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Blair Davis Burgess III April 18, 2011

The Diffusion of Charter School Policies Across the United States

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An abstract of
a thesis submitted to the Faculty of Emory College of Arts and Sciences
of Emory University in partial fulfillment
of the requirements of the degree of
Bachelor of Arts with Honors

Department of Mathematics and Political Science

April 18, 2011

Abstract

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By Blair Davis Burgess III

This thesis employes event history analysis to study of the rapid diffusion of a striking policy innovation in the United States: the adoption of charter school policies by state legislatures. Building upon a significant body of literature and drawing largely from data collected by Wong and Alngevin (2007), this study examines the influence of geographic, political, social, and educational characteristics of a state on the likelihood of charter school policy adotion in a given year. The results of this study support the existence of significant relationships between the likelihood of state adoption and several explanatory variables: th passage of time, the prevalence of private schools, and the diversity of the student population. Yet, only social and educational characteristics of states, not political or geographic, had a significant impact on the likelihood of the adoption of charter school policy. These findings have interesting theoretical consequences concerning the state of contemporary education systems and the nature of democracic practice within the states. The conclusion of this thesis discusses the theoretical implications of the findings and offers direction for future studies of state educational policy and policy innovation and diffusion.

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Acknowledgements

This project would have been impossible without the amazing support of my mentors, family, friends, and Emory University.

Without the support of Courtney Brown in the Mathematics and Political Science Joint Major, I would have never even considered attempting the methodology this thesis required. His constant encouragement, support, and guidance kept me going throughout the process. His amazing ability to write about math in an easily accessible way provided the model which I attempted to emulate in all my writing. I cannot express how lucky I am to have found such a strong advocate of my endeavors. For that, I thank him.

Andy Wilson, the education expert on my committee, helped me realize the importance of my findings and their implications for the real world. Without his input, it would have been hard to realize how my study, which was mostly numbers, described profound phenomenon in the real world. Furthermore, his deep insight and guidance throughout my time here at Emory helped me to truly appreciate the work necessary to complete this thesis. For his insight, his genuine concern for his students, and his brilliant ability to connect a political science study back to education, I thank him.

I must thank Michael Rich for helping me to realize how exciting this study could be by placing appropriate emphasis on context of the intense emotion that has characterized the charter school debate. His guidance pushed my paper to the next level.

I also must thank Vicki Powers for taking time out of her busy schedule to serve on the committee of a student she did not know. Without her generosity and willingness to help even a stranger, this process would have been incomplete.

Finally, I must thank my family and friends who stuck with me throughout the process. Even though I question whether they were successful in their attempts to help me maintain sanity throughout the process, I could always rely on them to welcome me back from the library with open and supportive arms. I thank my roommates Garrett and Anthony for not throwing my library books out of the window! I thank my friends Rylee and Rebecca for much needed comradery in the required course. And, I thank my mother, father, and sister, for the muffins, cupcakes, and unending love they sent to help me on my way.

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Introduction

After a decades-long build up of parent discontent with the education system and political leadership in support of educational reform, Minnesota adopted the first school choice policy. Adopted in 1985, The Postsecondary Enrollment Options Act allowed high school students to enroll in colleges and universities for high school credit. The legislation was the result of careful maneuvering by policy leaders to address the long-lasting disagreement between parents and employees of the educational system concerning what programs best serve students. Teachers and educators responded to the passage of the act quickly and negatively, claiming the possible impact of redirecting funds from secondary schools to post-secondary institutions could be devastating, but their claims could not prevent the spread of legislation. The act served as the "first event in a historical sequence of policy activism" (Wong and Langevin 2007, 441). In 1987, Minnesota passed the first open enrollment policy, and by 1992, nearly three quarters of the states had adopted similar school choice legislation. In 1991, Minnesota became the first state to adopt charter school legislation, and charter school policies spread at a similarly speedy rate across the United States (Wong and Langevin 2007, 441). Yet, despite the rapid spread of charter school policies, the debate between the proponents and critics of charter schools still furiously rages and has led to some of the most emotionally charged battles in the history of the nation's education system (Henig 2008).

So, what are charter schools and why are they so contentious? Charter schools straddle the line between public and private. Although publicly funded on a per-pupil base and forbidden from charging tuition, charter schools are able to acquire supplemental funding from outside sources. Charter schools are public schools that operate, to varying extents, outside the oversight of local boards of educations and state mandated curriculums. Instead, charter schools are

granted relative levels of autonomy in determining their governance structure and curriculum, allowing for greater levels of local leadership and classroom experimentation. Although not exempt from state educational standards, charter schools are able to employ additional methods of evaluation. Finally, charter schools also have greater control over their enrollment practices, although these practices must be nondiscriminatory. All of the above criterion are placed into a charter that, once approved, will allow the school to operate so long as the standards set in the charter are met. State governments empower certain entities the right to grant charters. Yet, the types of organizations or groups allowed to grant charters vary greatly among states, in some cases limited only to the local school district and at other times including multiple organizations (Hassel 1999). However, perhaps the most important feature of charter schools is their prominence in the push for greater school choice. As Jeffrey Henig (2008, 2) writes, charters schools are "just one in an array of school choice options that have been breaking down the historical link between where one lives and the school's one's children attends."

Charter schools introduce a fundamental restructuring of the American system of education. School choice, allowing parents to decide where their kids enroll, introduces market competition into the education system as a method to address the failure of government institutions to meet individual needs (Henig 1995). As the debate over charter schools continued, it transformed into a larger battle pitting the market against the government. This transformation, "has raised the partisan stakes and made the issue so volatile and the stakes so high that little room is left for complexity, nuance, and contingency [in the school choice and charter school debate]," as Henig (2008) writes. The emotion of the debate even captured two renowned political scientists, one from Harvard and the other from the University of Wisconsin, whose scholarly debate led to name-calling and was featured in an article in the *Wall Street Journal*

(Henig 2008). The intensity of the debate led many to question whether the debate had refocused on ideology and forgotten to consider the impact of the reform on students. However, the attempts to refocus the debate on educational outcomes could not escape the intense emotion pervading the issue. Numerous studies supporting both the superiority of the traditional public school system and the promise of charter schools emerged, blurring the lines that separate scholarly research and political warfare. To date, no conclusive evidence determines whether charter schools are more effective than traditional public schools (Henig 2008).

Regardless of absent or conflicting evidence supporting the effectiveness of charter schools and school choice, between 1991 and 2003, the charter school movement swept the nation. In only thirteen years, forty states adopted charter school legislation, and charter schools are still prominent in public discussions on education reform (Wong and Langevin 2007, 457). For example, in the Obama Administration's 2008 "Race to the Top" competition, states must have adopted charter school legislation in order to be eligible for the awarding of funds. Yet, even with establishment of multiple positive federal incentives and the widespread acceptance of charter school legislation across the U.S., ten states have still not adopted charter school legislation.

This paper explores the interstate and intrastate determinants that have influenced the adoption of charter school legislation, focusing on the key factors that determine whether and when states decide to adopt charter school legislation based on an analysis of state consideration of charter school legislation between 1991 and 2003. The key factors influencing charter school adoption were identified based on an analysis of a comprehensive body of research on charter schools drawing from multiple disciplines including educational studies, sociology, political science, and economics. The key questions this study seeks to answer include: how did political

factors of a state, such as the partisanship and power of its governor, impact the likelihood that a state would adopt charter school legislation? How did the social characteristics of a state, such as racial diversity and wealth, impact its likelihood of adopting charter school legislation? Finally, how did the characteristics of a state's education system impact the state's likelihood of adopting the charter school legislation? The answers to these three questions bear profound implications on the nature of the policymaking process in the United States.

