though this sacrificed an additional year of the data set, the degrees of freedom remained adequate while allowing for an examination of the sensitivity of the data to manipulation. The results have been organized by data type and equation, yielding the following 6 tables; two for each equation using the two different data manipulations. One must also keep in mind the fact that these coefficient estimates are elasticities. The elasticities indicate the manner in which the dependent variable will respond to a percentage change in the exogenous variables.

For those unfamiliar with the gradual switching regression technique, it is important to take note of the proper manner in which to interpret the variable "Shifter" results. The shift coefficient only affects the initial coefficient in the years following t_1, which the reader will remember as the starting point of a policy's effect used in constructing the time path vector λ_t. The manner of the shift coefficient's effect is evaluated by adding the shift coefficient (multiplied by the value of λ_t) to the initial coefficient. When the policy has taken its full effect, that is when $\lambda_t = 1$ or $t_2 = t$, the full value of the shift coefficient may be added to the initial coefficient to demonstrate the total effect. However, when $t_2 - t_1 > 1$, one must remember that the policy (and thus the shift coefficient) only takes a partial effect in the years between t_1 and t_2, as mitigated by the factional value of λ_t.

The first estimation of the system of equations used simple logged data to generate results in elasticity form. The results found on the next page in table 4.0 show the parameter estimates for the production function using the three different estimation techniques. The t-statistic for each respective estimate is shown immediately below in parentheses. The number of asterisks denotes the level of significance, with three indicating significance at the 1% level, two indicating the 5% level, and one indicating the 10% level.

While there were several points of consistency between the three estimation methods, the three stage least squares estimation technique created several results that were inconsistent with the other two methods of estimation. Though this could be a testament to the fact that coefficient estimates were not as robust as expected, it could also be attributed to model misspecification error due to the instruments select for the 3SLS procedure. Therefore, the primary focus of this result analysis will be with the OLS and SUR results in mind. The first result of note in table 5.0 is the coefficient attached to the expenditure variable (NIE), which was used to denote capital in Solow's 1956 growth model (Solow). It is positive, as expected, and significant at the 5% level in both the SUR and OLS results, though it appears to be negative in the 3SLS results.

Table 5.0 - Parameter estimates of the Production Function using logged data

Variable/ statistic	OLS	SUR	3SLS
Constant	0.956565***	0.820972***	1.450054**
	(-6.206649)	(5.439402)	(2.183284)
NIE	0.024194**	0.044066***	-0.250229***
	(2.555719)	(4.771872)	(-3.99992)
NIE Shifter	0.045953***	0.044086***	0.668971***
	(5.113418)	(5.113912)	(5.333546)
TEACH	0.520986***	0.534549***	1.41098***
	(18.17275)	(19.40147)	(6.837442)
TEACH Shifter	-0.120459***	-0.114261***	-1.625993***
	(-5.025552)	(-4.974109)	(-5.21512)
TS	0.021692	0.025066	0.043661
	(1.269695)	(1.49114)	(0.574705)
POV	0.016748	0.019026	0.547698***
	(1.14392)	(1.331484)	(3.847472)
POV Shifter	-0.067615***	-0.065321***	-1.203331***
	(-4.091614)	(-4.133209)	(-4.444053)
Lagged ENROL	0.477895***	0.446067***	0.229763**
	(19.25274)	(18.66777)	(2.28813)
D1	-0.009884	-0.010392	-0.029632
	(-0.907145)	(-0.969346)	(-0.779014)
D2	0.013951**	0.015271**	0.02862
	(2.236375)	(2.48801)	(1.313637)
D3	0.023531***	0.024814***	0.058649**
	(3.085967)	(3.308449)	(2.143443)
D4	0.008547	0.010828	-0.0097
	(0.781904)	(1.006861)	(-0.252605)
D6	0.002726	0.004605	0.0506
	(0.265886)	(0.456724)	(1.365251)
D7	-0.018942***	-0.018437***	-0.012228
	(-2.75959)	(-2.729913)	(-0.509923)
Trend	0.007023***	0.006749***	-0.003799
	(3.176632)	(3.105076)	(-0.429527)
Trend Shifter	-0.014185***	-0.015346***	0.038035
	(-3.248285)	(-3.575671)	(1.445726)
R Squared	0.968478	0.968115	0.611748
Adj. R Squared	0.967506	0.967132	0.599779

The SUR result indicates that a 10% increase in the level of capital would create a 0.44% increase in the number of students per school within that county system, which would suggest that capital levels are fairly inelastic relative to enrollment. Furthermore, the NIE shifter is positive and significant at the 1% level using all three estimating techniques, which indicated that the NCLB act increased the importance of NIE as it affected ENROL.

The other primary factor used in the production function, labor or the number of teachers per school, produced a coefficient estimate greater than .5 and significant at the 1% level using all three methods of estimation. Compared to facilities and non-instructional expenditure, it would appear that the instructional labor is vastly more important. However, the universal result following this estimate is that the NCLB act mitigated the impact of TEACH as it affects the number of students per school. Thus, the tradeoff between the production factors would appear to be an increased importance on capital resulting from the NCLB with a decreased importance on the number of teachers per school.

As for the technology function affecting the level of ENROL, there was mixed significance among the district dummies, but consistent positive results for the lagged dependent variable, indicating a moderate degree of memory within the system. In addition, the trend variable alluded to a positive trend prior to the impact of the NCLB act, but with a change toward a negative trend utilizing the shift variable. These results for the changes to the trend variable were significant at the 1% level in both the SUR and OLS methods of estimation. In addition, it was surprising to see that test score quality had no effect on the number of students per school. This would seem to say that a school's enrollment is not affected by the standardized achievement test results of the students.

Table 6.0 examines the coefficient estimates as provided by the 3 methods of estimation on the double log model with respect to the cost function. Most interesting in this set of results are the first two results, indicating a positive constant and constant shift term at the 5% level using both OLS and SUR. As was indicated by the Wald tests conducted in the data and models sections, the cost function was the only equation to exhibit an overall change due to a shift in the constant term. However, the shift was not an intuitive one, nor one that the U.S. government would appreciate. The constant shift coefficient of the cost function was 3.62, indicating that base costs increased as a result of the NCLB legislation. Coupled with the result of an insignificant effect on the test score quality equilibrium, this would point to a series of unexpected results coming from the NCLB.

However, as expected, the input factor prices PNIE and TPAY both exhibited positive signs with economic and statistical significance using all three methods of estimation. While the level of the factors did not have equal importance relative to the production function, the level of the prices of the factors have almost equal elasticities. Furthermore, the OLS and SUR results indicate a negative shift in the elasticity of TPAY, significant at the 1% level. This can be interpreted as teacher's wages becoming less contributory to the level of per school expenditure following the passage of the NCLB, which correlates with the drop in importance exhibited by the production function coefficient results for TEACH.

