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Essays on State Lottery Demand and Revenue Earmarks

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To the Graduate Council:

I am submitting herewith a dissertation written by Kara Diane Smith Mitchell entitled "Essays on State Lottery Demand and Revenue Earmarks." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Economics.

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Essays on State Lottery Demand and Revenue Earmarks

A Dissertation Presented for the

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Degree

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Dedication

This dissertation is dedicated to my husband, Trent, for his patient support and gracious endurance of the vicissitudes of graduate student life.

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Abstract

Since the first modern state-sponsored lottery was instituted in New Hampshire in 1964, lotteries have proliferated to 42 states and the District of Colombia. With little exception, research has shown that these lotteries are a highly regressive form of taxation. However, this body of research does not take into account a theoretical finding that the manner in which collected funds are earmarked impacts participation patterns. The goal of this dissertation is to test this finding empirically.

In the first analysis, I use sales data from the Tennessee Education Lottery and scholarship data from the TEL Scholarship program to test this theory directly. I find that instant game sales are increasing in the number of scholarships awarded in a given county and that the implicit tax incidence is less regressive than in certain other states. I also find that the relationship between scholarships and sales is stronger in higher income counties. Theory does not hold for Powerball sales. This may be due to a misconception that buying into a multi-state game does not directly subsidize programs in Tennessee.

In the second analysis, I focus on the Texas Lottery, which began as a revenue stream for the state’s General Fund, but eventually became a dedicated revenue stream for K-12 education. I exploit this change to test for a structural break in the demand for two lottery games. Then, I extend an existing theory of lottery demand to take this structural break into account. I find that there is a structural break at the time the earmark is implemented, and that the lottery is less regressive after the earmark.

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Chapter 1

The Economics of State Lotteries

1.1 Introduction

Lotteries have a long and storied history in America. In 1776, a lottery was authorized to raise money for the Colonial Army. Shortly thereafter, states and localities implemented lotteries to support specific expenditures when other means of taxation were not feasible. After the Civil War, a period of moral resistance resulted in prohibitions against legalized gambling. However, in 1964, New Hampshire instituted the first modern state lottery and, very quickly, other New England states followed suit.

Today, 43 states and the District of Colombia use lotteries as a mechanism to fund public programs. Much like the early American lotteries, most state lotteries are instituted to fund narrowly defined programs. About 90% of lottery states earmark lottery proceeds in whole or in part for specific programs. These earmarks are important politically, as lottery legislation often faces significant hurdles, such as constitutional amendments and public referendums. Not surprisingly, education is the most popular recipient of lottery proceeds, despite skepticism about whether such earmarks actually increase education funding dollar-for-dollar.

However, few studies examine the material importance of the earmarks to the potential players of the lottery. Morgan (2000) introduces a theoretical model demonstrating how lottery players respond to the value of the public good funded by their contributions. He finds that lottery purchases (ie, contributions to the public good) are increasing in the value of the public good that is funded. Further research (Landry and Price 2007) looks at highly aggregated sales data from lottery states, demonstrating that lottery purchases per capita are higher in states that earmark for education and that casino gambling is only a substitute for lottery play in states that do not earmark.

The purpose of this dissertation is to test Morgan's theory on a micro level. I do this with data sets from two different lottery states, Tennessee and Texas. I discuss the unique analyses for each state in Chapters 2 and 3. In this chapter, I discuss prior literature on the economics of state lotteries and the underlying theory describing why earmarks should be a part of lottery demand models.

1.2 Prior Literature

Although a lottery is not a conventional form of taxation, it does impose an implicit tax on the player. Because a fixed portion of the cost of a lottery ticket is state revenue, the tax is in fact very high (often 50% or more) on the actual value of the good (the expected prize). Lottery corporations are rarely explicit about the expected value of lottery tickets (particularly instant game tickets) which means that calculating the expected prize isn't a straightforward exercise. However, it is possible to get a crude measure of the tax rate of lottery games in a state by comparing the total dollar value of prizes awarded with total transfers to the government. For instance, in fiscal year 2010, the Tennessee Education Lottery transferred $288.87 million to the state for its lottery-funded education programs while awarding 707.17 million in prizes.[1] This implies an average tax rate of 40.8%. A similar calculation reveals that the tax rate on lottery tickets was 43.3% in Texas in fiscal year 2010.[2] As previously mentioned, the regressive nature of a state lottery's implicit tax is well documented. This conclusion has been reached using a variety of statistical and data methods.

First, lottery studies differ in the type of data used to estimate lottery ticket purchases. Early research often used surveys of state residents or winners (Brinner and Clotfelter 1975; Clotfelter and Cook 1987; Brown et al. 1992; Spiro 1974; Herring and

[1] Tennessee Education Lottery 2010 Annual Report. http://www.tnlottery.com/aboutus/reports.aspx
[2] Texas Lottery 2010 Annual Report. http://www.txlottery.org/export/sites/lottery/Documents/Audited_AFR_FY_2010_-_FINAL.pdf

Bledsoe 1994; Miyazaki et al. 1996; Langenderfer 1996; Burns et al. 1990). Other research used publicly available data on winners, assuming that winners are a random subsample of lottery players (Clotfelter and Cook 1987; Brinner and Clotfelter 1975). The most popular method, however, of approximating the individual demand for lottery tickets is the use of sales data aggregated by city (Jackson 1994), zip code (Oster 2004; Clotfelter 1979; Price and Novak 1999), or county (Garrett and Coughlin 2009; Miyazaki et al. 1998; Hansen et al. 2000; Hansen 1995; Mikesell 1989; Brinner and Clotfelter 1975).

I use county-aggregated data from Tennessee and zip code-aggregated data from Texas in this study. Although there may be concerns about the homogeneity of income (and therefore the distribution of lottery purchases) across a given geographic area, there are several advantages to using county-aggregated data. First, it eliminates response biases that are likely to exist in survey data. Second, unlike research on lottery winners only, county aggregated data allow me to estimate tax incidence on the entire population rather than just players.

Second, lottery studies differ in the statistical estimation of tax incidence. Some calculate a Suits index (Brinner and Clotfelter 1975; Miyazaki et al. 1998; Clotfelter 1979; Clotfelter and Cook 1987; Price and Novak 1999; Hansen 1995; Spiro 1974).[3] Other papers estimate income elasticity (Oster 2004; Garrett and Coughlin 2009; Hansen et al. 2000; Price and Novak 1999; Jackson 1994; Borg and Mason 1988; Mikesell 1989). These authors estimate the income elasticity by using a double log model (expressing both the dependent variable used to approximate lottery demand and the independent income variable in natural logs). The drawback to this approach is that it estimates a constant elasticity. Some, but not all, of these authors also include point estimates for various income brackets or estimate other functional forms of the double log model as a robustness check.

[3] A Suits index in this context is calculated from a Lorenz curve derived by plotting accumulated lottery sales against accumulated state income. The area under this curve is compared to a line of equality to calculate the Suits index. A number less than zero implies a regressive tax. A number greater than zero implies a progressive tax. For more information, see Suits (1977).

In addition to estimates of tax elasticity, these papers consistently find that lottery play is affected by certain demographic characteristics. For instance, increased lottery play is consistent with less formal education, minority status, increased age, and participation in other forms of gambling. Therefore, controlling for the demographic characteristics of county populations is important when estimating the demand for lottery tickets.

Moreover, there are differences in the income elasticity between lottery games. Price and Novak (1999) estimate the tax incidence of the Texas lottery, looking at three games independently. They find that instant games are the most regressive, large prize numbers games are the least regressive, and small prize numbers games are in between. Due to this finding, I estimate the income elasticity separately for each lottery game, rather than using aggregate sales data.

Finally, Oster (2004) finds that Powerball sales become less regressive as the prize increases. Therefore, in Chapter 2, I control for the size of the advertised Powerball prize when I calculate income elasticities in Tennessee. In Chapter 3, I test Oster's results using sales of a jackpot numbers game in Texas.