The Study of Policy Innovation and Diffusion

The study of the spread of school choice and charter school policies falls within a broader study of policy innovation. A policy innovation can be defined as a policy that is new to a unit of analysis, even though it is not new to a population. Jack Walker (1969) introduced the study of policy innovation to the political science literature with his seminal study of the factors that influence a state's innovation score - the proportion of 88 different policies adopted by a state legislature. Soon thereafter, Virginia Gray (1973) introduced the first work to explore innovations through the lens of educational policy. Gray (1973, 1174) provides the conceptual definition of innovation that will be used for this study: "an innovation is more specifically defined as a law which is new to the state adopting it." The policy does not have to be new or creative on a broader scale; it only has to bring change to the system in which it is passed (Welch and Thompson 1980, 715).

Gray (1973, 1175) presents another important conceptual definition: "the process by which an innovation spreads is called diffusion." Although these definitions remain useful for this study, early studies of innovation were limited in their analyses, as each study analyzed separately either the influences of internal characteristics of the states or the influences of

external regional or national factors. Frances Berry (1994, 442) describes three models of innovation that dominated early studies as follows:

> The *internal determinants* model claims that the primary factors leading a state to innovate are characteristics internal to the state. The other two are *diffusion* models - *regional diffusion*, and *national interaction* - that regard state adoptions of policy as emulations of previous adoptions by other states.

Researchers' inability to analyze the impacts of all three models simultaneously led to a decline in innovation and diffusion studies until Berry and Berry (1990, 1992) presented their studies of state lottery adoption and tax reform as policy innovations. Utilizing event history analysis (EHA), Berry and Berry (1990, 1992) introduced a method that allowed researchers in political science to analyze the internal determinants model and the diffusion models simultaneously, effectively reintroducing the study of policy innovation and diffusion to the political science literature.

Event History Analysis and Innovation Adoption

EHA describes the relative likelihood and timing of the occurrence of events. The analysis includes all members of a risk set, which Paul Allison (1984, 16) defines as, "the set of individuals who are at risk of event occurrence at each point in time." Allison (1984, 16) defines a second important term, the *hazard rate*: "the hazard rate is the probability that an event will occur at a particular time to a particular individual, given that the individual is at risk at that time." In the study of policy innovation in the United States, the risk set generally includes either all 50 states or the 48 contiguous states.[1]

[1] Alaska and Hawaii are generally removed from the risk set of states when researchers explore models of diffusion. Their geographic isolation from other states is expected to shield the states

Utilizing EHA with measures in continuous time presents both difficulties both computationally and in measurement. Therefore, EHA most often divides observations into discrete time periods during which an event can either occur or not occur. EHA allows researchers to analyze a time-series of cross-sectional data and determine what impact the internal and external characteristics of the states have upon the hazard rate, which is the likelihood of innovation in a given year (Berry 1994). Researchers of educational policy innovation and diffusion most often use a single calendar year as their discrete time interval, and this study follows this convention (Mintrom 1997; Mintrom and Vergari 1998; Renzulli and Roscigno 2005; Wong and Langevin 2005; Wong and Langevin 2007).

Although EHA merges the three models of innovation Berry (1994) identifies, simultaneously considering the impact of factors both external and internal to each state requires a trade-off. Though the method gains empirically supported generalizability, researchers must be cautious in their assertions of the type of relationships EHA reveals among the variables (Wong and Langevin 2007, 444). Event history analysis establishes correlations between the explanatory variables and changes in the hazard rate. Any claims to causation must be supported by specifying the theoretical rationale for relationships between concepts. Furthermore, each concept must have precise and accurate operational definitions that allow researchers to measure the impact of each influence upon a state's willingness to innovate. Effective theory originates in and builds upon existing literature, and this study builds upon both the case studies of particular states, such as those Hassel (1999) conducts in Colorado, Georgia, Massachusetts and Michigan, and the pursuant empirical studies that attempt to generalize the findings of the case studies. The

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from external forces of diffusion (Mintrom 1997; Mintrom and Vergari 1998; Renzulli and Roscigno 2005; Wong and Langevin 2005; Wong and Langevin 2007)

following section identifies the influences expected to impact the states' willingness to innovate, the operational definition that will be used for this study, and the hypothesized relationships.

Variables and Hypotheses

Dependent Variable

In this study of policy innovation, the dependent variable is the hazard rate for the adoption of charter school policy. In a period of a year, how likely was innovation within a state legislative body? Previous studies of school choice and charter school policies have utilized several different operational definitions of innovation. The first studies of school choice defined two measures of innovation: a state legislature's first consideration of a bill and the state legislature's passage of legislation, a useful framework for identifying the influence of policy entrepreneurs and policy networks (Mintrom 1997; Mintrom and Vergari 1998). Renzulli and Roscigno (2005) utilize a multi-level dependent variable of successive events, the passage of the policy in the state legislature and the pursuant implementation of that policy within the state. Other studies define innovation simply as the final adoption of the legislation (Wong and Langevin 2005; Wong and Langevin 2007; Wong Shen 2002). This study is limited in scope to the adoption of charter school legislation within the state legislature. Passing legislation and implementing it are fundamentally different phenomenon. Although, the characteristics of states that influence the adoption of legislation likely to also influence implementation, many other influences must also be included. Hence, implementation remains outside the scope of this study.

Figure 1 shows the hazard rate, the likelihood of adoption for each year over a fifteen-year span, as similarly presented by Wong and Langevin (2007) and Miller (1981) and Lee and Wang (1992). Figure 2 reveals the cumulative probability distribution over time.

(Insert figures 1 and 2 here.)

Explanatory Variables

Past studies of educational policy innovation identify several categories of important explanatory variables. Interstate diffusion forces, political and economic features of the state, the characteristics of the education system, social forces, and the effects of time are consistently featured in the past studies of the innovations in charter school policy (Mintrom 1997; Mintrom and Vergari 1998; Renzulli and Roscigno 2005; Wong and Langevin 2005; Wong and Langevin 2007).

Interstate Characteristics and Diffusion Forces. Whether in nations, states, or local districts, the importance of horizontal interaction among policy makers in networks external to the unit of analysis is clear. Cultural similarities among nations and states, the motivations of political leaders, competition among states, among other forces, have profound implications on the policies in place (Renzulli and Roscigno 2005, 348). The focus of this paper remains at the state level, as the constitutional structure of the United States places educational reform in the realm of state governments. This unit of analysis is convention in the study of the spread of school choice policy (Mintrom 1997; Mintrom and Vergari 1998; Renzulli and Roscigno 2005; Wong and Langevin 2005; Wong and Langevin 2007).

Spatial diffusion within policy networks may be the result of several influences. The three most commonly identified within the study of charter school policy diffusion are the social learning process and the mimetic tendencies of political actors. Gray (1976) suggests that states may act similarly to individuals. A learning process guides the adoption of new practices as others watch those who have incorporated change to determine whether or not the change is

desirable. A second reason may be that actors tend to mimic similar actors within their reference groups; states will mimic their border states or the states with which they are politically similar (Renzulli and Roscigno 2005, 348), as do local school districts (Rincke 2006, 190). In figure 2, the cumulative probability distribution of the likelihood of innovation takes on an "S shape." This shape is consistent with both the social learning process and with the interaction effect that suggests states exert competitive influence on others (Gray, 1976). Roscigno and Renzulli (2005) identify several factors that might cause states to have these mimetic tendencies, especially within the realm of educational policy. First, states and localities are constantly competing in order to promote industrial growth, tourism, and economic development. Therefore, the actions of policy makers may serve two roles. First, there is a real impact of competition: the quality of an educational system can play a significant role in attracting new business and, therefore, propel states to innovation. If states within a reference group pass school choice legislation, states that do not adopt similar legislation lose a competitive edge. Second, policy makers may act to maintain the perception that their state is competitive with states that other policy makers and voters perceive themselves to be in competition (Berry and Berry 1990, 1992). This second motivation explains why policies that have not been found effective by research may still diffuse across states. Berry and Berry (1990, 1992) posit that in addition to maintaining a competitive edge, policy makers not only attempt to compete, but also attempt to learn from the actions of the states around them to reduce the cost of implementation and avoid mistakes.