Again, one must be cognizant of the fact that the coefficients estimated by these regressions are elasticities. While the blanket statement may be made that the average teacher salary decreased in importance relative to the per school expenditure, the actual cause of this effect could have been brought about in many ways. It could be the case that

PG experienced and increase while TPAY remained the same, which would cause the absolute value of the coefficient of TPAY to decrease. Conversely, average teacher

Table 6.0 - Parameter estimates of the Cost Function using logged data

Variable/ statistic	OLS	SUR	3SLS
Constant	3.336715**	3.251405**	3.303595
	(2.448731)	(2.491728)	(1.146231)
Constant Shifter	3.624889**	2.80551**	2.98544
	(2.456522)	(1.98617)	(0.787628)
PNIE	0.500932***	0.493962***	0.521096***
	(14.84039)	(15.01227)	(14.56061)
TPAY	0.601847***	0.688032***	0.662643**
	(4.658093)	(5.567387)	(2.380237)
TPAY Shifter	-0.380992***	-0.301908**	-0.369103
	(-2.588709)	(-2.142354)	(-1.000537)
ENROL	0.937191***	1.039623***	0.99328***
	(24.9582)	(28.81375)	(23.57448)
TS	-0.05292	-0.084735**	-0.066623
	(-1.464571)	(-2.385232)	(-1.364486)
POV	-0.0237	-0.027327	-0.022947
	(-0.911799)	(-1.068965)	(-0.762301)
Lagged PG	0.002239	-0.086897**	-0.054147
	(0.06276)	(-2.54769)	(-1.352329)
D1	0.054284**	0.05597**	0.057188**
	(2.367689)	(2.481338)	(2.364506)
D2	-0.046565***	-0.049524***	-0.048173***
	(-3.526639)	(-3.81446)	(-3.453693)
D3	-0.031441**	-0.034183**	-0.031729*
	(-1.967977)	(-2.175404)	(-1.879332)
D4	-0.027072	-0.0378*	-0.031555
	(-1.178422)	(-1.672812)	(-1.291277)
D6	-0.059296***	-0.05761***	-0.058852***
	(-2.775262)	(-2.740606)	(-2.626849)
D7	-0.012571	-0.008368	-0.010412
	(-0.869772)	(-0.588423)	(-0.684445)
Trend	0.019785***	0.02147***	0.007575
	(4.810428)	(5.309977)	(1.256227)
Trend Shifter	0.039525***	0.047904***	0.123275***
	(3.892197)	(4.812781)	(4.524076)
R Squared	0.876775	0.873379	0.860313
Adj. R Squared	0.872976	0.869476	0.856006

salaries could have experienced a real decrease over the period while PG remained constant, which would also diminish the value of the elasticity. It could have also been a combination of the two factors. The important fact to remember is that this elasticity represents the contributory power of a change in TPAY relative to the overall cost per school, PG.

One of the additional objects of this paper was to examine the rate of returns to scale in Alabama county school systems. The coefficient of ENROL, which represents the production function output as it appears in the cost function, is not only significant at the 1% level using all three methods of estimation, but it is very close to one. This indicates that, in the short run, a 1% increase in enrollment per school creates almost a perfect 1% increase in the expenditure per school, or constant returns to scale.
This result alludes to the notion that county school systems in Alabama are very close to, if not already at, the point where the marginal cost of adding an additional student is equal to the average cost of all students. This level is the point at which a cost minimizing firm would optimally operate.

One of the more surprising results, again, was the lack of impact by the TS variable on cost. Though the NCLB act in theory would force TS to have an effect on cost, the data did not indicate such a reaction. However, the data did indicate a statistically significant increasing cost trend at the 1% level with increase in the rate made by the Trend Shifter variable after the impact of the NCLB act began to be felt. The shifter was significant at the 1% level using all three techniques while the trend was significant in only two.

Some of the more disappointing results were those coefficient estimates yielded by the test score quality equilibrium equation in Table 7.0, though the testable ones were

Table 7.0 - Parameter estimates of the Test Score Equilibrium using logged data

Variable/ statistic	OLS	SUR	3SLS
Constant	0.224959	0.33324	0.389978
	(0.256138)	(0.386253)	(0.417537)
RACE	-0.024875***	-0.024914***	-0.024949***
	(-5.126557)	(-5.229089)	(-5.223791)
INC	0.106527*	0.104445*	0.103285*
	(1.922974)	(1.920052)	(1.874572)
UNEMP	-0.003118	-0.004406	-0.006523
	(-0.13734)	(-0.197658)	(-0.240902)
UNEMP Shifter	-0.082255***	-0.082008***	-0.080098*
	(-4.049024)	(-4.109011)	(-1.748937)
Lagged TS	0.674526***	0.673741***	0.672546***
	(22.2129)	(22.58616)	(22.46186)
TSR	-0.02558	-0.010205	0.001567
	(-0.357657)	(-0.145291)	(0.021694)
TPAY	0.023691	0.011521	0.004683
	(0.338705)	(0.167649)	(0.063752)
RURAL	-0.004648	-0.00412	-0.003928
	(-0.524294)	(-0.473262)	(-0.449358)
POV	-0.022042	-0.023048	-0.023452
	(-0.623785)	(-0.664065)	(-0.6534)
D1	-0.018507	-0.018328	-0.018255
	(-1.059712)	(-1.06759)	(-1.062154)
D2	-0.019968*	-0.020486**	-0.020964**
	(-1.927857)	(-2.012276)	(-2.043679)
D3	-0.019801	-0.020734	-0.021514
	(-1.49291)	(-1.590489)	(-1.634407)
D4	-0.039862**	-0.039978**	-0.040246**
	(-2.291951)	(-2.338352)	(-2.352571)
D6	-0.050851***	-0.051445***	-0.051971***
	(-2.77489)	(-2.85654)	(-2.883987)
D7	-0.030859**	-0.030679**	-0.030439**
	(-2.393758)	(-2.421584)	(-2.400721)
Trend	-0.002761	-0.002778	-0.00265
	(-0.867416)	(-0.887753)	(-0.686881)
Trend Shifter	0.013848***	0.013754***	0.013257
	(2.585229)	(2.613307)	(1.128655)
R Squared	0.824931	0.824914	0.824877
Adj. R Squared	0.819186	0.819168	0.819129

generally consistent with the results found by Kinnucan et al in 2004. As was discovered in “State Aid and Student Performance, a Supply-Demand Analysis”, the Race variable yielded a slight negative coefficient using all three methods of estimation, significant at the 1% level. Additionally consistent was the estimation of a positive coefficient attached to the income variable, significant at the 10% level using all three estimation methods. This would confirm the recommendation made by the authors that one of the most effective manners in which to boost test scores would be to stimulate county economies, rather than to pour money directly into schools (Kinnucan et al). However, this could be interpreted as a genetic effect; scilicet that the progeny of high income earners are likely to succeed in the same manner as their parents.