Despite an extensive literature regarding the tax incidence of state lotteries, no research has incorporated the importance of the value of the public good funded with lottery revenue. The theoretical foundation for this relevance is introduced by Morgan (2000). Morgan views lotteries as a practical means of overcoming the free-rider problem in the provision of public goods. He assumes that agents are risk-neutral expected utility maximizers with heterogeneous preferences and quasi-linear utility functions. The assumption of risk-neutrality is of particular importance, as love-of-gambling or risk-seeking behaviors are often assumed to be the motives for playing a lottery with a negative expected return. However, as Morgan demonstrates, this may not be the case when a socially desirable public good is funded with the proceeds.

The sensitivity of lottery play to the value of the public good funded has been tested relatively little, despite heterogeneity in lottery earmarks across states. Landry and Price (2006) compare total per capita expenditures in states that earmark for education and those that do not. They find that expenditures are higher in states that earmark for education, suggesting that perhaps the earmark in and of itself affects the level of play. They also find that the introduction of casino gambling negatively impacts lotto play in general fund states but has no impact in states that earmark for education. This calls into question whether love of gambling is the main driver of lottery purchases in states that earmark.

It is important to note that earmarking for education in one way or another (K-12, higher education supplements, student scholarships) is by far the most popular earmark among states, despite evidence that lottery funds do not fully supplement, rather than supplant, other funding. Pantusco, Seyfried and Stonebraker (2007) find that earmarking proceeds for education does not typically increase education expenditures more than placing lottery proceeds in the state general fund. Evans and Zhang (2007) find that 50-70 cents of each lottery dollar earmarked for K-12 education ends up in local school districts, in contrast to 30 cents in states that deposit lottery revenue into a general fund.

However, actually funding the program(s) in question may be a secondary reason to push certain earmarks. States seeking to institute a lottery typically face a deeply divided electorate. Moral objections to legalized gambling and ideological objections to highly regressive taxation generate staunch opposition. It is possible that such earmarks serve a political purpose, softening marginal opposition and allowing lottery legislation and referendums to pass.

Some studies have examined the budgetary incidence of lotteries with these specific earmarks, thereby calculating a "net incidence." Borg and Mason (1988) find that earmarking lottery proceeds for education in Illinois reduces the implied regressivity, but does not eliminate it. Similarly, Rubenstein and Scafidi (2002) examine the Georgia Lottery for Education and find that regressivity is not eliminated by earmarking for education programs. In particular, they find that expenditures on the Georgia HOPE Scholarship for higher education exacerbate this net regressivity, as benefits typically accrue to higher-income Georgians.

A 2004 study by Stranahan and Borg is of particular interest because it estimates the net budgetary incidence of the Florida Bright Futures scholarship, a lottery-funded scholarship program that is similar in structure to, though smaller than, the Tennessee

Education Lottery Scholarship program. The authors conclude that the lottery tax-funded scholarships disproportionately benefit high-income, well-educated, white households. This is consistent with the findings of Rubenstein and Scafadi.

According to the theory in Morgan (2000), this finding corresponds to a public good with a marginal per capita return that increases with income. Therefore, I would expect to find that lottery sales are less regressive in a state which earmarks most lottery revenue for scholarships, such as Tennessee, relative to a state that earmarks for K-12 education, such as Texas, or does not earmark at all.

1.3 Theory

Although Morgan (2000) first presented theory demonstrating that lottery play is affected by the good funded with revenue, Lange, List, and Price (2007) extend that theory to allow lottery players to have heterogeneous values for the public good. I present here a simplified version of that theory. The comparative statics derived below have important implications for the empirical analysis that follows.

Morgan views a lottery as a means of overcoming the free rider problem in the provision of public goods. When a classic voluntary contributions mechanism is used to fund a public good, each participant contributes zero in equilibrium. However, when a lottery is added as a means of inducing participation, players then get two returns, the expected prize and the return from the public good. If the return from the public good is sufficiently high, even risk-neutral players may maximize utility through participation.

Assume that players are heterogeneous in the return from the public good. Therefore, an individual faces a linear utility function of the form:

$$U = w_i - t_i + \frac{t_i}{t_i + t_{-i}} * P + h_i(G)$$

where $w_i - t_i$ is the individual's income, net of contributions to the public good (lottery ticket purchases), $\frac{t_i}{t_i + t_{-i}} * P$ is the expected value of the lottery prize, and h_i is the individual's valuation of the public good. Total public goods provision is given by

$$G = t_i + t_{-i} - P.$$

The individual's contribution (ticket purchase) decision is defined by the first order condition

$$P * \frac{t_{-i}}{(t_i + t_{-i})^2} + h_i'(G) = 1 .$$

Individuals are heterogeneous in the marginal per capita return from the public good, h'_i. Stranahan and Borg (2004) show that the MPCR of higher education scholarships increases with income. Therefore, if G is a higher education scholarship program, as h' increases, it must be that the first term of the FOC decreases for equilibrium to hold. Note that the first term decreases faster in t_{-i} than in t_i.

As income increases, h' increases, and it follows that the contributions of all other individuals falls as a proportion of total contributions. As the share of the higher-income individuals' contributions increases, the implicit tax becomes less regressive.

Intuitively, higher income individuals typically play the lottery less because they recognize that it is a poor bet. As a result, the lottery tax is regressive. However, if Morgan's theory is true, the expected value of winnings is not the only return from purchasing a lottery ticket. It may be that the marginal per capita return of the public good sufficiently augments the "bad bet" to induce participation. The result is less regressivity overall.

Chapters 2 and 3 are empirical tests of the principles of this theory. In Chapter 2, I directly test the link between the value of the public good and purchases of lottery tickets in Tennessee. Because Tennessee allocates the vast majority of lottery revenue to fund college scholarships, the number of scholarships awarded in a given county serves as a proxy for the value of the public good. I test whether this proxy is correlated with sales, holding other common determinants of lottery demand constant. In Chapter 3, I extend Oster's (2004) model which suggests that the regressivity of a jackpot-driven numbers game decreases when the prize increases. I use data from the Texas lottery, which began earmarking five years after sales began, to test for a structural break in demand and in the relationship between prizes and regressivity.

Chapter 2

The Tennessee Education Lottery Scholarship Program and Lottery Sales

2.1 Introduction

There is an extensive body of research which examines the tax incidence of state lotteries. The vast majority of this work confirms that lotteries are regressive. That is, as the income of an individual rises, on average, the share of income spent on lottery tickets declines. However, despite numerous studies on lottery ticket demand and the incidence of the implicit tax, none have incorporated the findings of Morgan (2000) and Landry and Price (2007) that the value of the public good funded by lottery revenue may bear significance. In this chapter, I calculate a tax incidence of Tennessee's lottery which is comparable to prior research. Then, I extend prior models of lottery demand by including a proxy for the value of the public good.

I do this by examining sales data from the Tennessee Education Lottery. The TEL has three unique features which make it ideal for this study. First, it allocates the majority of net revenue to college scholarships.[4] Second, there are merit- and need-based scholarships available to students attending private post-secondary schools in Tennessee.

[4] As of December 31, 2008, 86% of all expenditures from the Lottery for Education account since its creation in January 2004 funded scholarships. The remainder funded after-school programs, pre-kindergarten programs, and administrative costs. The Lottery for Education account holds revenue net of prize payouts and retailer commissions.

This allows students from a very wide range of income to benefit from the scholarship program. Third, since the inception of the TEL Scholarship program, there have been a number of increases to the size of the program, generally in the form of reduced academic standards to receive the grant (not in the dollar value of the grant). These changes in the number of scholarships awarded are subject to legislative action and, therefore, not directly correlated with sales.

To test Morgan's theory, I must use a proxy for the value of the public good. This proxy is generated using a unique data set, records of Tennessee Education Lottery scholarship recipients. If Morgan's theory holds empirically, a change in the number of scholarship recipients will have a significant effect on lottery play, holding all other indicators of lottery play constant.