Although existing literature supports that states in reference groups impact diffusion, the study of what factors determine which states fall into reference groups remains largely undeveloped. Initial studies focused only on the role of neighbor states (Berry and Berry 1990; Mintrom and Vergari 1998; Boehmke 2007). One might expect that the technological advances

of the past decades in transportation, communication, and scholarship would weaken the influence of geographic proximity on diffusion and expand reference groups to include other actors. However, there are several reasons why geographic proximity is still an important factor. First, Strang and Meyer (1993) emphasize the importance of "cultural linkages," which include more than just structural similarities such as the institution of state governments. These linkages refer to real and perceived cultural and social similarities. Often these apply to regional identities such as the South or Midwest, and Renzulli and Roscigno (2005) present evidence suggesting the proportion of states within a census region that have passed policy innovations increases the likelihood that a state will pass charter school legislation. Furthermore, geographic proximity naturally results in heightened levels of interaction between states that share borders, as they must cooperate to promote commerce, law enforcement, natural resource management, and many other realms of governance. Additionally, proximity increases the spread of news and ideas among citizens, through both word of mouth and media (Renzulli and Roscigno 2005, 348). Therefore, many researchers have observed an increased likelihood of innovation in states whose direct neighbors have already passed a policy (Berry and Berry 1990; Mintrom and Vergari 1998; Wong and Langevin 2005; Wong and Langevin 2007).

Wong and Langevin's (2007) work to clarify the reference group support the intuitive reasoning above. Wong and Langevin (2007) create four models to compare the influence of different operationalizations of diffusion forces. The four models incorporate no geographic control, the proportion of neighboring states that have innovated, the proportion of states within the region that have innovated, and the proportion of states with a similar political culture that have innovated. Of the four, the model including the proportion of neighboring states that have innovated produced the model with the best fit. Therefore, this study will operationalize the

geographic diffusion variable as the proportion of neighboring states that have adopted charter school policies, and will share the expectation of nearly all prior studies of charter school policy innovation:

> *Expectation 1: As the proportion of neighboring states that have already passed charter school legislation increases, the likelihood that a state will pass charter school legislation in a given year will increase.*
> *Expectation 2: The marginal influence of horizontal diffusion forces on the likelihood that a state will pass charter school legislation in a given year will decrease as time increases.*

Political Characteristics. Several political characteristics of states have important influence on the likelihood that a state will adopt an innovation. However, partisan control of the policy making process stands out as an influence studied by nearly every other study of the diffusion of charter school policy. Several other political features of the state are fundamental to the educational system, and these items will be discussed in the next section.

Prior studies suggest that politicians use educational reform as an item on their policy agenda during elections to gain public support. Several authors have even suggested that school choice policy has been predominantly motivated by the potential for personal political gain rather than for increased student achievement (Renzulli and Roscigno 2005; Wong and Langevin 2007; Snook 2009). Additionally, although no difference exists in the adoption of any charter school legislation between Republican and Democratic legislatures and governors, researchers have discovered a positive correlation between a Republican governor and the passage of strong

charter school law (Renzulli and Roscigno 2005; Wong and Langevin 2007). Additionally, when Republicans control at least one house of the state legislature and the governorship, the influence becomes even more pronounced (Hassel 1999).

The governor's incentive to support educational reform, in part, comes from the electoral benefit of passing a policy agenda. Charter school legislation often becomes the reform of choice because it fits the ideological point of view of Republican voters that promotes decentralization and market competition. Additionally, other more drastic education reforms, such as passing a voucher program, are less likely to provide legislative successes or garner support from the party base (Hassel 1999; Renzulli and Roscigno 2005, 349). Still, the level of control the gubernatorial office exerts on the policy-making institutions may condition the magnitude of the influence of gubernatorial partisanship. McLendon et al. (2006) introduces the gubernatorial power index, which scores governors based on multiple characteristics of the governor, the partisanship of the legislature, and the state legislative process.

This study combines the gubernatorial power index and the partisanship of the governor to create an index representing partisan control over the policy making process. On a scale of 0 to 10, 0 indicates the strongest democratic control over the policy making process, and 10 indicates the strongest Republican control over the policy making process. Following the reasoning of the above paragraphs, this study presents the following expectation:

> *Expectation 3: As the level of Republican control over the policymaking process increases, the probability that a state will pass charter school legislation in a given year will increase.*

Educational characteristics. Closely related to the political features of the state are the educational characteristics of the states. The state government determines, to a great extent, how the local school system operates. Since charter school policy innovation attempts to introduce market competition into the education system as a catalyst for widespread improvement, the current condition of a state's education system will have a profound impact on the likelihood of innovation. Several particular characteristics are expected to have a significant impact on the likelihood of the passage of charter school policy, and descriptions of each follow below.

Wong and Langevin (2007) write, "the budgetary process in state legislatures features the most divisive confrontations in American government." These confrontations are the result of the mismatch between the electoral limitations on states' abilities to collect revenue and the high cost of social redistributive policy. Wong and Langevin (2007) identify the implications of this mismatch on the education system: "state lawmakers are frequently limited in their capacity to resolve citizen demands for reform in traditional public schools by legal rules ad regulations for classroom spending and resource allocation." Wong and Langevin (2007) propose a conceptual linkage between the level of classroom spending and the pupil teacher ratio and the states likelihood of passing charter school policy. Based on the assumption that states with the greatest limitation on the professional discretion of local schools will be more likely to produce calls for reform, they propose that the states with the highest pupil to teacher ratios and the lowest levels of classroom spending are more likely to adopt charter school legislation. This study shares Wong and Langevin's (2007) expectations:

> *Expectation 4: As a state education system's pupil to teacher ratio increases, the likelihood of the passage of charter school legislation will increase.*

Expectation 5: As the percentage of funds budgeted to classroom instruction in a state education system decreases, the likelihood of the passage of charter school innovation will increase.

Two characteristics of a state education system's fiscal governance are likely to influence the probability that a state will pass charter school legislations. The first characteristic includes the percentage of a state education system's yearly revenues allocated by the state government. Burkman and Plutzer (2005) describe the regimes that govern educational finance and support that the school systems that rely more on local funding, most often in the form of property tax, are more responsive to the policy preferences of their constituents and garner greater levels of support from their constituencies. Additionally, when local expenditures on education are high, policy makers may view the local tax base as revenue that can support systemic reform without greater reliance on the state (Wong and Langevin, 2007).

Another line of reasoning may explain the relationship between the level of centralization in the state government and the likelihood of innovation. Republicans support small government and decentralization. In states with high levels of centralization, Republicans may view charter school legislation as one way to reduce the level of centralized governmental power. Furthermore, Democrats generally support higher levels of centralization. When Democrats are in control of the policy making process, high levels of centralization are unlikely to alter their political agenda. The above reasoning leads to the following expectations:

Expectation 6: As the level of centralization of the state government decreases, the likelihood that a state legislature will pass charter school legislation will increase.

Expectation 7: As the level of Republican control over the policy making process increases, the marginal influence of the level of centralization of a state government will increase.

The ability of a state's education system to meet the needs of the education system also relies on the governance structure that determines education funding. Wong and Langevin (2007) identify the adequacy of the fiscal policies that govern education finance as an influence that could play a large role in determining the likelihood that a state is willing to pass charter school legislation. The adequacy of the fiscal structure is operationalized as the number of "court rulings on the constitutionality of the state education finance system." (Wong and Langevin, 2007). States with weaker fiscal structures are likely to be more accepting of the arguments that promote charter schools as market driven reforms, leading to the following directional hypothesis:

Expectation 8: As the number of educational finance litigation cases that have occurred in a state in a given year increases, the likelihood that the legislature will pass charter school policy will also increase.

A final characteristic of a state's education system that likely plays a significant role in the passage of charter school legislation is the number of private schools operating in a state.