With the exception of some varying statistically significant cross sectional results yielded by the dummy variables, the final notable result of the test score quality equilibrium equation was the elasticity of 0.67 attached to the lagged dependent variable, which was found to be significant at the 1% level using all three methods of estimation. This, again, indicates a high degree of memory in the system. While it may not be a result that pleases policy makers, it would seem to indicate that test scores for different districts have remaining relatively consistent over the 9 year period.

Table 8.0 marks the first of the three sets of tables in which the first difference of the logged data was taken prior to estimation. The results in these three table serve as confirmations of the robustness of some of the variables, while it casts doubt on others. The first equation estimated was the production function.

This set of estimations yielded some consistent results as well as some inconsistent results. The first results were the confirmation of the positive sign and 5% or better levels of significance of the two primary production factors, NIE and TEACH.

Table 8.0 - Parameter estimates of the Production Function using differenced data

Variable/ statistic	OLS	SUR	3SLS
Constant	-0.007582**	-0.007462**	-0.017591**
	(-2.018254)	(-2.019227)	(-2.267886)
NIE	0.025113**	0.032289***	-0.194723**
	(2.051473)	(2.688294)	(-2.346521)
NIE Shifter	0.01892	0.020543	0.510446***
	(1.059963)	(1.174948)	(3.035636)
TEACH	0.749805***	0.745858***	1.520644***
	(16.94831)	(17.17216)	(12.09249)
TEACH Shifter	-0.564828***	-0.561919***	-1.572283***
	(-10.81307)	(-10.95996)	(-9.809108)
TS	-0.018171	-0.007596	-0.404835***
	(-0.66676)	(-0.283401)	(-2.948979)
POV	0.024034	0.022687	1.063175***
	(0.517148)	(0.497546)	(5.246066)
POV Shifter	-0.141355**	-0.143538***	-1.729573***
	(-2.520932)	(-2.612534)	(-5.746083)
Lagged ENROL	-0.098256***	-0.082853***	-0.008176
	(-3.098695)	(-2.665935)	(-0.130155)
D1	-0.000595	-0.001011	-0.011982
	(-0.054338)	(-0.093909)	(-0.574737)
D2	0.007052	0.006812	0.001244
	(1.145974)	(1.125144)	(0.105335)
D3	0.007371	0.006973	0.007936
	(1.053444)	(1.012911)	(0.598943)
D4	-0.003772	-0.004021	-0.010817
	(-0.343356)	(-0.372084)	(-0.498815)
D6	-0.00748	-0.00694	-0.001132
	(-0.775438)	(-0.731253)	(-0.062531)
D7	-0.005402	-0.005269	0.005146
	(-0.804274)	(-0.797267)	(0.406177)
R Squared	0.502207	0.500869	-1.492833
Adj. R Squared	0.486856	0.485477	-1.569705

Furthermore, all three methods of estimation confirmed the negative shift in the TEACH variable following the passage and effect of the NCLB.

Perhaps one of the more puzzling results presented in Table 8.0 is the appearance of a negatively signed coefficient for the lagged dependent variable at the 1% level of significance in both the OLS and SUR estimations. Given the theory of a partial adjustment model, the fact that the lagged dependent variable has a magnitude less than one indicates that the system is gradually converging to an optimal level of enrollment per school. However, the negative sign of the lagged dependent variable alludes to the idea that the path of adjustment is an oscillatory one. So again, it indicates that the system has a degree of memory (albeit a small one), but that the equation reacts in the opposite fashion each following year. It should be noted that this change only occurred after the first differencing of the data, which is an issue to be examined in further research.

One will most likely note the disappearance of the time trend variable in the production function in the new data form. This is due to the fact that such a trend is eliminated by taking the logged first difference, making the addition of such a variable unnecessary.

Table 9.0 contains coefficient estimates generated by the estimation of the cost function using data in which the first differences of the logged data were computed. Though the sign of both the constant and the constant shift term remained the same (as well as significant in all three methods of estimation), the magnitudes decreased in a proportional manner. In all three instances, the NCLB effect appears to have been a statistically significant increase in the level of funding per school.

The data also confirmed both the sign and apparent magnitude of the input factor prices, with PNIE and TPAY containing positive signs and 1% level significance using OLS, SUR, and 3SLS. Furthermore, the TPAY shifter coefficient again appears to be of a large magnitude and significant at the 5% level or better. This confirms the finding in table 5.0 that the NCLB act decreased the effect of price on per school spending.

Table 9.0 - Parameter estimates of the Cost Function using differenced data

Variable/ statistic	OLS	SUR	3SLS
Constant	0.020205*	0.023724**	0.026949**
	(1.88483)	(2.251476)	(2.470371)
Constant Shifter	0.055099***	0.053259***	0.051258***
	(4.516332)	(4.456308)	(4.170431)
PNIE	0.47438***	0.459216***	0.471803***
	(11.94053)	(11.77597)	(12.01995)
TPAY	0.526221***	0.621314***	0.787063***
	(3.145321)	(3.789576)	(3.875056)
TPAY Shifter	-0.45642**	-0.51865***	-0.78518***
	(-2.504711)	(-2.903745)	(-3.459496)
ENROL	0.966104***	1.092654***	1.099593***
	(10.97202)	(12.65365)	(12.13626)
TS	0.04744	0.097064	0.319545*
	(0.692028)	(1.440201)	(1.882478)
POV	0.095899	0.113047*	0.11541
	(1.373589)	(1.646005)	(1.601695)
Lagged PG	-0.406113***	-0.403902***	-0.400615***
	(-11.26669)	(-11.43612)	(-11.28775)
D1	0.009789	0.008912	0.006732
	(0.347735)	(0.32175)	(0.237926)
D2	-0.005379	-0.007299	-0.008814
	(-0.340341)	(-0.46945)	(-0.55384)
D3	0.00508	0.003166	0.001
	(0.282585)	(0.179009)	(0.055201)
D4	0.031434	0.032563	0.032501
	(1.115204)	(1.174216)	(1.149455)
D6	-0.020368	-0.019028	-0.019609
	(-0.819558)	(-0.778171)	(-0.786498)
D7	-0.012251	-0.010687	-0.012169
	(-0.709317)	(-0.628913)	(-0.700926)
R Squared	0.502207	0.502177	0.482914
Adj. R Squared	0.486856	0.486826	0.466969

Very reassuringly, the sign and magnitude of the production function output variable ENROL retained both its magnitude of near 1.0 and 1% level of significance. This further confirms the conclusion that Alabama county school systems are operating at levels of constant returns to scale, which can have interesting policy implications for the state. It is interesting to note that the magnitude of the returns to scale coefficient appears to have increased in all three estimation techniques.

As with the production function, the lagged dependent variable yielded a negatively signed coefficient of economic and statistical significance. This again points to an oscillating convergence path per the partial adjustment model framework, which is not an intuitive result.