I find that sales of instant games (scratch-off tickets) in Tennessee are less regressive than instant game sales as reported in at least one prior study based on sales in another state. I find the income elasticity of instant games to be either 0.55 or 0.085, depending on the income measure used. Instant games often have a negative elasticity. In addition, consistent with theory, it appears that at least part of this change in regressivity can be attributed to the value of the public good funded with lottery revenue. Furthermore, I find that the relationship between scholarships and play is not consistent across incomes. Higher income counties tend to respond more strongly to an increase in scholarships than do poorer counties. This heterogeneity of scholarships and lottery play suggest that earmarking a state lottery for a good whose benefits rise with income may reduce the regressivity of the lottery. Theory does not hold for Tennessee Powerball sales. However, because Powerball is a multi-state game, there may be confusion regarding the allocation of proceeds.

Section 2.2 provides background knowledge on the Tennessee Education Lottery. Section 2.3 discusses my data and method. Section 2.4 reports and discusses the empirical results. Section 2.5 concludes.

2.2 Tennessee Education Lottery Corporation

The Tennessee Education Lottery Corporation (TEL) was created in 2003, after a voter referendum amended the constitution to allow a state-run lottery. The amendment directs lottery revenues primarily to higher education scholarships for Tennessee residents attending public and private post-secondary schools within the state. The constitution allows revenue *in excess* of scholarship needs to fund pre-kindergarten and after-school programs.

Subsequent legislation clarifies how lottery dollars are appropriated year-to-year. First, unclaimed prize money is placed in a special account to fund after-school programs. In addition, lottery dollars available for pre-kindergarten are limited to $25 million each fiscal year. (Tennessee's voluntary pre-kindergarten program is funded largely by general fund appropriations.) As a result of these restrictions, college scholarships for Tennessee's students have been, by far, the largest fiscal commitment for the lottery account.[5] In addition, the lottery scholarship program is the most visible and celebrated work of the TEL. Billboards and television advertising regularly tout the millions of dollars raised for higher education. According to the Tennessee Higher Education Commission, the TEL has awarded a cumulative $1.6 billion to 532,000 students.[6] Therefore, if potential lottery players are responding to a specific earmark, it is most likely the subsidy for post-secondary education.

The data for this study encompasses two lottery games; Powerball and Instant games.[7] Powerball is a multi-state numbers game. The player chooses five numbers between 1 and 59, and one number between 1 and 39 (the "powerball"). Twice a week, numbers are drawn at random. Winning the jackpot requires matching all six balls, which happens with odds of 1 in 195,249,054. If no one wins the jackpot at a particular drawing, the pot remains intact and increases in size as tickets are purchased for the next drawing. Including players in several states and inducing a low probability of any player winning the main prize results in huge, multi-million dollar jackpots. Instant games are commonly known as "scratch-offs". Lottery organizers classically change these games

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[5] In addition, this percentage is likely to rise in the current and next fiscal years. As lottery revenues fall, the constitution requires that scholarships receive first priority, reducing the funds available for pre-kindergarten. Lottery outlay data come from the Tennessee Department of Finance and Administration lottery account summaries for fiscal years 2005-2009.

[6] *Tennessee Education Lottery Scholarship Program Annual Report*. April 28, 2011.

[7] All information regarding the lottery games comes from the Tennessee Education Lottery website, http://www.tnlottery.com/howtoplay/

frequently, keeping it new and exciting for players. There are typically dozens of ongoing instant games at any given time.

The Tennessee Education Lottery Scholarship program encompasses eleven separate scholarships designed to assist Tennessee residents with specific needs and backgrounds attend college. For the purposes of this paper, I will focus on 4 specific programs which comprise more than 98% of awards. The largest and most prominent scholarship is the Tennessee HOPE Scholarship, which offers a grant to graduating seniors from Tennessee high schools attending public and private 2- and 4-year institutions. The grant is based purely on the achievement of minimum academic standards. Because it is not need-based and can be used at any public or private school in Tennessee, the HOPE scholarship benefits families at all income levels. Students with superior academic achievement in high school receive an additional scholarship on top of the HOPE grant called the General Assembly Merit Scholarship. Students who meet the academic requirements for the HOPE scholarship and come from low-income families are awarded a supplemental grant, the Aspire Award. The final award which will be studied is the Tennessee HOPE Access Grant. This scholarship is available to students from low-income families that meet reduced academic achievement standards in high school. The Access Grant is awarded in lieu of the HOPE scholarship.

Many students receiving the HOPE and Merit scholarships are likely to attend college in the absence of the public program. However, the Aspire Award and Access Grant are designed to make college accessible to students which are less likely to pursue higher education without a substantial public subsidy. Therefore, they may have a distinctly different public good value. In the empirical analysis that follows, I will use an aggregate measure of scholarships, followed by a series of analyses which separate Hope and Merit scholarships from Access and Aspire.

2.3 Data and Methods

Each of the models in this essay is a panel regression with monthly data from January 2004 through December 2008 across the 95 Tennessee counties. Summary statistics for each variable and year are shown in Table 2.1. Each column represents the annual average for the year noted (with the exception of the scholarship variables, which are

Table 2.1 Summary Statistics - Annual Averages

Variable	2004 Mean	2004 Std. Dev.	2005** Mean	2005** Std. Dev.	2006 Mean	2006 Std. Dev.	2007 Mean	2007 Std. Dev.	2008 Mean	2008 Std. Dev.
Per Capita Powerball Sales ($)			2.08	2.08	2.31	1.99	2.00	1.80	1.69	1.54
Per Capita Instant Sales ($)	9.30	5.31	10.04	5.36	10.75	5.19	11.16	5.48	10.93	5.30
Per Capita Personal Income ($)	24858.82	4516.38	25870.44	4687.74	26854.34	5145.84	27980.37	5292.70	28780.81	5267.19
Weekly Wages (x4.3 to generate a measure of one month's income) ($)	2367.86	434.57	2424.96	429.29	2510.05	488.78	2589.10	483.83	2645.25	488.86
Per Capita Scholarships (x1,000)*	1.99	0.00	5.65	0.00	7.11	0.00	8.72	0.00	9.35	0.00
Per Capita Hope and Merit Scholarships (x1,000)*	1.36	0.00	3.99	0.00	4.76	0.00	5.93	0.00	6.53	0.00
Per Capita Access and Aspire (x1,000)*	0.63	0.00	1.41	0.00	2.03	0.00	2.39	0.00	2.64	0.00
Max Poweball Prize ($10 M)	12.95	5.16	10.53	8.74	15.79	7.75	12.08	7.86	12.43	6.42
Percent age 65 and up (%)	0.14	0.02	0.14	0.02	0.15	0.03	0.15	0.03	0.15	0.03
Percent male(%)	0.49	0.02	0.49	0.02	0.49	0.02	0.49	0.02	0.49	0.02
Percent black (%)	0.08	0.10	0.07	0.10	0.08	0.10	0.08	0.10	0.08	0.10
Percent hispanic (%)	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.02
Unemployment	6.34	1.57	6.62	1.85	6.12	1.70	5.68	1.37	7.68	2.01

*Data for 2004 is August - December only

**2005 is the first full year of Powerball sales in Tennessee averages for August-December of 2004, and the full year thereafter). Due to considerable seasonality in lottery purchases, annual averages are a better representation of the growth of lottery purchases over the five-year panel. Because Powerball tickets were first sold mid-2004, the summary statistics begin in 2005, rather than 2004. Source notes for each variable are in Appendix Table A.15.

I use two measures of income to estimate each model. The first is per capita personal income, which is published by the Bureau of Economic Analysis. According to the BEA, "personal income is a comprehensive measure of the income of all persons from all sources. In addition to wages and salaries, it includes employer-provided health insurance, dividends and interest income, social security benefits, and other types of income".[8] This income measure is published once a year, so it is constant for 12-month periods in the data. The second measure, weekly wages, is published by the Bureau of Labor Statistics as a part of the Quarterly Census of Employment and Wages. Weekly wages are reported quarterly by employers covering 98 percent of U.S. Jobs.[9] The weekly measure is transformed into a monthly wage by multiplying each value by 4.3. This measure is constant for 3-month periods in the data. I estimate each model with both measures as a robustness check on the income elasticity estimate. While personal income doesn't vary much over the panel of the model, it is a more complete measure of income. In particular, it is likely that the weekly wage measure underestimates the income of wealthy individuals, as it does not take into account investment income and high-value job-related benefits.