This number adequately represents three phenomena which may contribute to the passage of charter school legislation. First, the percentage of schools under private operation reveals the extent to which citizens have decided to opt out of the public school system. Second, it reveals the extent of popular demand for educational alternatives (Chubb and Moe, 1990; Mintrom, 1997; Wong and Langevin, 2007). Third, it influences policy makers by providing an example of institutional alternatives to the public education system (Mintrom 1997). As the prevalence of private schools in a state captures both public opinion and influences on policy makers, this study presents the following expectation:

> *Expectation 9: The greater the percentage of schools under private operation, the greater the likelihood of the passage of charter school policy in a given year.*

Social Characteristics. Several social factors also need to be considered in the diffusion of charter school policy.

First, the degree of diversity within the student population is important. Past studies present multiple theories to explain the impact of minority populations on educational policy innovations, but all maintain that states with a greater percentage of minority students in the population are more likely to innovate. Traditionally, school choice has been used to aid in "white flight," offering a way for white parents to remove their children from schools that enroll large numbers of minority students (Renzulli and Rosigno 2005). Therefore, a state having a large proportion of the population as members of a minority provides an incentive for white voters and their elected officials to support charter schools. Yet, charter schools are also viewed as an important and promising alternative to a public education system that has largely

underserved minorities, and, therefore, may receive greater support from minorities in areas with greater minority diversity (Renzulli and Rosigno 2005). Charter schools have been viewed as an especially promising solution for troubled urban schools that have a majority of minority students (Wong and Langevin, 2007). Therefore, the presence of minority diversity is expected to increase the likelihood a state will pass an innovation. This expectation was supported by Renzulli and Roscigno (2005) and Wong and Langevin (2007), but was not included in several analyses (Mintrom, 1997; Mintrom and Vergari, 1998; Wong and Shen, 2002; Wong and Langevin, 2005). Therefore, including the percentage of minority students enrolled in schools remains an important feature of any study of the spread of charter school legislation. How the percentage of minority population will increase the likelihood of a state passing each provision though remains unclear, leaving the following broad hypothesis.

> *Expectation 10: As the proportion of minority students enrolled in the public school system increases, the likelihood of a state passing a charter school policy will increase.*

Second, the per capita personal income of state residents may impact the likelihood that that a state is likely to innovate. Income may impact charter school innovations in several ways. First, Walker (1969) posits that wealthier populations remain more open to social change and therefore more likely to innovate. Second, Berry and Berry (1992) suggest that the heightened demands of state residents with high incomes pressure governments to innovate. Particularly, engaged residents may apply these pressures in order to make the state more competitive in its

attempts to heighten levels of economic development (Wong and Langevin 2007). These concerns lead to the following expectation:

> *Expectation 11: As the per capita income of a state increases, the likelihood that the state will pass charter school legislation in a given year will also increase.*

Time. The passage of time may also influence the hazard rate. Therefore, the analysis will control for temporal dependence of event occurrence using a linear time counter of the number of years a state has been in the risk set.

Analysis

The analysis begins with more descriptive statistics of the hazard rate and the data set. Following is a discussion of the analytic methodology. The next section presents the results. Figures 1 and 2 do not identify when each state passed legislation. Table 1 presents the cumulative data describing the passage of charter school legislation. This data is consistent with all event history analyses of charter school legislation as policy innovation and, in this case, was collected by Wong and Langevin (2007). Figure 3 is a map of the United States showing which states have passed charter school legislation and which have not.

(Insert table 1 and figure 3 here.)

Data.

This study utilizes the data compiled by Wong and Langevin (2007) and is available through the Interuniversity Consortium of Political and Social Research. The data is structured to utilize a state-year as the unit of analysis. Following sections are descriptions of each variable.

Dependent Variable. The dependent variable, the passage of charter school legislation, is a dichotomous, time-dependent variable. In a given year, if a state legislature does not pass charter school policy, that state is coded 0. In the year that an innovation occurs, the state is coded 1. Since innovation, the first passage of charter school legislation, can only occur once, the state is removed from the risk set after an innovation occurs. This is consistent with nearly all past works on educational policy innovation (Mintrom 1997; Mintrom and Vergari 1998; Renzulli and Roscigno 2005; Wong and Langevin 2005; Wong and Langevin 2007).

Explanatory Variables. Authors in the past have used several variables to represent the diffusion forces of horizontal interactions among states. This study utilizes the variable that produced the most accurate estimates in Wong and Langevin (2007), the time-dependent variable measuring the proportion of neighboring states that have adopted charter school legislation. The use of this variable precludes the inclusion of Hawaii and Alaska in the analysis, reducing the risk set by 2.

Among the political characteristics, the presence of a Republican governor is a tie-dependent dichotomous variable coded 1 during years in which the states have a republican governor and coded 0 during the years the states have a Democratic governor. The time-dependent gubernatorial strength variable is based on Beyle's (2005) gubernatorial power index variable which McLendon, Hearn, and Deaton (2006) describe as "a metric combining scores on six individual indices of gubernatorial power, including the governor's tenure potential, appointment power, budget power, veto power, extent to which the governor's party also controls

the legislature, and whether the state provides for separately elected executive branch officials." The metric averages a zero to five score for each component and rounds to the nearest tenth decimal place.

Several variables fall within the category of educational variables. The time-dependant variable pupil to teacher ratio is the number of students enrolled in the state's public primary and secondary school system divided by the number of teachers employed by the state. Classroom spending is a time-dependent variable measuring the percent of a state's expenditures allocated to instructional expenses. State centralization is a time-dependent variable calculated by dividing a state education system's total revenues into the revenues provided by the state government. Wong and Langevin (2007) collected the data above from the Common Core of Data. The adequacy of a state's education finance structure is a time-dependent measure of the, as Wong and Lagevin (2007 write, "total number of state court rulings on the constitutionality of the stated education finance system." Wong and Langevin (2007) based this variable on the work conducted and data compiled by Springer, Liu, and Guthrie (2005). The final variable measuring educational characteristics of a state is the time-dependent percentage of primary and secondary schools privately operated in the state. Wong and Langevin (2007) compiled this data from the Private School Universe Survey and the Common Core of Data.

The social characteristics included in this study include the time varying measure of states' per capita personal income and the percentage of the school age population that are racial minorities. Wong and Langevin (200) compiled the first from the Bureau of Economic Analysis and the second from the Common Core of Data. This study follows Wong and Langevin (2007) and Wong and Shen (2002) by using the logarithm of the per capita personal income in order to produce "more stable parameter estimates," as Wong and Langevin (2007) write.

Implications. Since each observation is comprised for the covariate values of each state-year unit, it is important to account for the dependency that arises among similar observations for each state. Since there are a myriad of unobserved forces that influence each state, the covariate values for a given state in any year are likely dependent upon the covariate values for that state in years prior. However, by incorporating the robust variance estimator method developed by Lin and Wei (1989) into the regression, it is possible to adjust the standard errors of the regression to account for the dependency within state observations produced by unobserved heterogeneity. The regressions for both models calculate the robust standard errors clustered by state.

Results

The maximum partial likelihood estimates of the coefficients produced by the Cox regression of model 1 are presented in table 2. Three statistics are used to assess model fit, the log-likelihood ratio, Aikake's Information Criterion (AIC), and Schwarz's Bayesian Criterion (SBC). The AIC is an adapted form of the log likelihood adapted to penalize for the addition of more covariates. It is simply the log-likelihood plus 2 times the number of covariates. The SBC penalizes even more harshly for the addition of covariates. It is the sum of the log-likelihood and the product of the number of covariates multiplied by the number of observations. None of these model fit statistics reveal an absolute goodness of fit. Instead, they provide a mechanism by which to compare different models to each other (Allison 2010). The regression allows for a test of the global null hypothesis using the likelihood ratio test, the score test, and the Wald test. All three verify that the regression of model 1 supports the rejection of the global null hypothesis. Furthermore, the functional form and proportional hazards model were verified using diagnostic tests of Schoenfeld residuals. Table 3 displays the results of a diagnostic test of the underlying

assumption of proportional hazards. As no correlation exists between the Schoenfeld residuals of each covariate and time, model 1 meets the proportional hazards assumption.

(Insert tables 2 and 3 here.)