The final results table is table 10.0, which provides the coefficient estimates for the test score quality equilibrium using logged, first-differenced data with the three aforementioned regression techniques. These results tended to be the most inconsistent of the three equations, with the RACE and INC variables no longer resulting in significant coefficient estimates. Though the idea of TPAY having a positive effect on test score quality is a positive assumption to make (Hanushek 1986), the fact that it was not significant in the previous set of regressions using the simply logged data makes it a questionable statistic to give credence to. While TPAY might have an intuitive coefficient result, the estimation of the teacher student ratio (TSR) coefficient defies logic. The notion that a smaller teacher student ratio negatively affects test scores is a very difficult one to logically accept. Therefore, unlike the results in table 6.0 which seemed to confirm several of the findings from Kinnucan et al’s work in 2002, this table seems to be victim to an unknown statistical error.

Table 10.0 - Parameter estimates of the Test Score Equilibrium using differenced data

Variable/ statistic	OLS	SUR	3SLS
Constant	-0.000413	-0.000235	0.006572
	(-0.045186)	(-0.026189)	(0.736212)
RACE	-0.084676	-0.081587	-0.063179
	(-1.365674)	(-1.340353)	(-1.082016)
INC	0.146085	0.158639	0.117401
	(1.290101)	(1.427038)	(1.073149)
UNEMP	-0.013997	-0.012814	-0.077302*
	(-0.359768)	(-0.335423)	(-1.663357)
UNEMP Shifter	0.110289**	0.110017**	0.228199***
	(2.051874)	(2.084599)	(3.173266)
Lagged TS	-0.323116***	-0.324274***	-0.301179***
	(-7.754792)	(-7.926923)	(-7.418173)
TSR	-0.188885*	-0.179938*	-0.352032***
	(-1.867357)	(-1.81203)	(-3.683482)
TPAY	0.250693***	0.249044***	0.370516***
	(2.579999)	(2.610454)	(4.034914)
RURAL	-0.013581*	-0.013638*	-0.017031**
	(-1.676008)	(-1.71447)	(-2.236762)
POV	-0.029309	-0.02757	-0.012221
	(-0.639902)	(-0.612545)	(-0.268038)
D1	0.010609	0.010612	0.012699
	(0.595058)	(0.605655)	(0.722936)
D2	0.004007	0.003968	0.003138
	(0.398413)	(0.401417)	(0.316976)
D3	0.014052	0.014	0.014243
	(1.237076)	(1.254044)	(1.274292)
D4	-0.000253	-0.000393	-0.000357
	(-0.014211)	(-0.022453)	(-0.020319)
D6	0.00666	0.006556	0.005372
	(0.413484)	(0.414163)	(0.339592)
D7	0.006108	0.006072	0.005392
	(0.556872)	(0.563244)	(0.499579)
R Squared	0.1793	0.1792	0.165892
Adj. R Squared	0.152124	0.152021	0.138273

The final table in the results section, table 11.0, presents the results of the two tests mentioned in the data and the models sections regarding long run returns to scale and the relationship of the coefficient values in the cost function. The theory behind these tests was also addressed in the derivations presented in appendix 1. The first restriction tested was the one regarding the long run returns to scale being equivalent to 1. This restriction was rejected at the 1% level. The second restriction tested was the hypothesis formulated in appendix 1 which stated that the coefficient of the production output variable as it appears in the cost function will be equal and opposite in sign to the sum of the coefficients of the technology shift parameters in the cost function.

Table 11.0 - Restriction testing

Restriction	Test Stastistic	Value	DoF	Probability
Long Run RTS	Chi-square	9.322459	1	0.0023
Coef Q = - ∑ Coef A(t)	Chi-square	483.415	1	0

This restriction was also rejected at the 1% level, yielding inconclusive results.

V. CONCLUSION

This paper began with three primary objectives that were set forth in the introduction section. The first objective was to develop a system of equations examining important components of the Alabama county school system, and to produce robust coefficient estimates for several of these determinants. The second objective was to determine whether the No Child Left Behind Act of 2001 resulted in a statistically and economically significant impact on these coefficient estimates over the nine year period using the gradual switching regressions technique. The final objective was to analyze the rate of returns to scale of Alabama schools, and to attempt to determine the rate at which the systems were currently operating. The objectives have all been partially or wholly achieved, utilizing a technique heretofore unused by the educational economics community.

For the first objective, the system of equations was specified using rigorous economic theory, and produced a set of mixed results regarding the significance of the estimated determinants. While the primary factors and prices of the production and cost equations were of the proper sign, magnitude, and significance that intuition would suggest, the equations seemed to suffer slightly from specification errors relating to the use of the three stages least squares technique. However, the production factors and prices did prove to be fairly robust irregardless of the data manipulation conducted in taking the first difference of the set. The test score quality equilibrium proved to have less explanatory power than the other two equations in the system, yet the significant coefficient estimates produced matched the results obtained by Kinnucan et al in 2004. This would seem to indicate, as Kinnucan et al noted, that one manner in which to approach the issue of test score quality might be to stimulate income growth and poverty reduction within the counties, letting the indirect effects filter into the schools. However, it was disappointing to note that the TS variable seemed to have little if any effect on enrollment per school and expenditure per school, indicating that schools may not be as reactive toward test score quality as is commonly assumed.

The second objective was met extremely well, with the No Child Left Behind Act creating structural impact in all three equations and an overall impact in the cost equation. The shift of the constant term in the cost function illuminated by the gradual switching regressions seems to indicate an increased level of expenditure per school due to the impact of the No Child Left behind Act. This result, though counterintuitive, would point to inadvertent effects of the NCLB act, providing more evidence for Hanushek's 2003 piece "The Failure of Input-Based School Policies." However, the Wald tests noted in the data and models section unequivocally indicated the NCLB act had statistically significant effects within the educational system. It merely appears that the effects were absorbed primary through structural shifts rather than overall shifts. The analysis of the No Child Left Behind Act yields some interesting policy implications. As previously mentioned, it highlights the inefficient manner in which the resources of this act were absorbed by the system without producing desired effects. However, this also could be a result created by manipulation of this testing system and its results as noted in the literature review section (Haney).

The final objective of examining the level of constant returns to scale of the Alabama county school system yielded the finding that the systems are presently operating at constant returns to scale. The coefficient of production function output as it appeared in the cost function maintained a value close to 1 and significant at the 5% level or greater in all six regressions. This statistic has apparently not been evaluated in educational economic literature regarding Alabama schools systems, and provides an interesting basis for policy making regarding the creation of new facilities.

Opportunities for further study regarding this topic abound, including the investigation as to the cause of the consistently significant and negative coefficient of the lagged dependent variables using logged first differenced data. The application of this same system to another state would be an excellent test for the robustness of the coefficient estimates, as would a comparison of another state's results contrasted with Alabama's. Finally, it would be beneficial to test not only whether the optimal functional form had been selected for the time path vectors, but the optimal rate as well.