I include four demographic variables, percent of the population that is age 65 and up, percent of the population that is black, percent of the population that is Hispanic, and the percent of the population that is male. The four "percentage" variables are expressed on a 0-1 scale to facilitate interpretation of the coefficients. As they are reported annually, they remain constant for 12 month periods. The maximum Powerball prize is

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[8] Local Area Personal Income Release, April 21, 2011. http://bea.gov/newsreleases/regional/lapi/lapi_newsrelease.htm

[9] Bureau of Labor Statistics. http://www.bls.gov/cew/

included in both regressions. The inclusion of this variable in the regression on instant game sales captures the substitutability or complementarity between the two games.

I initially estimate a two-way fixed effects panel data model which will produce tax elasticity estimates that are comparable to estimates from prior research. The model is as follows:

$$y_{it} = I_{it}\delta + P_t\lambda + X_{it}\beta + \mu_i + \lambda_m + \omega_t + \nu_{it}$$

where y_{it} is the natural log of per-capita gross sales for one game (Powerball or instant games) in county *i* in month *t*, I_{it} is the natural log of an income measure (discussed below) in county *i* in month *t* , P_t is a vector of the top Powerball prize each month scaled by 10 million, X_{it} is a matrix of county and month-specific demographic variables, μ_i are county-specific fixed effects, λ_m is a vector of 12 month-specific dummy variables, ω_t are month fixed effects, and ν_{it} are normal error terms. I compare my estimates to income elasticity estimates from prior studies, such as Price and Novak (1999) and Oster (2004).

The month fixed effects serve to net out seasonality in lottery purchasing behavior. The county fixed effects capture any distortions in sales resulting from shopping across county borders, assuming that such shopping is consistent across time (Garrett and Coughlin 2009). In addition, they capture educational attainment (percent of the population with a high school degree), as the data are only available at the county level through the decennial census. The use of fixed effects is convenient for these purposes and the loss of degrees of freedom is tolerable. In addition, fixed effects make economic sense because I am using data on all 95 counties to make inferences on the implicit tax regressivity for the Tennessee population.

The second model will test the predictions of Morgan (2000) and clarify the findings of Landry and Price (2007) by including a variable to proxy for the value of the public good.

$$y_{it} = I_{it}\delta + S_{it}\eta + P_t\lambda + X_{it}\beta + \mu_i + \lambda_m + \omega_t + \nu_{it}$$

In the equation above, S_{it} is generated using a data set that contains the home county of every recipient of the Tennessee Education Lottery Scholarship. From this raw data, I calculate the number of scholarship recipients from each county for each month. This number is scaled by county population and expressed in natural logs. In the third and fully-specified model, an interaction term for income and scholarships will be included to allow the regressivity of the lottery tax to vary with changes in the level of the public good provided.

$$y_{it} = I_{it}\delta + S_{it}\eta + I_{it}S_{it}\varphi + P_t\lambda + X_{it}\beta + \mu_i + \lambda_m + \omega_t + v_{it}$$

Three variables (per capita sales, per capita income, and per capita scholarships) are expressed in natural logs. The use of logged variables is consistent with Oster (2004), Price and Novak (1999), and Garrett and Coughlin (2009) to generate a constant income elasticity measure. In addition, this method generates an elasticity measure for the responsiveness of sales to changes in the number of scholarships.

The next set of analyses will draw out more starkly how income affects the decision to purchase tickets in the TEL and how the use of lottery revenue for scholarships creates a greater incentive for higher income players than lower income players. I create four dummy variables to represent the 10 highest income counties and 10 lowest income counties by per capita personal income and weekly wages. Figure 2.1 summarizes which counties are included in the top 10 and bottom 10 by each measure, each year. I run the three models described above, but add interaction terms between each income and scholarship variable and the top 10 and bottom 10 dummy variables described above. This allows me to calculate unique income and scholarship elasticities of sales for the highest- and lowest-income Tennessee counties.

In the final analysis, I will estimate the fully-specified model using two new variables which are subsets of the public good proxy variable discussed above. Rather than using the total number of lottery-funded scholarships, I will disaggregate Hope and Merit scholarships from Access and Aspire scholarships. It is possible that the public good value of Access and Aspire scholarships is different from that of Hope and Merit scholarships, since Access and Aspire are designed to encourage higher education by

10 Highest Income Counties by Per Capita Personal Income (BEA)

2004	2005	2006	2007	2008
Williamson	Williamson	Williamson	Williamson	Williamson
Davidson	Davidson	Davidson	Davidson	Davidson
Shelby	Shelby	Shelby	Shelby	Shelby
Hamilton	Hamilton	Hamilton	Hamilton	Hamilton
Wilson	Wilson	Wilson	Wilson	Montgomery
Knox	Knox	Montgomery	Montgomery	Wilson
Loudon	Montgomery	Knox	Knox	Knox
Sumner	Sumner	Fayette	Loudon	Fayette
Montgomery	Fayette	Sumner	Fayette	Loudon
Fayette	Loudon	Loudon	Sumner	Sumner

10 Lowest Income Counties by Per Capita Personal Income (BEA)

2004	2005	2006	2007	2008
Hancock	Hancock	Hancock	Hancock	Hancock
Lake	Lake	Lake	Lake	Lake
Wayne	Johnson	Wayne	Wayne	Wayne
Johnson	Wayne	Johnson	Johnson	Johnson
Lauderdale	Lauderdale	Scott	Scott	Scott
Scott	Scott	Lauderdale	Lauderdale	Lauderdale
Bledsoe	Cocke	Cocke	Cocke	Bledsoe
Cocke	Bledsoe	Grundy	Grundy	Cocke
Union	Hickman	Bledsoe	Bledsoe	Grundy
Hickman	Hardeman	Hickman	Lewis	White

10 Highest Income Counties by Weekly Wage (BLS)

2004	2005	2006	2007	2008
Roane	Williamson	Roane	Williamson	Williamson
Anderson	Roane	Williamson	Roane	Roane
Shelby	Anderson	Anderson	Shelby	Davidson
Maury	Shelby	Davidson	Davidson	Shelby
Williamson	Davidson	Shelby	Anderson	Anderson
Davidson	Maury	Maury	Sullivan	Sullivan
Sullivan	Sullivan	Van Buren	Rutherford	Rutherford
Blount	Blount	Rutherford	Humphreys	Humphreys
Rutherford	Rutherford	Blount	Blount	Hamilton

10 Lowest Income Counties by Weekly Wage (BLS)

2004	2005	2006	2007	2008
Hancock	Hancock	Hancock	Hancock	Hancock
Lewis	Lewis	Lake	Lake	Lake
Pickett	Lake	Lewis	Lewis	Lewis
Houston	Houston	Grundy	Grundy	Grundy
Lake	Grundy	Pickett	Pickett	Pickett
Grundy	Pickett	Houston	Sequatchie	Clay
Benton	Macon	Cannon	Houston	Houston
Morgan	Morgan	Polk	Bledsoe	Wayne
Polk	Polk	Benton	Macon	Cannon

Shaded boxes represent counties that remain in the top 10 or bottom 10 for the entire panel.

Figure 2.1. Highest and Lowest Income Counties over 5 years by Two Income Measures

students that otherwise could not or would not choose to pursue a college degree. Hope and Merit scholarships, however, are more likely to be granted to students that would go to college anyway, and therefore represent a financial windfall for the students and their families, but not necessarily a public good benefit.

2.4 Results

The baseline regression results are shown in Table 2.2. The coefficients on Per Capita Personal Income and Weekly Wage are income elasticity measurements, and their significance has been tested against zero and one. A value less than one indicates a regressive tax. A value greater than 1 indicates a progressive tax. Although it is not a direct test of regressivity, due to the use of aggregated data, it is at least suggestive that the relationship exists on the individual level. I find that per capita sales of Powerball in Tennessee using either income measure (IE= 0.105 and IE= 0.051, respectively) are less regressive than what is reported in Oster's 2004 study using data from Connecticut, a state which does not earmark lottery proceeds (IE = -0.709). I find per capita sales of instant games (IE = 0.051 and IE = 0.085) are considerably less regressive than in Texas (IE= -0.405, Price and Novak 1999), but more regressive than in West Virginia (IE=0.220, Garrett and Coughlin 2009), neither of which earmark lottery proceeds for specific programs. I also find that a larger Powerball prize increases sales of both Powerball and instant games suggesting that they are complementary goods. It appears that counties with a larger share of women or Hispanics purchase more tickets. These results also suggest that a higher unemployment rate is correlated with lower lottery sales. However, Morgan's theory suggests in order to accurately model the data generating process for lottery sales requires controlling for the value of the public good funded with proceeds. In the second model, I do just that.