The substantive interpretation of table 2 follows. Utilizing the common convention of applying a 5% level of significance, 5 parameter estimates are statistically significant: the percentage of neighboring states that have adopted charter school *legislation*, the log of per capita income, the pupil-teacher ratio, the prevalence of private schools, and the minority population in the state. The signs of the parameter estimates indicate the directional relationships that exist between the explanatory variable and the hazard rate. A simple transformation of the hazard ratio makes this relationship clearer. The hazard ratio is the exponentiated estimate of the parameter and is easily interpretable with the following equation,

$$\Delta h(t) = 100 \, (\, Hazard \, Ratio_k - 1),$$

where $\Delta h(t)$ is the percent change in the hazard rate for each 1-unit increase in independent variable k all else equal.

Accordingly, the parameter estimates confirm several expectations of this study. First, following the equation above, the model suggests that for every unit increase in the pupil-teacher ratio, the likelihood of the passage of charter school legislation will increase by 43.8%. This increase confirms expectation 4.

The findings of model 1 also confirm expectations 9 and 10, reinforcing the findings of Wong and Langevin (2007). Model 1 predicts that for even minute incremental increases in the percentage of private schools in the state or in the percentage of students who are minorities, the likelihood of the passage of charter school legislation will increase dramatically.

However, the results of model 1 also suggest that several of the expected relationships do not hold true. The parameter coefficients of the proportion of neighbors having adopted charter school legislation and the log per capita income support the existence of two relationships that are opposite of the expected direction. Following the transformation above, a 25% increase in the percentage of neighboring states having adopted charter school legislation will produce on average a 23.25% decrease in the likelihood that a state will adopt charter school legislation in a given year. An increase of 0.1 in the log of a states per capita income will produce on average a 9.94% decrease in the likelihood of adoption in a given year. (An increase of 0.1 is a useful magnitude for increase in a states log per capita income because this variable has a standard deviation of 0.136.) Note, though, that for this study, the directional relationships that the point estimates indicate are more important than the point estimate values themselves.

Furthermore, Model 1 does not support expectations 3, 5, 6, and 8. None of the following variables had a significant impact on the likelihood of innovation: the degree of Republican control over the policy making process, level of classroom spending, proportion the school budget provided by state revenue, and the number of education finance litigation cases.

The results of the Cox regression of model 2 are shown in table 4, and the results of the diagnostic test in table 5. All three model fit statistics suggest that model 2 better estimates the effect of each explanatory variable on the hazard rate. Again, it is not surprising that the tests of the global null hypothesis support its rejection.

(Insert tables 4 and 5 here.)

However, it is surprising that the inclusion of the interaction terms provides different substantive conclusions from the data than model 1. Again following the convention of utilizing a 5% level of significance, four explanatory variables have a statistically significant impact on the likelihood that a state will pass charter school legislation. A discussion of each follows.

The time dependency variable is the first with a statistically significant parameter estimate. Model 2 revealed a negative directional relationship between the linear time counter and the hazard rate. As time passes, the likelihood of a state innovating will decrease all else equal. This is an interesting

Second, the model supports the expected negative directional relationship between classroom spending and the likelihood of passage identified in expectation 5. As classroom spending decreases even incrementally, the likelihood of passage increases dramatically, all else equal.

Third, model 2 supports the directional relationships between the likelihood of passage and both the prevalence of private schools and the proportion of the student population who are minorities. These results confirm expectations 9 and 10. Although the positive directional relationship between the percentage of private schools and the likelihood of innovation indicated by model 2 does not produce a hazard rate nearly as dramatic as model 1, the relationship still suggests that incremental increases in the percentage of schools under private operation dramatically increase the likelihood of adoption. Model 2 also suggests that, all else equal, as the proportion of students who are minorities increases by 0.01, the likelihood of a state passing

charter school legislation will increase by 12.5%. This finding reconfirms the results presented by Wong and Langevin (2007) and Renzulli and Roscigno (2005).

Furthermore, the analysis did not provide sufficient evidence to conclude that the likelihood function is influenced by the conditional relationships between time and the proportion of neighboring states who have already innovated and between the level of Republican power of the policy making process and the level of state centralization. These relationships were described in expectations 2 and 7. Importantly, the point estimate of the parameter coefficient of the influence of geographic diffusion forces on the likelihood of innovation is now positive. Although the estimate is not statistically significant, the change in sign reveals that the respecified model no longer contradicts the direction that the theory predicts.

Model 2 did not support any of the predicted relationships described in expectations 1, 3, 4, 6, 8, 11. These include the proportion of neighboring states that have already innovated, extent of Republican control over the policy-making process, pupil-teacher ratio, fiscal centralization, the number of education finance litigation cases, and the log of the per capita income. Still, the improvement in the expected direction of some parameter values, plus the improvement of the model fit suggests that model 2 is superior to model 1 in explaining charter school adoption.

Finally, several findings in model 2 reveal substantively different relationships than those suggested in past works. First, the directional relationship between time and the likelihood of passage is negative, and the coefficient estimate is statistically significant. Wong and Langevin (2007), found the opposite to be true, although they used a different operational definition of time. Although time is only a control variable, the difference in these two results is noteworthy. The respecification of the influence of time that is developed here suggests that time plays a

more complicated role in the process of educational innovation than is suggested by Wong and Langevin. Second, model 2's estimate of the influence of a state's log per capita income on the likelihood of adoption is negative whereas Wong and Langevin's (2007) model produces a positive estimate. Lastly, the coefficient estimate indicating the influence of the percentage of educational funds provided by a state's revenues on a state's likelihood of adoption also changes signs from Wong and Langevin's (2007) model. Although neither estimates are statistically significant by conventional standards of $p < \alpha = 0.05$, the change in signs remains a unique contribution and calls into question the influence of wealth and centralization of state governments on the likelihood of charter school policy innovation.

Conclusion

Drawing upon event history analysis, a methodological framework introduced to the political science literature by Berry and Berry (1990), this study presents two models of the diffusion of charter school policy across the United States. Taking advantage of the historic rise of the charter school movement as an example of policy diffusion, this study contributes to a large body of existing literature on the diffusion of policy innovations. After a brief review of the charter school movement and the literature studying the diffusion of charter school and school choice policies, this study employs the semi-parametric, Cox proportional hazards model of event history analysis to explore charter school diffusion. This method is used to estimate two model specifications, which produce results reinforcing the findings of several past studies. In particular, the analysis indicates that the prevalence of private schools in a state and the level of diversity within a state's student population share positive directional relationships with the likelihood of the passage of innovation, confirming the findings of Renzulli and Roscigno (2005) and Wong and Langevin (2007).

These findings offer interesting theoretical conclusions. The prevalence of private schools represents public perception that traditional public school systems are inadequate, at least among those financially able to enroll their children in alternative systems. The influence of minority diversity further supports the conclusion that the public perception of the adequacy of a school system impacts policy innovation, but it reveals a deeper social complexity. In heterogeneous populations, social conditions create public discontent with the traditional public school system. Although it is impossible based on the evidence of this study to specify whether an increased likelihood of innovation is driven by minority groups' discontent with traditional public schools, majority groups' desires to move away from schools with large minority populations, or a combination of the two forces, it is clear that states with heterogeneous populations are more likely to adopt this educational reform. This suggests that racial and ethnic tensions still impact educational policy decisions. However, the results of this study also provide a source of optimism when considering the responsiveness of state governments; the adoption of charter school policy seems to result not from the rise and fall of political parties but from the prevalence of constituent preferences, even if those preferences are prejudiced.