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APPENDICES

APPENDIX A

Data Definitions and Manipulations

Before starting, a few words to the wise should be mentioned about using the National Center for Education Statistics (NCES) Common Core of Data (CCD) Table Builder function. 1) One must remember that the definition of “district” as referred to by the NCES is equivalent to this paper’s use of the word “system”. This paper’s use of the word “district” refers to the ALSDE designation of 7 districts grouping counties within the State of Alabama. Thus, whenever selecting the “Row” designator using Table Builder, always select “district”, NOT “county”. Selecting “county” will provide statistics relevant to the entire county, which lumps together county systems as well as city systems within the county as a whole. This will provide erroneous results, when compared to the ALSDE annual reports’ references to county systems. 2) A small, but important point is the fact that this paper lists “Saint Clair” county alphabetically before “Shelby” county. However, many other sources, such as the Department of Examiners of Public Accounts and the NCES list “Shelby” county alphabetically before “St. Clair” county. This should always be checked before adding values to the data set, or the two values will often be juxtaposed.

Q8R, Q8M, Q8L

These variables are Stanford Achievement Test Scores by Alabama County for the 8th grade. Each subject is annotated by R for reading, M for Math, and L for language. It should be noted that test scores prior to 2003 were in the Stanford 9 format as opposed to the Stanford 10 currently used format. They can be converted using the “Percentile Rank Conversion Tables” provided by Harcourt Assessment. The data were obtained via the ALSDE accountability reporting system, at http://www.alsde.edu/Accountability/preAccountability.asp. The file containing the scores is the "YEAR Stanford 10 test results complete (zip file)". The scores used were the ones for "all students" and "entire system". In addition, at the time of gathering, the 2007 zip file was not available, so it should be noted that these scores are also available through the "YEAR Chief State School Officer's Report For Stanford 10" where it may be copied value by value.

Q8 or TS

These variables are the simple average of each grades score in the three selected subjects.

$Q8^{-1}$ or TS^{-1}

These variables are the once lagged values of Q3, Q4, and Q8.

SF, PN, FF, OF

These variables were gathered from the ALSDE Annual Reports, on the page titled "Local Education Agencies (LEA)". The annual reports are found at http://www.alsde.edu/html/annual_reports.asp?menu=none&footer=general . The top of each column is titled "State Revenue", "Local Revenue", "Federal Revenue", and "Other Revenue" respectively. The data were then converted to a per school value by dividing each figure by its county's number of schools, which is found in the NCES CCD. The numbers are then deflated, using 1982 – 1984 as a base value of 100, and then the respective year's CPI, found at ftp://ftp.bls.gov/pub/special.requests/cpi/cpiai.txt . An example of the location of the values would be page 38 of the 2004 annual report for Revenues.

PG

This variable is simply the sum of the per school, deflated values of SF, PN, FF, and OF.

PG^{-1}

This variable is the once lagged value of the PG variable.

NIE

This variable was constructed by dividing the sum of the "Instructional Support" and "Instructional Services" Expenditure figures by the "Total Expenditure" figure per county "LEA". The three figures needed to compute this percentage are found in each year's annual report, located at http://www.alsde.edu/html/annual_reports.asp?menu=none&footer=general . The Instructional Support and Instructional Services figures in the 2004 report can be found on page 44, while Total Expenditures can be found on page 45. The pages are titled "System Expenditures by Function FY 2004". It was then converted to non instructional expenditures by subtracting the aforementioned percentage from one. Finally, this percentage was multiplied by total expenditures per school to create a value for dollars of non instructional expenditure dollars per school.

PNIE

The percentage of non instructional expenditures by a system, created by dividing the sum of all expenditures excluding instructional support and instructional expenditure by total expenditure. These values are found in the ALSDE annual reports at http://www.alsde.edu/html/annual_reports.asp?menu=none&footer=general

TSR

The number of pupils per teacher (Teacher-Student Ratio) per county can be found at the National Center for Education Statistics, using the Common Core of Data Facility. This webpage is located at “http://nces.ed.gov/ccd/”. At this webpage, one can use the “build a table” function listed under “CCD Data Tools” to build a table listing the “Pupil/Teacher Ratio (School)” per district per year per state. The number reported by the table is the number of pupils per teacher per system. It is very important to note that when using the build a table function, the first column of the table must be selected as “district” and NOT “county”. Using county will account for the TSR in the county, and NOT the TSR in the county system. To get the TSR in the county system, all districts must be pulled up.

ENROL

These variables denote Average Daily Membership (ADM) and the square root of the ADM respectively. These numbers are listed in the ALSDE Annual Reports, found at http://www.alsde.edu/html/annual_reports.asp?menu=none&footer=general , and recorded as totals per county. The statistics for the 2004 ADM’s could be found on page 21 of the 2004 Annual Report, under the column “TOTAL” on the page titled “Average Daily Membership (ADM)”. This was then converted to average ADM per school by dividing enrollment by the number of schools in the county system.

ENROL^{-1}

This variable is the once lagged value of Enrol.

POV and INC

Found using census data’s SAIPE function at : http://www.census.gov/hhes/www/saipe/tables.html . One can use the SAIPE table creation function to create an excel table by county by year. POV was defined as the percentage of children ages 5-17 per county in families in poverty relative to the counties children of the same age. INC was the SAIPE's estimate for Median Family Income per county per year. The INC numbers were deflated in the same manner as the funding variables PG, SF, PN, FF, and OF , using the CPI base of '82 – '84 as 100 and then corresponding BLS CPI figures for each year located on the BLS website.

UNEMP

The yearly, county level, annual averages for unemployment were obtained at the BLS website: http://www.bls.gov/lau/#tables . From this website, one can scroll down to the county level data section and open text tables for each year's unemployment statistics.

RACE

The RACE variable is a percentage defining the percentage of non-white students per county system per year. These variables are found in each year's respective ALSDE Annual Report, found at http://www.alsde.edu/html/annual_reports.asp?menu=none&footer=general. However, demographic information ceased to be reported as of the 2006 annual report. Thus, the observations for 2006 and 2007 were generated using a diminishing weighted average. The immediate prior year carries a weight of .5, the second previous year's weight is .33, and the third previous year's weight is .17. It can be computed also as $(3*R_{t-1} + 2*R_{t-2} + 1*R_{t-3})/6 = R_t$.

TPAY

The TPAY variable is the deflated average salary per full time equivalent teacher in each system per year. The variable is first created using the NCES's Common Core of

Data located at http://nces.ed.gov/ccd/ . The two statistics needed to create the undeflated TPAY numbers are "FTE Teachers (District)", located under the "Teacher/ Staff Information" section as well as "Salary-Instruction Expenditures (District – Fin)" located under the "Current Expenditure Details" section. Remember, these numbers must be computed per District (under the first Rows selection choice) and NOT per county. The numbers were deflated in the same manner, using the same factors as the funding numbers. Finally, data was not available at the time for the 2007 "Salary-Instruction Expenditures", so observations were generated using a weighted average of the previous three years in the same manner as the missing yearly RACE variables.

Rural

This is a dummy variable used to denote rural counties in the state of Alabama, found at http://cber.cba.ua.edu/edata/maps/AlabamaMaps1.html , the University of Alabama's Center for Business and Economic Research.