The second set of regression results are shown in Table 2.3. Here, I have included the variable which proxies for the value of the good funded with lottery proceeds, a county- and month-specific count of scholarships awarded from lottery revenue. The inclusion of the proxy variable has little effect on the income elasticity estimates. The

Table 2.2 Baseline Model Estimating Constant Income Elasticity

	Personal Income				Weekly Wage			
Variable	**Powerball (ln)**		**Instant (ln)**		**Powerball (ln)**		**Instant (ln)**	
Per Capita Personal Income (ln)	0.105	+	0.55	*+				
	(0.083)		(0.114)					
Weekly Wage (ln)					0.051	+	0.085	*+
					(0.026)		(0.036)	
Max Powerball Prize ($10 million)	0.036	*	0.002	*	0.036	*	0.002	*
	(0)		(0.001)		(0)		(0.001)	
Percent age 65 and up	0.673		0.853		0.761		1.233	*
	(0.432)		(0.595)		(0.429)		(0.592)	
Percent male	-1.621	*	-3.522	*	-1.537		-3.502	*
	(0.785)		(1.081)		(0.786)		(1.086)	
Percent black	-0.086		0.49		-0.113		0.388	
	(0.503)		(0.693)		(0.502)		(0.694)	
Percent Hispanic	0.473		3.06	*	0.37		2.554	*
	(0.493)		(0.68)		(0.488)		(0.674)	
Unemployment Rate	-0.009	*	-0.007	*	-0.009	*	-0.008	*
	(0.001)		(0.002)		(0.001)		(0.002)	
Overall R-sq	0.2656		0.494		0.2574		0.0973	
N	5130		5130		5130		5130	
F(94,4976)	1386.04		647.02		1389.09		632.23	

*Indicates significantly different from 0 at the 5% level.

+Indicates significantly different from 1 at the 5% level.

Standard errors shown in parentheses.

County, month, and season fixed effects were included in each of the above regressions.

Table 2.3 Model Estimating Income and Scholarship Elasticity

Variable	Personal Income Powerball (ln)		Personal Income Instant (ln)		Weekly Wage Powerball (ln)		Weekly Wage Instant (ln)	
Per Capita	0.07	+	0.574	*+				
Personal Income (ln)	(0.083)		(0.115)					
Weekly Wage (ln)					0.05	+	0.082	*+
					(0.026)		(0.036)	
Per Capita	-0.045	*+	0.023	+	-0.044	*+	0.024	+
Scholarships (ln)	(0.009)		(0.013)		(0.009)		(0.013)	
Max Powerball Prize	0.036	*	0.002	*	0.036	*	0.002	*
($10 million)	(0)		(0.001)		(0)		(0.001)	
Percent age 65 and up	0.618		0.839		0.685		1.237	*
	(0.43)		(0.594)		(0.426)		(0.591)	
Percent male	-1.551	*	-3.38	*	-1.464		-3.404	*
	(0.784)		(1.083)		(0.785)		(1.088)	
Percent black	0.104		0.578		0.081		0.455	
	(0.506)		(0.699)		(0.505)		(0.7)	
Percent Hispanic	0.579		3.092	*	0.504		2.556	*
	(0.493)		(0.682)		(0.488)		(0.675)	
Unemployment Rate	-0.009	*	-0.006	*	-0.009	*	-0.007	*
	(0.001)		(0.002)		(0.001)		(0.002)	
Overall R-sq	0.2761		0.0574		0.2719		0.0918	
N	5035		5035		5035		5035	
F(94,4881)	1417.92		655.77		1422.31		638.66	

*Indicates significantly different from 0 at the 5% level.

+Indicates significantly different from 1 at the 5% level.

Standard errors shown in parentheses.

County, month, and season fixed effects were included in each of the above regressions.

coefficients on the proxy variable suggest that more scholarships are correlated with lower sales of Powerball tickets, and have a very small, possibly zero, effect on instant game sales. However, this model estimates the relationship between scholarships and sales on average. It is likely that scholarships are more important to higher income households, and that this relationship shouldn't be constant. Therefore, in the final specification, the scholarship elasticity is allowed to vary across incomes.

The regression results for the fully specified model are reported in Table 2.5. Point elasticity estimates based on the fully specified model are reported in Table 2.4. Figure 2.2 plots income and scholarship elasticity at each observed value of per capita scholarships, per capita personal income, or weekly wages, respectively, using the following equation:

$$IE = \beta_{\ln(income)} + \beta_{\ln(inc)*\ln(schol)} * \ln(scholarships)$$

The point elasticity estimate of income is calculated at the mean of log scholarships over the panel. The elasticity of scholarships with respect to income is calculated similarly.

$$IE = \beta_{\ln(scholarships)} + \beta_{\ln(inc)*\ln(schol)} * mean[\ln(income)]$$

Table 2.4 Point Elasticity Estimates of Income and Scholarships based on the Fully-Specified Model

	Personal Income				**Weekly Wage**			
Variable	**Powerball**		**Instant**		**Powerball**		**Instant**	
Income Elasticity	0.058	+	0.539	*+	0.053	*+	0.075	*+
	(0.083)		(0.115)		(0.026)		(0.036)	
Scholarship Elasticity	-0.041	*+	0.034	*+	-0.047	*+	0.030	*+
	(0.010)		(0.013)		(0.009)		(0.013)	

*Indicates significantly different from 0 at the 5% level.

*Indicates that the estimate is statistically different from 1 at the 5% confidence level.

In this model, I find that both games are regressive. Focusing on the scholarship estimates, I find that instant game sales are increasing in the number of scholarships using either measure of income. Furthermore, Figure 2.2 shows that as income rises, sensitivity to the per capita level of scholarships increases. (Powerball sales seem to behave differently, which will be discussed below.) Therefore, I can tentatively conclude that lottery play increases when additional scholarships are awarded. This is a necessary condition for Morgan's theory to hold empirically. Furthermore, as the number of scholarships awarded in a county increases, instant game and Powerball purchases (using personal income) become less regressive. This is clear both from the positive values on the coefficient of the income-scholarship interaction, and from Figure 2.2 which shows an upward sloping relationship between income elasticity and per capita scholarships. This suggests that higher income counties are more responsive to the value of the public good funded with lottery proceeds than lower income counties.

However, the results for Powerball are less clear. The point estimates of scholarship elasticity using either income measure are significant and negative. Furthermore, this relationship stays relatively flat across observed income levels. In fact, using wage as the income measure results in a decrease in scholarship elasticity as income increases. Although this is inconsistent with theory, there are a couple of reasons why this may be the case. First, Powerball represents a relatively small share of total lottery sales at about 6%. Second, there may be a misconception that, because Powerball is a multi-state game, proceeds do not stay in-state to benefit Tennessee's programs. In fact, the Multi-State Lottery Corporation, the organization that runs Powerball, concedes on their website that "the perception that the money leaves the state is one of the most difficult concepts we have to deal with. Some lottery players actually refuse to play the Powerball game… because they believe that the profits go to the federal government or to some other 'outside' group." Therefore, it is likely that most Powerball purchases are motivated by a love of gambling, not in support of the lottery scholarship program. My results are consistent with high-income individuals substituting instant game purchases for Powerball purchases with the intention to support the lottery scholarship program.