This study does more than simply confirm the findings of past studies. It also supports the revision of thought concerning the relationships that exist between three variables and the likelihood of innovation. First, it suggests that the passage of time by itself may in fact not increase the likelihood of adoption. We should be careful not to suggest at this point that time does not matter at all. But these results do suggest that there is an underlying level of complexity in the evolution of innovation that others may not have fully appreciated. Second, it presents the possibility that wealthier states, measured by the log of per capita income, may not in fact be more likely to support charter school policy adoption. In the case of charter school policies,

greater wealth does not produce a more dynamic policy environment. However, this finding should not be extended too far. For example, one might think that this relationship could be the result of wealthier states spending more on education, thereby stabilizing existing educational policy frameworks by decreasing the prevalence of perceptions that the school system is inadequate. However, greater wealth does not guarantee higher levels of educational spending, nor do higher levels of spending guarantee more effective educational systems. This finding simply states that an increase in a state's per capita personal income does not increase the likelihood of innovation. Third, this study presents a possibility that states with greater levels of centralization - in particular greater level of budgetary support for the school districts by state governments - may increase the likelihood of innovation. Theoretically, this offers a new understanding of state legislators' motivations for supporting charter schools. Since policy entrepreneurs often present charter schools as a method of reducing educational expenditures, legislators may be more likely to respond to the potential budgetary benefits when the state government will experience a larger share of the potential savings resulting from the policy. Prior theories, on the other hand, presented legislators as more likely to support innovation when the potential costs of the innovation would be covered by local tax bases, as is the case in more decentralized states.

Still, there is more to be learned about the diffusion of charter school policy throughout the United States. New model specifications that include variables that represent better defined and operationalized concepts may lead to a more accurate understanding of this instance of diffusion. In particular, advancing our understanding of diffusion forces may lead to a deeper understanding of the relationship between the states. For example, studies that include new data sets with variables capturing the activity of policy entrepreneurs, measures similar to those used

by Mintrom (1997), could reveal how the maturation of the diffusion process impacts the influence of policy entrepreneurs have on the likelihood of adoption. Still, most future analyses will rely on the creation of new longitudinal data sets to combat the possible omitted variable bias, which impacts most analyses of charter school innovation, including this one. Particularly, including variables that capture the influence of special interest groups, such as teacher unions and state chambers of commerce, may allow researchers to compare the relative influence of social and educational characteristics of the state with the influence of special interests on the probability of innovation. Additionally, it may be possible to gain more insight into diffusion by advancing further the methods used to test these models, especially by using Bayesian analysis.

Furthermore, innovation is only one short stage in the life of a policy. Studies of the evolution and implementation of charter school policy could determine if the same influences that lead to the adoption of charter school policy influence how the policy changes over time. Additionally, as the number of charter schools in the states increase, it may be possible to measure if the educational policies that existed prior to charter school innovation changed as a result of the introduction of market competition into the educational system. As major efforts to increase the validity of national measurements of school achievement continue, it will be possible to more accurately determine whether any real relationship exists between student achievement and the processes of policy innovation, evolution, and implementation, or if the primary forces motivating the policy debate are special interests.

Finally, the rise of charter school policy provides significant insight into one instance of policy innovation and diffusion, and its subsequent evolution will provide another useful case for the study of policy evolution. Although the study of charter school innovation and diffusion has greatly progressed, it is still some years away from a point of saturation. Still, there is sufficient

reason to hope a rigorous meta-analysis of past studies, which could provide a sort of conclusion to the study of charter school diffusion, is on the horizon.

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Tables

Table 1:
Descriptive Statistics of Charter School Policy Innovation within the United States

Year	States Adopting Charter School Legislation	Number of State Adoptions	Cumulative Number of State Adoptions	Cumulative Proportion of State Adoptions	Size of Risk Set	Hazard Rate
1991	MN	1	1	0.02	50	0.02
1992	CA	1	2	0.04	49	0.02
1993	CO, GA, MA, MI NM, WI	6	8	0.16	48	0.13
1994	AZ, HI, KS	3	11	0.22	42	0.07
1995	AK, AR, DE, LA , NH, RI, TX, WY	8	19	0.38	39	0.21
1996	CT, FL, IL, NJ, NC, SC	6	25	0.5	31	0.19
1997	MS, NV, OH, PA	4	29	0.58	25	0.16
1998	ID, MO, NY, UT, VA	5	34	0.68	21	0.24
1999	OK, OR	2	36	0.72	16	0.13
2000		0	36	0.72	14	0
2001	IN	1	37	0.74	14	0.07
2002	IA, TN	2	39	0.78	13	0.15
2003	MD	1	40	0.8	11	0.09
2004		0	40	0.8	10	0
2005		0	40	0.8	10	0
2006		0	40	0.8	10	0

Table 2:
Maximum Likelihood Estimates of Cox Regression for Model 1

Parameter	Parameter Estimate	Standard Error	p-value	Hazard Ratio
Neighbor's Adoption	-2.65764	0.67582	< 0.0001	0.07
Republican Gubernatorial Power Score	0.13951	0.07197	0.0526	1.15
Education Finance Litigation	0.24322	0.16003	0.1285	1.275
Log of Per Capita Income	-5.17148	2.3438	0.0274	0.006
Pupil Teacher Ratio	0.36299	0.1203	0.0026	1.438
Classroom Spending	-18.1338	10.52576	0.0849	0.00
State Revenue Percentage	-4.536	3.16506	0.1518	0.011
Private Schools	9.96094	3.24421	0.0021	21182.75
Minority Population	3.86269	1.56263	0.0134	47.593

Tests of the Global Null Hypothesis	Chi-Square	Degrees of Freedom	Pr > ChiSq
Likelihood Ratio	72.8502	9	<0.0001
Score test	29.9407	9	0.0004
Wald test	60.0523	9	<0.0001

Model Fit Statistics	Values Without Covariates	Values With Covariates
-2 Log Likelihood	370.54	297.69
AIC	370.54	315.69
SBC	370.54	330.188
Number of Observations		336

Table 3:
Schoenfeld Residuals for model 1.

Parameter	Duration	Log(Duration)	Duration Squared
duration	1	0.93421	0.96559
		<.0001	<.0001
	336	336	336
logduration	0.93421	1	0.81816
	<.0001		<.0001
	336	336	336
duration2	0.96559	0.81816	1
	<.0001	<.0001	
	336	336	336
schnbrpro	0.11373	0.13623	0.08985
Schoenfeld Residual for nbrpro	0.5027	0.4214	0.5969
	37	37	37
schexecpwr	0.0046	0.018	-0.02503
Schoenfeld Residual for execpwr	0.9785	0.9158	0.8831
	37	37	37
schedfinlaw	-0.17868	-0.22048	-0.13171
Schoenfeld Residual for edfinlaw	0.29	0.1898	0.4371
	37	37	37
schpcpinc2	-0.13741	-0.18662	-0.08452
Schoenfeld Residual for pcpinc2	0.4174	0.2687	0.6189
	37	37	37
schpuptch	0.10154	0.00423	0.12662
Schoenfeld Residual for puptch	0.5498	0.9802	0.4552
	37	37	37
schpctinstr	0.15007	0.16076	0.13274
Schoenfeld Residual for pctinstr	0.3753	0.3418	0.4335
	37	37	37
schstrevpct	-0.00651	-0.04704	0.00527
Schoenfeld Residual for strevpct	0.9695	0.7822	0.9753
	37	37	37
schpctprvsc	0.0207	-0.04084	0.07304
Schoenfeld Residual for pctprvsc	0.9032	0.8104	0.6675
	37	37	37
schpctnowhi	-0.02079	-0.0243	-0.02937
Schoenfeld Residual for pctnowhi	0.9028	0.8865	0.863
	37	37	37

Each cell contains the pearson correlation coefficients, the p > |r| under Ho: Rho=0, Number of Observations

Table 4:
Maximum Likelihood Estimates of Cox Regression Model 2

Parameter	Parameter Estimate	Standard Error	Pr > ChiSq	Hazard Ratio
Neighbor's Adoption	2.8905	2.05078	0.1587	18.002
Time (years)	-17.3855	0.19762	< 0.0001	0
Interaction: Neighbor's Adoption and Time	-0.23949	0.29609	0.4186	0.787
Partisan Control of Policymaking Process	0.45086	0.25406	0.076	1.57
Education Finance Litigation	0.22088	0.12271	0.0719	1.247
Log of Per Capita Income	-0.54604	1.76806	0.7574	0.579
Pupil Teacher Ratio	0.11855	0.0883	0.1794	1.126
Classroom Spending	-13.8836	6.35927	0.029	0
State Revenue Percentage	3.20477	3.67285	0.3829	24.65
Interaction: State Decentralization and Partisan Control of Policymaking Process	-0.66244	0.53012	0.2114	0.516
Private Schools	6.62371	2.97956	0.0262	752.73
Minority Population	2.60517	1.21509	0.032	13.534