D1 – D7

This collection of 6 dummy variables is used to denote which ALSDE school district each system belongs to, using District 5 as a default base district. The map denoting school districts can be found on the ALSDE website, at http://www.alsde.edu/html/school_info.asp?menu=school_info&footer=general&sort=county.

TEACH

This value represents the number of teachers per school within a given county system, as provided by the NCES's Common Core of Data located at http://nces.ed.gov/ccd/ . However, the CCD only provided the number of FTE teachers per system, so in order to create an average number of teachers per school, the number of teachers was divided by the number of schools in the system.

l1 – l28

These dummy variables were created to test different rates of linear change using the gradual switching regressions technique. The GSR shift variables takes one of three sets of values depending on the current time period relative to pre set values of t1 and t2. If current t is less than or equal to t1, the shift variable is 0. If the current t is greater than or equal to t2, the shift variable is 1. If the current t is between t1 and t2, then the shift variable is equal to "(current t – t1)/(t2-t1)". T1 represents when a policy first began taking effect and t2 represents when it finishes taking effect. The versions of the shift variable tested represent every possible combination of t1 and t2 beginning with policy implementation in 2001 and every value up to it taking full effect by 2008.

nlv1 – nlv28

These dummy variables are non linear convex gradual switching regression sets, created by taking the values of l1-l28 and squaring them. This creating dummies that increased at an increasing rate.

nlc1 – nlc28

These dummy variables are non linear concave gradual switching regression sets, created by taking the values of l1-l28 and taking the square root of them. This created dummies that increased at a decreasing rate.

t

This variable is simply a time trend variable starting at 1 and increasing by 1 each year.

APPENDIX B

Cost Function Derivation

The purpose of appendix B is to describe the derivation of Robert Solow's 1956 growth model into a cost function using standard economic theory. A Cobb-Douglas version of Solow's growth model (including technology shift parameter) results in equation (1). This equation is examined in conjunction with a standard cost function (cost being equal to sum of the input factors multiplied by their respective prices) in equation (2), and the restriction found in equation (3).

(1) $Y = K^{\alpha}L^{\beta}A(t)$

(2) $C=rK + wL$

(3) minimize: $rK + wL$, subject to $Y - K^{\alpha}L^{\beta}A(t)=0$

Y represents output, K represents a capital factor input, L represents a labor factor input. C is the total cost, with r representing the factor price of K and w the factor price of L (rental rate of capital and wages, respectively, for the purpose of this appendix). A(t) is an unknown function of technology shifting the production isoquant.

Using the dual nature of the production function, the cost function (2) can be examined subject to the restriction (3). This yields the Lagrangian in equation (4).

(4) $L\ (K,L,\lambda) = rK + wL + \lambda(Y - K^{\alpha}L^{\beta}A(t))$

Taking the derivative of this Lagrangian with respect to the choice variables yields equation (5), (6), and (7).

(5) $\delta L / \delta K = r - \lambda\alpha AK^{\alpha-1}L^{\beta} = 0$

(6) $\delta L / \delta L = w - \lambda\beta AK^{\alpha}L^{\beta-1} = 0$

(7) $\delta L / \delta\lambda = Y - K^{\alpha}L^{\beta}A(t) = 0$

Dividing equation (5) by equation (6) yields ratio of factor prices, (8).

(8) $r/w = \alpha L/\beta K$

Solving (8) for L and substituting into the constraint (7) yields (9), allowing K to be solved for in terms of parameters and output. The symmetric nature of the function allows for the same to be done for L, yielding equation (10). The substitution of both (9) and (10) into (2) yields (11), or the minimized cost using optimal demand for L and K.

(9) $K = (Y/A)^{1/(\alpha+\beta)} * (\alpha w/\beta r)^{\beta/(\alpha+\beta)}$

(10) $L = (Y/A)^{1/(\alpha+\beta)} * (\beta r/\alpha w)^{\alpha/(\alpha+\beta)}$

(11) $C = r[(Y/A)^{1/(\alpha+\beta)} * (\alpha w/\beta r)^{\beta/(\alpha+\beta)}] + w[(Y/A)^{1/(\alpha+\beta)} * (\beta r/\alpha w)^{\alpha/(\alpha+\beta)}]$

With a bit of factoring, (11) can be reduced to (12), with z defined by (13)

(12) $C = z\,(Y/A)^{1/(\alpha+\beta)}[r(w/r)^{\beta/(\alpha+\beta)} + w(r/w)^{\alpha/(\alpha+\beta)}]$

(13) $z = (\alpha/\beta)^{\beta/(\alpha+\beta)} + (\beta/\alpha)^{\alpha/(\alpha+\beta)})$

Further factoring and algebraic manipulation of equation (12) yields equation (14)

(14) $C = z * A^{-1/(\alpha+\beta)} * Y^{1/(\alpha+\beta)} * w^{\beta/(\alpha+\beta)} * r^{\alpha/(\alpha+\beta)}$

Taking the natural logarithm of equation (14) yields equation (15), which is the linear cost equation used in this paper. It can be further simplified into the more aesthetically appealing equation (16).

(15) $\ln(C) = \ln(z) - (1/(\alpha+\beta))\ln(A) + (1/(\alpha+\beta))\ln(Y) + (\beta/(\alpha+\beta))\ln(w) + (\alpha/(\alpha+\beta))\ln(r)$

(16) $\ln(C) = \gamma_0 - \gamma_1\ln(A) + \gamma_1\ln(Y) + \gamma_2\ln(w) + \gamma_3\ln(r)$

Substituting the generic variables from Solow's growth function with variables used in this paper and adding the lagged dependent variable to maintain the partial adjustment model framework, would result in equation (20):

(20) $\ln(PG) = \gamma_0 - \gamma_1\ln(POV, TS) + \gamma_1\ln(Enrol) + \gamma_2\ln(TPAY) + \gamma_3\ln(PNIE) + \gamma_4\ln(PG^{-1})$

Equation (20) yields some interesting and testable results in addition to being the cost function used in this paper. The first testable result is that the coefficient of ln(POV, TS) should be equal and opposite in sign to the coefficient of ln(Enrol), if the firm in question is indeed a cost minimizing firm. The second interesting result is that of the coefficient of ln(Enrol), which in this case represents the short run returns to scale of the respective Alabama county school system using logged data. In theory, the long run returns to scale should be constant. The test of this theory would be represented by equation (21)

$$(21) \qquad 1.0 = \gamma_1/(1- \gamma_4)$$

These tests are evaluated using Wald coefficient tests in the results section of this paper

APPENDIX C

Time Path Vector Values

This appendix lists the 84 different time path vector values of λ_t, as defined by equation (4) and (5) in the literature review and used to test for the optimal fit. The starting point of the effect is indicated by the value of t_1 and the point at which the full effect has taken place is indicated by t_2. All possible linear, concave, and convex time paths were tested beginning with $t_1 = 3$, indicating that the No Child Left Behind Act first began affecting the educational system in school year 2001, which was the year of the bill's passage. The current period is indicated by t, which begins at 1 with the year 1999. Though the λ_t values have been reduced to three decimal places for the sake of fitting into this page, the actual values used were carried to six decimal places. In addition, the labels for λ_t, l_{number}, nlv_{number}, and nlc_{number}, represent linear time path, non-linear convex time path, and non-linear concave time path respectively.