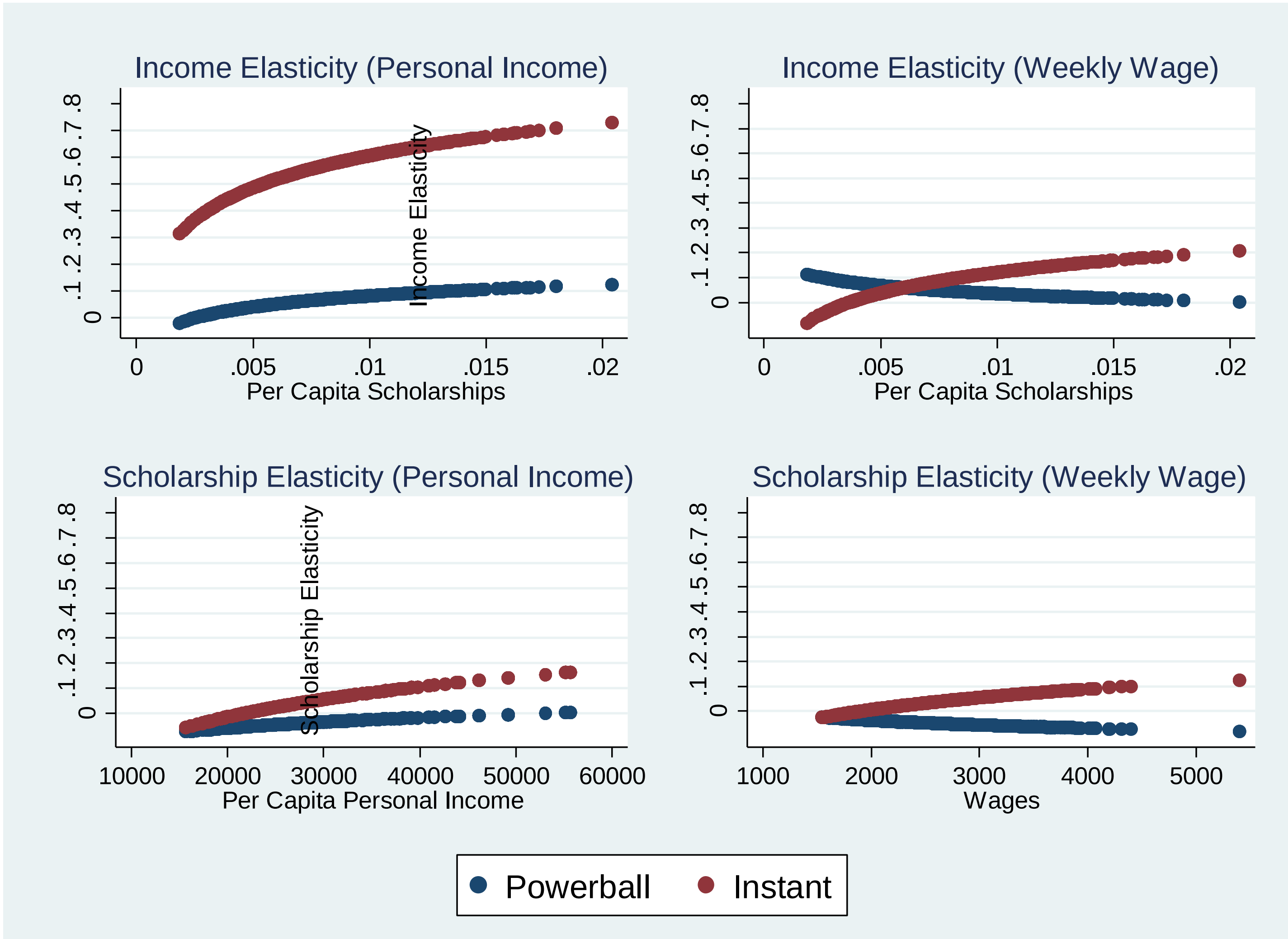

Figure 2.2 Distribution of Income and Scholarship Elasticity Estimates based on the Fully-Specified Model

Table 2.5 Model Estimating Income and Scholarship Elasticity with Interaction Term

	Personal Income				Weekly Wage			
Variable	Powerball (ln)		Instant (ln)		Powerball (ln)		Instant (ln)	
Per Capita (ln) Personal Income	0.357	*+	1.407	*+				
	(0.128)		(0.177)					
Weekly Wage (ln)					-0.18	+	0.676	*+
					(0.106)		(0.147)	
Per Capita Scholarships(ln)	-0.652	*+	-1.737	*+	0.318	*+	-0.911	*+
	(0.207)		(0.285)		(0.162)		(0.224)	
Per Capita Personal Income (ln) * Per Capita Scholarships (ln)	0.06	*+	0.174	*+				
	(0.02)		(0.028)					
Weekly Wage (ln) * Per Capita Scholarships (ln)					-0.047	*+	0.121	*+
					(0.021)		(0.029)	
Max Powerball Prize ($10 million)	0.037	*	0.002	*	0.036	*	0.002	*
	(0)		(0.001)		(0)		(0.001)	
Percent age 65 and up	0.731		1.167	*	0.591		1.478	*
	(0.431)		(0.594)		(0.428)		(0.592)	
Percent male	-1.461		-3.121	*	-1.441		-3.465	*
	(0.784)		(1.08)		(0.785)		(1.086)	
Percent black	0.114		0.607		0.076		0.467	
	(0.505)		(0.697)		(0.505)		(0.699)	
Percent Hispanic	0.288		2.247	*	0.646		2.192	*
	(0.503)		(0.693)		(0.491)		(0.68)	
Unemployment Rate	-0.01	*	-0.007	*	-0.009	*	-0.008	*
	(0.001)		(0.002)		(0.001)		(0.002)	
Overall R-sq	0.2733		0.0604		0.2723		0.091	
N	5035		5035		5035		5035	
F(94,4880)	1418.26		659.03		1421.68		635.03	

*Indicates significantly different from 0 at the 5% level.

+Indicates significantly different from 1 at the 5% level.

Standard errors shown in parentheses.

County, month, and season fixed effects were included in each of the above regressions.

I find that the size of the Powerball jackpot has a positive effect on sales of Powerball and instant games. Though the effect on instant games is very small, it suggests that Powerball and instant games are complimentary goods. That is, players which are induced to participate in Powerball due to a large jackpot are likely to purchase instant tickets at the same time. I find that a larger Hispanic population is correlated with higher instant game sales and is uncorrelated with Powerball sales. This is consistent with findings from prior research. Interestingly, I find that an older population is correlated with increased sales of instant games, and that a larger black population is not correlated with sales at all. I also find that a larger male population is correlated with fewer sales of both games. While neither of these results is consistent with prior literature, it is important to recall that these variables change very little over the relatively short panel of data. Given the inclusion of county fixed effects as well, it is unlikely that these coefficients are particularly informative. Finally, I find that higher unemployment is correlated with lower lottery sales.

In order to draw out the distinction between the wealthiest and the poorest counties in Tennessee, I repeat the three models above, but interact each elasticity measure with dummy variables for the ten wealthiest counties and the ten poorest counties by each income measure. The counties that are included in these categories are outlined in Figure 2.1. Full regression results for each model can be found in Appendix Tables A.16 through A.18. Table 2.6 presents point estimates of income and scholarship elasticity for the ten wealthiest and ten poorest counties in each model. Point elasticity estimates for the third model are calculated using the mean values of ln(scholarships) and ln(income) for the top 10 or bottom 10 income counties, respectively.