Tests of the Global Null Hypothesis	Chi-Square	Degrees of Freedom	Pr > ChiSq
Likelihood Ratio	160.173	12	<0.0001
Score test	43.4499	12	<0.0001
Wald test	11705.8362	12	<0.0001

Model Fit Statistics	Values Without Covariates	Values With Covariates
-2 Log Likelihood	370.54	210.367
AIC	370.54	234.367
SBC	370.54	253.698
Number of Observations		336

Table 5:
Schoenfeld Residuals of Model 2

parameter	duration	logduration	duration2
duration	1	0.93421	0.96559
		<.0001	<.0001
	336	336	336
logduration	0.93421	1	0.81816
	<.0001		<.0001
	336	336	336
duration2	0.96559	0.81816	1
	<.0001	<.0001	
	336	336	336
schnbrpro	0	0.00976	-0.01109
Schoenfeld Residual for nbrpro	1	0.9543	0.948
	37	37	37
schduration	0.60644	0.68255	0.4732
Schoenfeld Residual for duration	<.0001	<.0001	0.0031
	37	37	37
schnbrproyear	-0.02464	-0.00841	-0.04556
Schoenfeld Residual for nbrproyear	0.8849	0.9606	0.7889
	37	37	37
schexecpwr	0.13022	0.08614	0.13792
Schoenfeld Residual for execpwr	0.4424	0.6122	0.4156
	37	37	37
schedfinlaw	-0.23112	-0.25938	-0.19294
Schoenfeld Residual for edfinlaw	0.1687	0.1211	0.2526
	37	37	37
schpcpinc2	-0.07742	-0.11989	-0.0437
Schoenfeld Residual for pcpinc2	0.6488	0.4797	0.7973
	37	37	37
schpuptch	-0.04035	-0.10733	-0.02484
Schoenfeld Residual for puptch	0.8126	0.5272	0.884
	37	37	37
schpctinstr	-0.012	-0.01829	0.00602
Schoenfeld Residual for pctinstr	0.9438	0.9144	0.9718
	37	37	37
schstrevpct	-0.14241	-0.16418	-0.12767
Schoenfeld Residual for strevpct	0.4005	0.3315	0.4514
	37	37	37
schstrevpctpwr	0.09899	0.02822	0.11479
Schoenfeld Residual for strevpctpwr	0.56	0.8683	0.4987
	37	37	37
schpctprvsc	-0.05718	-0.10842	-0.00747
Schoenfeld Residual for pctprvsc	0.7368	0.523	0.965
	37	37	37
schpctnowhi	-0.07801	-0.1152	-0.06113
Schoenfeld Residual for pctnowhi	0.6463	0.4972	0.7193
	37	37	37