Table 12.0

λ_t	t_1	t_2	99	00	01	02	03	04	05	06	07
l1	3	4	0.000	0.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000
l2	3	5	0.000	0.000	0.000	0.500	1.000	1.000	1.000	1.000	1.000
l3	3	6	0.000	0.000	0.000	0.333	0.667	1.000	1.000	1.000	1.000
l4	3	7	0.000	0.000	0.000	0.250	0.500	0.750	1.000	1.000	1.000
l5	3	8	0.000	0.000	0.000	0.200	0.400	0.600	0.800	1.000	1.000
l6	3	9	0.000	0.000	0.000	0.167	0.333	0.500	0.667	0.833	1.000
l7	3	10	0.000	0.000	0.000	0.143	0.286	0.429	0.571	0.714	0.857
l8	4	5	0.000	0.000	0.000	0.000	1.000	1.000	1.000	1.000	1.000
l9	4	6	0.000	0.000	0.000	0.000	0.500	1.000	1.000	1.000	1.000
l10	4	7	0.000	0.000	0.000	0.000	0.333	0.667	1.000	1.000	1.000
l11	4	8	0.000	0.000	0.000	0.000	0.250	0.500	0.750	1.000	1.000
l12	4	9	0.000	0.000	0.000	0.000	0.200	0.400	0.600	0.800	1.000
l13	4	10	0.000	0.000	0.000	0.000	0.167	0.333	0.500	0.667	0.833
l14	5	6	0.000	0.000	0.000	0.000	0.000	1.000	1.000	1.000	1.000
l15	5	7	0.000	0.000	0.000	0.000	0.000	0.500	1.000	1.000	1.000
l16	5	8	0.000	0.000	0.000	0.000	0.000	0.333	0.667	1.000	1.000
l17	5	9	0.000	0.000	0.000	0.000	0.000	0.250	0.500	0.750	1.000
l18	5	10	0.000	0.000	0.000	0.000	0.000	0.200	0.400	0.600	0.800
l19	6	7	0.000	0.000	0.000	0.000	0.000	0.000	1.000	1.000	1.000

l20	6	8	0.000	0.000	0.000	0.000	0.000	0.000	0.500	1.000	1.000
l21	6	9	0.000	0.000	0.000	0.000	0.000	0.000	0.333	0.667	1.000
l22	6	10	0.000	0.000	0.000	0.000	0.000	0.000	0.250	0.500	0.750
l23	7	8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	1.000
l24	7	9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.500	1.000
l25	7	10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.333	0.667
l26	8	9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000
l27	8	10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.500
l28	9	10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
nlv1	3	4	0.000	0.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000
nlv2	3	5	0.000	0.000	0.000	0.250	1.000	1.000	1.000	1.000	1.000
nlv3	3	6	0.000	0.000	0.000	0.111	0.444	1.000	1.000	1.000	1.000
nlv4	3	7	0.000	0.000	0.000	0.063	0.250	0.563	1.000	1.000	1.000
nlv5	3	8	0.000	0.000	0.000	0.040	0.160	0.360	0.640	1.000	1.000
nlv6	3	9	0.000	0.000	0.000	0.028	0.111	0.250	0.444	0.694	1.000
nlv7	3	10	0.000	0.000	0.000	0.020	0.082	0.184	0.327	0.510	0.735
nlv8	4	5	0.000	0.000	0.000	0.000	1.000	1.000	1.000	1.000	1.000
nlv9	4	6	0.000	0.000	0.000	0.000	0.250	1.000	1.000	1.000	1.000
nlv10	4	7	0.000	0.000	0.000	0.000	0.111	0.444	1.000	1.000	1.000
nlv11	4	8	0.000	0.000	0.000	0.000	0.063	0.250	0.563	1.000	1.000
nlv12	4	9	0.000	0.000	0.000	0.000	0.040	0.160	0.360	0.640	1.000
nlv13	4	10	0.000	0.000	0.000	0.000	0.028	0.111	0.250	0.444	0.694
nlv14	5	6	0.000	0.000	0.000	0.000	0.000	1.000	1.000	1.000	1.000
nlv15	5	7	0.000	0.000	0.000	0.000	0.000	0.250	1.000	1.000	1.000
nlv16	5	8	0.000	0.000	0.000	0.000	0.000	0.111	0.444	1.000	1.000
nlv17	5	9	0.000	0.000	0.000	0.000	0.000	0.063	0.250	0.563	1.000
nlv18	5	10	0.000	0.000	0.000	0.000	0.000	0.040	0.160	0.360	0.640
nlv19	6	7	0.000	0.000	0.000	0.000	0.000	0.000	1.000	1.000	1.000
nlv20	6	8	0.000	0.000	0.000	0.000	0.000	0.000	0.250	1.000	1.000
nlv21	6	9	0.000	0.000	0.000	0.000	0.000	0.000	0.111	0.444	1.000
nlv22	6	10	0.000	0.000	0.000	0.000	0.000	0.000	0.063	0.250	0.563
nlv23	7	8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	1.000
nlv24	7	9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.250	1.000
nlv25	7	10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.111	0.444
nlv26	8	9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000
nlv27	8	10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.250
nlv28	9	10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
nlc1	3	4	0.000	0.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000
nlc2	3	5	0.000	0.000	0.000	0.707	1.000	1.000	1.000	1.000	1.000
nlc3	3	6	0.000	0.000	0.000	0.577	0.816	1.000	1.000	1.000	1.000
nlc4	3	7	0.000	0.000	0.000	0.500	0.707	0.866	1.000	1.000	1.000
nlc5	3	8	0.000	0.000	0.000	0.447	0.632	0.775	0.894	1.000	1.000