Focusing, again, on the scholarship elasticity in the third and fully-specified model, there is some evidence that responsiveness to changes in the public good is stronger in the highest income counties than in the poorest counties. The effect is somewhat stronger when personal income is used than weekly wage. Personal income is likely to be a better indicator of overall wealth than the weekly wage, as it includes a

Table 2.6 Summary of Income and Scholarship Elasticity for Top 10 and Bottom 10 Counties by Income

	Personal Income				Weekly Wage			
	Powerball		Instant		Powerball		Instant	
Model 1 - Baseline								
Income Elasticity								
Top 10	0.277	*+	0.736	*+	0.048	+	0.092	*+
	(0.100)		(0.138)		(0.026)		(0.036)	
Bottom 10	0.105	+	0.465	*+	0.046	+	0.091	*+
	(0.088)		(0.121)		(0.027)		(0.037)	
Model 2 - Scholarships included								
Income Elasticity								
Top 10	0.109	+	0.596	*+	0.071	*+	0.104	*+
	(0.121)		(0.168)		(0.027)		(0.038)	
Bottom 10	0.093	+	0.508	*+	0.112	*+	0.035	+
	(0.088)		(0.122)		(0.028)		(0.039)	
Scholarship Elasticity								
Top 10	-0.008	+	0.086	*+	-0.047	*+	0.031	*+
	(0.019)		(0.027)		(0.010)		(0.013)	
Bottom 10	-0.079	*+	-0.023	+	0.040	*+	-0.0411	*+
	(0.013)		(0.017)		(0.15)		(0.020)	
Model 3 - Scholarships and Income-Scholarship Interaction								
Income Elasticity								
Top 10	0.121	+	0.519	*+	0.070	*+	0.101	*+
	(0.122)		(0.168)		(0.029)		(0.041)	
Bottom 10	-0.382	*+	0.468	*+	0.224	*+	0.133	+
	(0.116)		(0.160)		(0.054)		(0.075)	
Scholarship Elasticity								
Top 10	-0.010	+	0.093	*	-0.049	*+	0.052	*+
	(0.019)		(0.027)		(0.013)		(0.018)	
Bottom 10	-0.039	*+	-0.024	+	-0.246	*+	-0.051	+
	(0.014)		(0.020)		(0.088)		(0.022)	

*Indicates significantly different from 0 at the 5% level.
+Indicates significantly different from 1 at the 5% level.
Standard errors shown in parentheses.

number of income classes, such as investment income, which are not included in weekly wages. Therefore, it makes sense for personal income to be a better indicator of the value of college scholarships. It is also worth noting that the difference in scholarship elasticity is larger for instant games than Powerball. This is likely due to the unique features of Powerball previously discussed, such as the confusion about whether Powerball revenue leaves the state.

As a final analysis, I have disaggregated the scholarship variable into two categories: HOPE and Merit scholarships, which are awarded based solely on merit, and Access and Aspire scholarships, which are based on merit and financial need and are designed to make college accessible to students that may not otherwise attend. Full regression results are in Appendix Tables A.19 and A.20. Table 2.7 presents the income and scholarship elasticity estimates for the two scholarship categories.

The results show that scholarship elasticity is generally greater than zero for HOPE and Merit, but less than zero for Access and Aspire. Furthermore, the elasticity of HOPE and Merit scholarships to sales is larger for instant games than for Powerball. This suggests two conclusions. First, the HOPE and Merit scholarship programs, exclusively, increase lottery purchases among higher income individuals. This is rational, as the Access and Aspire programs do not directly benefit these individuals. Second, this reinforces the earlier conclusion that people who are motivated to play the Tennessee Lottery to support the scholarship program purchase instant games, not Powerball.

To test for the possibility that the largest counties are skewing these results, I run the fully specified model (presented earlier in Tables 2.4 and 2.5) excluding Knox, Davidson, Hamilton, and Shelby counties. The income and scholarship elasticity estimates are presented in Table 2.8 (full regression results are in Appendix Table A.21), and demonstrate that the exclusion of urban counties has a minimal effect on the sign, significance, and magnitudes of the coefficients. The coefficients on income elasticity decrease slightly, which is to be expected as the four urban counties are also four of the highest-income counties.

Table 2.7 Elasticity Estimates derived from Fully-Specified Model, Limited to the Specific Scholarship Types Listed Below

HOPE and Merit								
	Personal Income				Weekly Wage			
Estimate	Powerball		Instant		Powerball		Instant	
Income Elasticity	0.081	+	0.621	*+	0.026	+	0.136	*+
	(0.084)		(0.115)		(0.027)		(0.038)	
Scholarship Elasticity	0.005	+	0.044	*+	-0.005	+	0.038	*+
	(0.009)		(0.013)		(0.009)		(0.013)	

Access and Aspire								
	Personal Income				Weekly Wage			
Estimate	Powerball		Instant		Powerball		Instant	
Income Elasticity	0.148	+	0.697	*+	0.038	+	0.127	*+
	(0.085)		(0.118)		(0.033)		(0.046)	
Scholarship Elasticity	-0.078	*+	-0.017	+	-0.080	*+	-0.020	*+
	(0.007)		(0.010)		(0.007)		(0.010)	

*Indicates significantly different from 0 at the 5% level.
+Indicates that the estimate is statistically different from 1 at the 5% confidence level.

Table 2.8 Elasticity Estimates Derived from the Fully-Specified Model, Excluding the Four Metropolitan Counties: Davidson, Hamilton, Knox, Shelby

	Personal Income				Weekly Wage			
Estimate	Powerball		Instant		Powerball		Instant	
Income Elasticity	0.024	+	0.523	*+	0.052	*+	0.076	*+
	(0.084)		(0.118)		(0.026)		(0.037)	
Scholarship Elasticity	-0.036	*+	0.37	*+	-0.044	*+	0.032	*+
	(0.010)		(0.014)		(0.010)		(0.014)	

*Indicates significantly different from 0 at the 5% level.
+Indicates that the estimate is statistically different from 1 at the 5% confidence level.

As a second robustness check, I repeat the fully specified model, but exclude counties that border Alabama, Arkansas, and Mississippi, none of which had a state lottery during months of this study, to check for the possibility that sales across state lines may skew results.[10] That is, sales in a given county may not be indicative of the lottery interest among that county's population if a large portion of sales are to non-residents. The full regression results can be found in Appendix Table A.22. Income and scholarship elasticity estimates are presented in Table 2.9. While the scholarship elasticity estimates are unaffected, the income elasticity of instant games does become a bit more regressive when non-lottery border counties are excluded. (Although Powerball regressivity when measured by personal income does change signs, in both regressions it is not significantly different from zero.) However, the change is minimal and does not affect the conclusions of this paper.

2.5 Conclusions

The research presented here contributes significantly to the existing literature on state lotteries by incorporating the theoretical findings of Morgan (2000). Morgan suggests that the way in which lottery proceeds are spent matters to players and should have a causal effect on the level of play. In particular, if the proceeds are used to fund a

[10] Excluded counties include: Dyer, Fayette, Franklin, Giles, Hardeman, Hardin, Lauderdale, Lawrence, Lincoln, Marion, McNairy, Shelby, Tipton, Wayne.

Table 2.9 Fully-Specified Model, Excluding Counties that Border States without a Lottery (Alabama, Arkansas, Mississippi)

	Personal Income				Weekly Wage			
Estimate	**Powerball**		**Instant**		**Powerball**		**Instant**	
Income Elasticity	-0.069	+	0.340	*+	0.049	+	0.064	+
	(0.089)		(0.127)		(0.027)		(0.039)	
Scholarship Elasticity	-0.048	*+	0.034	*+	-0.052	*+	0.031	*+
	(0.010)		(0.015)		(0.011)		0.015	

*Indicates significantly different from 0 at the 5% level.
+Indicates that the estimate is statistically different from 1 at the 5% confidence level.

socially desirable public good, there are two payoffs from the purchase of a lottery ticket. As a result, risk-loving behavior is not required to induce participation.

I test this theory using sales data from the Tennessee Education Lottery and by constructing a proxy variable for the public good using data on scholarship recipients. I find that instant game sales are sensitive to the public good and less regressive than sales in at least one other state that has been studies. Thus, instant game sales are consistent with theory. When the elasticity of sales with respect to scholarships is calculated for the ten highest and ten lowest income counties separately, the responsiveness to changes in the public good is stronger in the highest income counties than in the poorest counties

Powerball sales are not consistent with theory. This may be due to confusion on the part of players regarding the use of revenue from Powerball, which is a multi-state game. Some may infer that Powerball purchases do not fund the scholarship program as directly as instant game purchases. If this is the case, then many more Powerball purchasers are motivated by a pure love of gambling, and we expect a more regressive incidence. Finally, it appears that increased lottery purchases are not motivated by the two scholarship programs designed to increase education attainment among students from lower-income families.

There are some important limitations to this analysis. First, I am testing a theory which predicts individual behavior, but using county-aggregated data to estimate the model. The empirical analysis could be clarified with a large-scale randomized survey of

Tennesseans to elicit an individual value of the scholarship earmark. Second, this analysis is limited to one state. It is unknown whether these results are robust to lottery participation in other states.