Figures

Figure 1: Hazard Rate for State Adoption of Charter School Policy

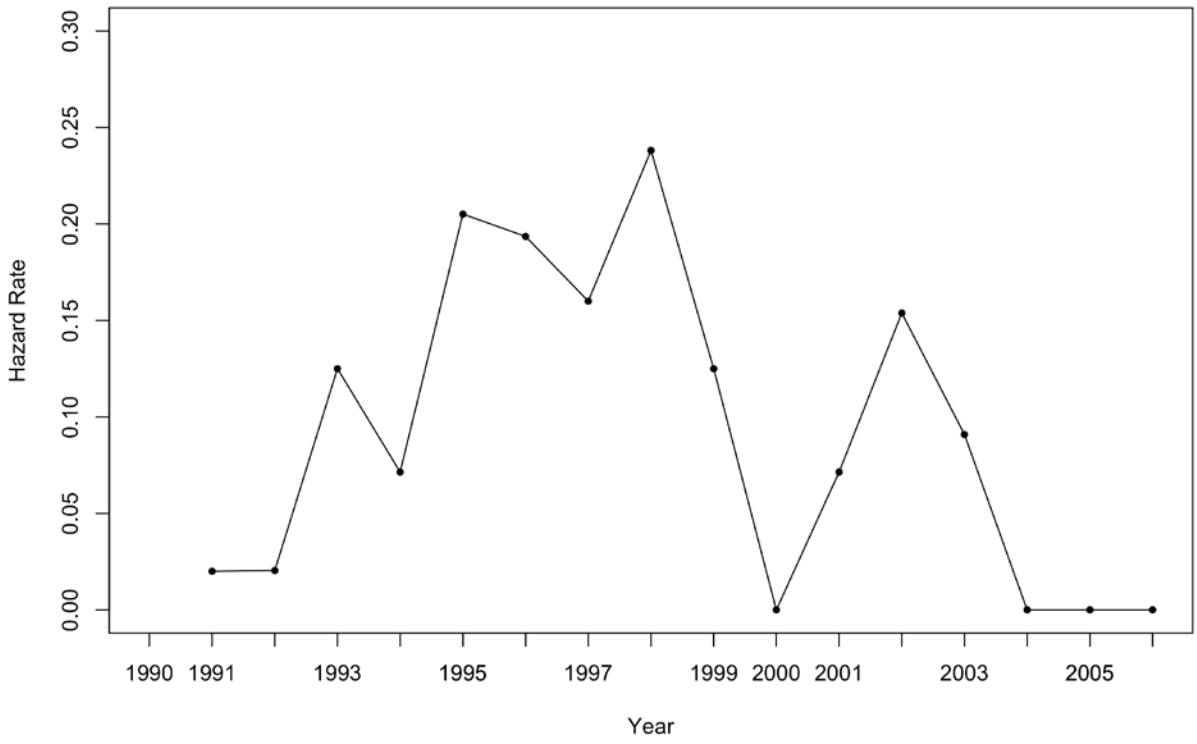


Figure 2: Cumulative Proportion of State Policy Innovation

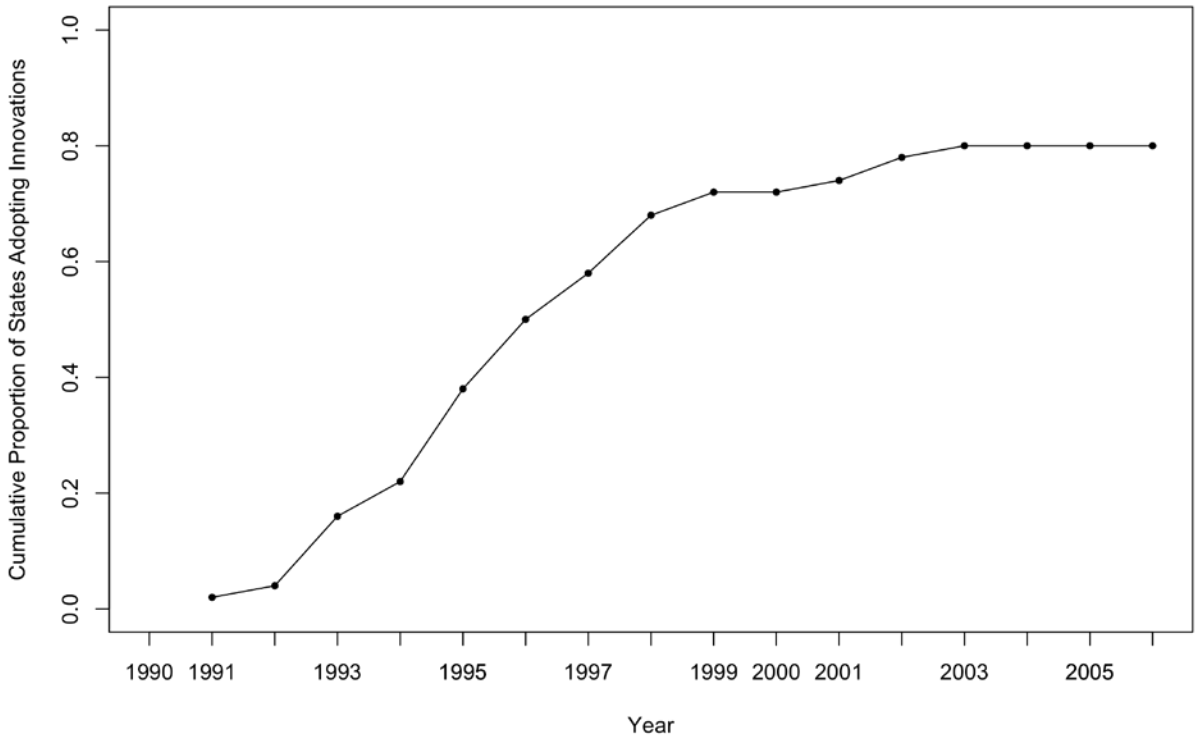
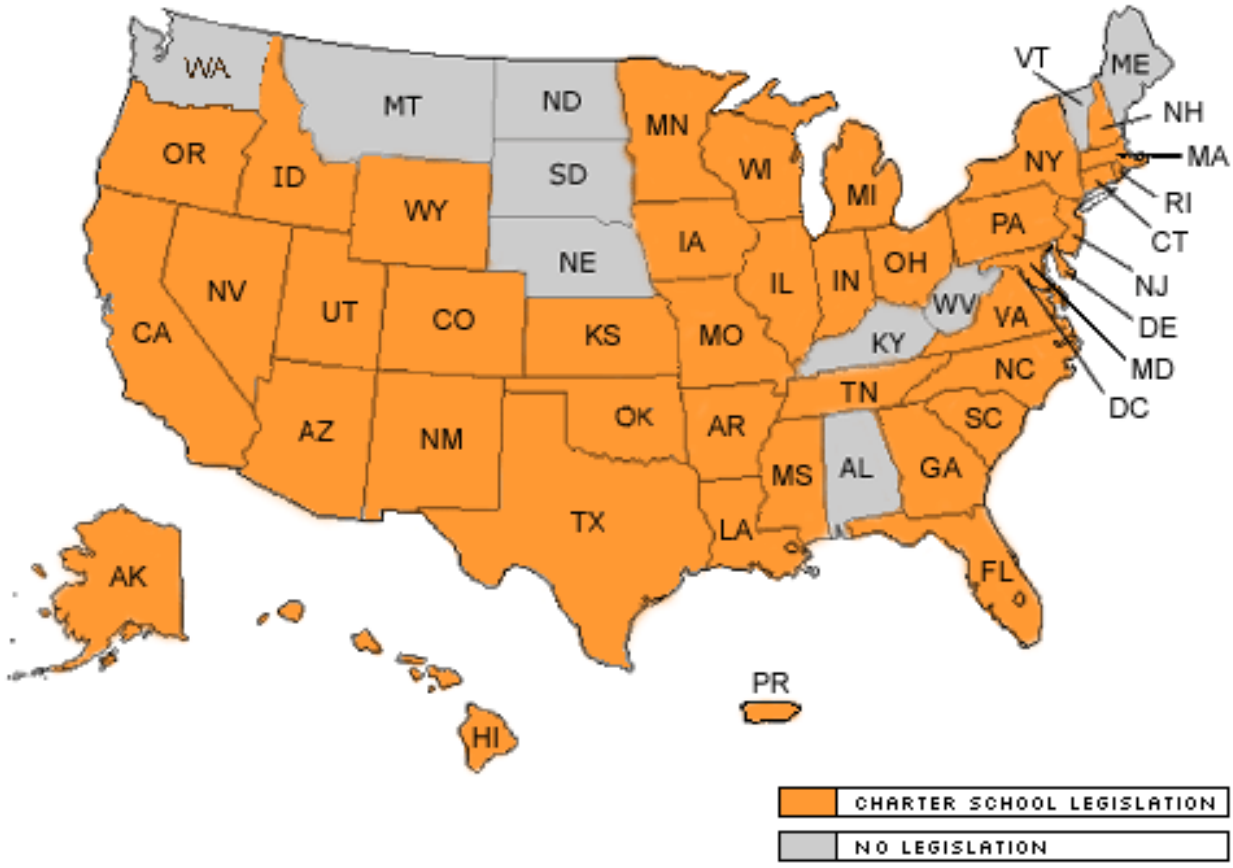


Figure 3: Charter School Adoption in the U.S. (2006 - current)



(Washington Charter School Resource Center 2011)

Appendix: Analytic Methodology

The majority of the analysis falls in determining the impact of each of the above variables on the hazard rate. The hazard rate, $h(t)$, is the likelihood that passage of legislation will occur, given that it has not already occurred, and is described by the function,

$$h(t) = \Pr(T = t_i \mid T \geq t_i, x),$$

where T is a discrete random variable indicating the time of event occurrence, t_i indicates the observation of event occurrence at time i, and x indicates the relationships of the covariates (Wong and Langevin 2005). Cox's proportional hazards model assumes that $h(t)$ can be expressed as,

$$h_i(t) = \lambda_0(t) \exp\left(\beta_1 x_{i1}(t) + \ldots + \beta_{ik} x_{ik}(t)\right),$$

where $\lambda_0(t)$ is the baseline hazard function for individual i at time t, or the hazard function given that all the covariates take the value 0, and $\beta_1 x_{i1}(t) + \ldots + \beta_{ik} x_{ik}(t)$ is a linear function of k time-dependent covariates (Allison, 2010). (There are several tests of the validity of this assumption, and the three which are used in this analysis will be discussed in the results section.) Taking the log of the $h_i(t)$ produces the function,

$$\log h_i(t) = \propto(t) + \beta_1 x_{i1}(t) + \ldots + \beta_{ik} x_{ik}(t),$$

where $\propto(t)$ is the log of the hazard function. The ratio of the hazards of two events can expressed as,

$$h_i(t) / h_j(t) = \exp\{ \beta_1 [x_{i1}(t) - x_{j1}(t)] + \ldots + \beta_{ik} [x_{ik}(t) - x_{jk}(t)].$$

The hazard for an individual at time *t* is a fixed proportion of the hazard for any other individual at time *t* (Allison 2010).

Maximum partial likelihood estimation, developed by that statistician for whom this regression is named, Cox (1972), allows the coefficients to be estimated without necessitating the estimation of the baseline function. However, maximum partial likelihood estimation comes with a tradeoff. Although the estimators are still consistent and asymptotically normal, they are not fully efficient. Therefore, the standard errors will vary more than if maximum likelihood estimation were used. However, the increased variation does not preclude the estimations from maintaining their explanatory power (Allison 2010).

Partial likelihood estimation utilizes the following expression,

$$PL = \prod_{i=1}^{n} \left(\frac{e^{\beta x_i(t)}}{\sum_{j=1}^{n} Y_{ij} e^{\beta_j(t)}} \right)^{\delta_i}$$

As the formula displays, the estimation is based on the rank of events, not on the numerical values of event times. In simpler terms, the partial likelihood is the likelihood that out of all units, or states, observation *i* would leave the risk set. The partial likelihood estimates the coefficients that maximize the likelihood that the event occurs in unit *i*. Whereas this makes the handling of time much easier for some data, it complicates the analysis of tied data, or data in which multiple units leave the risk set at the same rank. In discrete data, the rank of event

occurrence is unnkown. Therefore, the partial likelihood function must include all possible orderings of event occurrence for the tied data. For most years that states passed charter school legislation, more than one state adopted the legislation and left the risk set. Therefore, the analysis in this study must account for tied data. Maximizing the coefficients all possible orderings of event occurrence for each year is computationally inefficient and without powerful computers is impractical. Therefore, the analysis of this study employs the approximation for the estimation of the partial likelihood function designed by Efron (1977), an approximation that is becoming the standard for the estimation of partial likelihood for tied data due to the (Fox, 2002; Allison, 2010).