nlc6	3	9	0.000	0.000	0.000	0.408	0.577	0.707	0.816	0.913	1.000
nlc7	3	10	0.000	0.000	0.000	0.378	0.535	0.655	0.756	0.845	0.926
nlc8	4	5	0.000	0.000	0.000	0.000	1.000	1.000	1.000	1.000	1.000
nlc9	4	6	0.000	0.000	0.000	0.000	0.707	1.000	1.000	1.000	1.000
nlc10	4	7	0.000	0.000	0.000	0.000	0.577	0.816	1.000	1.000	1.000
nlc11	4	8	0.000	0.000	0.000	0.000	0.500	0.707	0.866	1.000	1.000
nlc12	4	9	0.000	0.000	0.000	0.000	0.447	0.632	0.775	0.894	1.000
nlc13	4	10	0.000	0.000	0.000	0.000	0.408	0.577	0.707	0.816	0.913
nlc14	5	6	0.000	0.000	0.000	0.000	0.000	1.000	1.000	1.000	1.000
nlc15	5	7	0.000	0.000	0.000	0.000	0.000	0.707	1.000	1.000	1.000
nlc16	5	8	0.000	0.000	0.000	0.000	0.000	0.577	0.816	1.000	1.000
nlc17	5	9	0.000	0.000	0.000	0.000	0.000	0.500	0.707	0.866	1.000
nlc18	5	10	0.000	0.000	0.000	0.000	0.000	0.447	0.632	0.775	0.894
nlc19	6	7	0.000	0.000	0.000	0.000	0.000	0.000	1.000	1.000	1.000
nlc20	6	8	0.000	0.000	0.000	0.000	0.000	0.000	0.707	1.000	1.000
nlc21	6	9	0.000	0.000	0.000	0.000	0.000	0.000	0.577	0.816	1.000
nlc22	6	10	0.000	0.000	0.000	0.000	0.000	0.000	0.500	0.707	0.866
nlc23	7	8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	1.000
nlc24	7	9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.707	1.000
nlc25	7	10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.577	0.816
nlc26	8	9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000
nlc27	8	10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.707
nlc28	9	10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

APPENDIX D

Time Path Vector Rankings

The following are the results produced by testing the 84 possible linear, convex, and concave time path vector values of λ_t. The first column represents the time path vector tested (the value of which can be found in Table 10 of appendix 2), then the corresponding R^2 value for each of the three functions followed by its overall ranking. The value of "NSM" for the R^2 represents a near-singular matrix error in Eviews 6.0 which prevented the particular regression from being estimated.

Table 13.0

λ_t	Production R^2	Rank	Cost R^2	Rank	TS R^2	Rank
l1	0.965603	60	0.872865	73	0.824684	31
l2	0.966232	47	0.874822	65	0.825574	14
l3	0.966607	35	0.876366	24	0.823752	52
l4	0.967596	18	0.87646	23	0.824193	46
l5	0.967035	26	0.876172	33	0.824283	40
l6	0.965051	65	0.876358	25	0.823643	55
l7	0.965051	66	0.876358	26	0.823643	56
l8	0.965877	55	0.874994	59	0.825571	15
l9	0.966445	41	0.875754	46	0.82289	67
l10	0.967917	11	0.876594	22	0.823101	66
l11	0.967392	21	0.875988	37	0.824404	38
l12	0.965552	63	0.876119	34	0.824628	35
l13	0.965552	64	0.876119	35	0.824628	36
l14	0.966587	36	0.877856	4	0.822239	73
l15	0.968328	8	0.877764	9	0.825191	25
l16	0.967873	13	0.87608	36	0.8238	51
l17	0.966676	31	0.875832	40	0.823644	53
l18	0.966676	32	0.875832	41	0.823644	54
l19	0.968485	3	0.87792	1	0.82641	1
l20	0.967906	12	0.87564	49	0.82541	22
l21	0.967684	14	0.877252	13	0.824252	41
l22	0.967684	15	0.877252	14	0.824252	42
l23	0.96383	67	0.874424	69	0.825798	5
l24	0.963749	74	0.874977	62	0.825403	23
l25	0.963749	75	0.874977	63	0.825403	24
l26	NSM		NSM		NSM	
l27	NSM		NSM		NSM	
l28	NSM		NSM		NSM	
nlv1	0.965603	61	0.872865	74	0.824684	32

nlv2	0.966083	49	0.875115	56	0.825797	8
nlv3	0.96661	33	0.876797	19	0.822824	70
nlv4	0.968349	7	0.877162	15	0.824242	43
nlv5	0.967517	19	0.875813	45	0.824148	47
nlv6	0.965968	53	0.875827	42	0.823615	60
nlv7	0.965968	54	0.875827	43	0.823615	61
nlv8	0.965877	56	0.874994	60	0.825571	16
nlv9	0.966579	39	0.877036	16	0.822292	72
nlv10	0.968576	2	0.877479	12	0.824722	28
nlv11	0.967655	16	0.875532	52	0.824145	48
nlv12	0.96686	27	0.875644	47	0.823327	64
nlv13	0.96686	28	0.875644	48	0.823327	65
nlv14	0.966587	37	0.877856	5	0.822239	74
nlv15	0.968715	1	0.877828	7	0.826325	4
nlv16	0.967413	20	0.875096	57	0.824931	27
nlv17	0.96737	22	0.875896	38	0.823459	62
nlv18	0.96737	23	0.875896	39	0.823459	63
nlv19	0.968485	4	0.87792	2	0.82641	2
nlv20	0.966028	50	0.874534	68	0.825427	20
nlv21	0.966255	42	0.876271	29	0.823636	57
nlv22	0.966255	43	0.876271	30	0.823636	58
nlv23	0.96383	68	0.874424	70	0.825798	6
nlv24	0.963774	70	0.875297	53	0.824717	29
nlv25	0.963774	71	0.875297	54	0.824717	30
nlv26	NSM		NSM		NSM	
nlv27	NSM		NSM		NSM	
nlv28	NSM		NSM		NSM	
nlc1	0.965603	62	0.872865	75	0.824684	33
nlc2	0.96616	48	0.874108	72	0.825066	26
nlc3	0.966461	40	0.875056	58	0.824402	39
nlc4	0.966843	29	0.875217	55	0.824675	34
nlc5	0.966608	34	0.875557	51	0.824513	37
nlc6	0.966009	51	0.876224	31	0.824226	44
nlc7	0.966009	52	0.876224	32	0.824226	45
nlc8	0.965877	57	0.874994	61	0.825571	17
nlc9	0.966236	46	0.874851	64	0.823952	49
nlc10	0.967077	25	0.875623	50	0.823628	59
nlc11	0.96675	30	0.875817	44	0.825424	21
nlc12	0.96562	58	0.876285	27	0.825579	12
nlc13	0.96562	59	0.876285	28	0.825579	13
nlc14	0.966587	38	0.877856	6	0.822239	75
nlc15	0.967607	17	0.877776	8	0.823841	50

nlc16	0.967303	24	0.876957	17	0.82277	71
nlc17	0.96625	44	0.876759	20	0.822864	68
nlc18	0.96625	45	0.876759	21	0.822864	69
nlc19	0.968485	5	0.87792	3	0.82641	3
nlc20	0.968482	6	0.876869	18	0.825765	9
nlc21	0.968075	9	0.877741	10	0.825431	18
nlc22	0.968075	10	0.877741	11	0.825431	19
nlc23	0.96383	69	0.874424	71	0.825798	7
nlc24	0.963774	72	0.874728	66	0.825708	10
nlc25	0.963774	73	0.874728	67	0.825708	11
nlc26	NSM		NSM		NSM	
nlc27	NSM		NSM		NSM	
nlc28	NSM		NSM		NSM	