Nonetheless, the results discussed here have important policy implications. If the goal of state lottery design is to reduce the regressivity of its implicit tax incidence, earmarking proceeds for a "progressive" public good may be an effective option.

Chapter 3

Testing for a Structural Break in Demand for Two Texas Lottery Games

3.1 Introduction

This chapter will further explore the relationship between state lottery ticket purchases and statutory earmarks on lottery revenue. The Texas Lottery sold its first ticket in 1992 with the proceeds of the lottery allocated to the state's General Fund, the main checking account for tax revenues and for funding state programs and services. However, as of August 1, 1997, the statutory earmark for lottery proceeds was changed to benefit the Foundation School Fund, which funds local K12 school districts. This chapter exploits this change, first, to evaluate whether there is a structural break in the demand at the time of the earmark change. Second, I will replicate the methodology employed by Oster (2004) to determine whether the regressivity of a lottery changes with prize level. However, I will alter her specification to take into account the (potential) structural break. I use sales data aggregated by zip code and month for two games, Instant games and Texas Lotto, a jackpot-driven numbers game. Income and other socioeconomic variables are matched from Census 2000 Zip Code Tabulation Areas files.

I find that there is a structural break in demand in August 1997. While my findings confirm that the regressivity of Texas Lotto changes with the prize level in a way that is consistent with Oster's finding, I do not find convincing evidence that the regressivity-prize relationship changes with the implementation of the K12 earmark.

Section 3.2 provides details about the Texas Lottery. Section 3.3 outlines my data and methods. Section 3.4 presents and discusses the results. Section 3.5 concludes.

3.2 Texas Lottery

The Texas Lottery was created by Legislative action followed by voter approval in 1991 as a revenue stream for the Texas General Fund. The first instant game ticket was sold in 1992. Late the same year, Lotto Texas was launched, a numbers game with a progressive jackpot. In 1997, Texas began depositing net revenue in the Foundation School Fund, which serves as the primary source of state funding for local school districts.[11] Unclaimed prizes continue to be deposited into the General Fund.

Over time, the Texas Lottery grew its offerings to include four additional numbers games, Mega Millions, and Powerball. Although the addition of new numbers games has certainly cannibalized play in the original game, Lotto Texas, it has remained a popular game. Players choose six numbers from 1 and 54. In order to win the jackpot, all 6 numbers must be matched in order. Drawings are held twice each week. If no players win the jackpot, it remains intact and increases in size as players purchase tickets in advance of the next scheduled drawing. Lotto Texas is an excellent candidate to test Oster's theory because it is, like Powerball, jackpot driven. However, as Chapter 2 discusses, lottery players may not understand that Powerball purchases directly benefit programs in their state. So, Texas Lotto has the added advantage of being an in-state game.

3.3 Data and Methods

This essay will use two tests to detect any effect that the change in lottery revenue earmark may have on sales. The same data set is used for both tests, which is comprised of data from the Texas Lottery Commission and Census 2000. The Texas Lottery Commission has provided sales data for two games, Lotto Texas and Instant Games, for each zip code and each month from January 1993 through December 2006. They have

[11] Texas Education Agency. http://www.tea.state.tx.us/index2.aspx?id=7721

also provided the advertised prize level for every Lotto Texas drawing between 1993 and 2006. There are two drawings each week, so for the purpose of this analysis, a monthly average of the advertised prize is calculated.

I am using seven variables which are published by the Census Bureau as a part of Census 2000's Zip Code Tabulation Areas: median household income, percent urban, percent African American, percent Hispanic, percent that has completed at least high school, the unemployment rate, and total population. Zip Code Tabulation Areas, or ZCTAs, are built to correspond as closely as possible to the five-digit zip codes used by the U.S. Postal Service. While they are not a perfect match for every address in the U.S., they are very close. Furthermore, although they do not change over the 14-year panel, demographic characteristics typically change slowly over time, and the snapshot provided by Census 2000 is in the middle of the time period covered by my data. Table 1, below, contains summary statistics for the first and last year of the panel. (Variable descriptions and source notes can be found in Appendix Table A.23.) I have reported annual averages due to the strong seasonality of lottery ticket purchases. To compare the first and last month, January 1993 and December 2006, would distort the changes in sales over the panel.

Over the 14-year panel of data, mean per capita purchases of instant games more than doubled, while sales of Lotto Texas decreased by nearly 70%. The most likely reason for this decrease in Lotto Texas sales is the introduction of new lottery games since 1993, and, especially, the introduction of two multi-state mega-jackpot games, MegaMillions and Powerball. However, for players seeking instant gratification, there is no substitute for an instant game.

The use of Census 2000 ZCTA data presents some unique challenges in terms of matching the socioeconomic data with the sales data. The primary issue is that as zip codes were added by the Post Office after the release of Census 2000 data, no additional ZCTAs were added. There are 1,871 unique zip codes for which some sales data is provided. 194 of those are excluded due to a lack of a corresponding ZCTA file. As the crux of this essay depends on a change in the lottery earmark which occurred in 1997, a

Table 3.10 Summary Statistics - Annual Averages

	1993		2006	
Variable	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
Per Capita Instant Sales ($)	7.34	14.71	16.43	35.93
Per Capita Texas Lotto Sales ($)	5.24	11.88	1.62	4.23
Average Texas Lotto Advertised Prize (Millions)	9.19	3.53	17.66	11.67
Median Household Income	38161.37	15327.10	38904.38	16410.32
Percent urban (%)	0.53	0.43	0.51	0.44
Percent black (%)	0.10	0.14	0.09	0.14
Percent Hispanic (%)	0.26	0.25	0.26	0.25
Percent High School and above (%)	0.47	0.11	0.48	0.11
Unemployment Rate (%)	0.06	0.04	0.06	0.04
Observations	17,244		18,312	

loss of sales data after 2000 is not a great concern. In addition, 249 ZCTA files have no corresponding sales data and are excluded. There are two plausible reasons why there may be a zip code with no sales. First, zip codes do not follow state lines. Some zip codes may appear in a Texas ZCTA file although most of the population and land mass is located in a neighboring state. It may also be that the zip code is so sparsely populated that there are no lottery retailers. The average population for all zip codes in Texas in 2000 was just under 14,000. The average population among zip codes with no sales was 688. Finally, three zip codes were excluded because, despite the existence of a corresponding ZCTA file, no statistics were reported. For one of these, the zip code was merely a P.O. Box. The other two were in dense urban areas that, presumably, have no residents. It is of some concern that sales in these zip codes will not be attributed to any geography; however, it is a tiny fraction of overall sales.

In each of the models, I control for the seasonal nature of lottery sales using a set of dummy variables for February through December of each year. I control for the addition of new games to the Texas Lottery portfolio using a set of dummy variables that are constant across zip codes. These variables are equal to one after the introduction of one of the five games that begins during the panel. The five games which are introduced over the pane (and the first month of sales) are Pick3 (October 1993), Cash5 (October 1995), Texas Millionaire (May 1998), Texas 2 Step (May 2001), and Mega Millions (December 2003).

The first model is designed to test for a structural break at the time the earmark for K-12 education goes into effect. This occurs on August 1, 1997. Therefore, I create a dummy variable which is equal to one for August 1997 and each month thereafter, and equal to zero otherwise. In the first model, this dummy variable is interacted with each dependent variable. I estimate the following model, using either Lotto Texas or Instant game sales as the dependent variable:

$$Y_{i,t} = P_t\beta_1 + H_i\beta_2 + S_i\beta_3 + N_t\gamma + I_t^{K12}\delta + P_tI_t^{K12}\beta'_1 + H_iI_t^{K12}\beta'_2 + S_iI_t^{K12}\beta'_3 + N_tI_t^{K12}\gamma + \rho_m + \varepsilon_{it}$$

where Y_{it} is the log of sales for either Lotto Texas or Instant Games, P_t is the average advertised Lotto prize in each month, H_i is the log of median household income of each zip code at the time of Census 2000, S_i is a vector of socioeconomic characteristics from Census 2000, N_t controls for the introduction of new games in the Texas Lottery, and I_t^{K12} is the dummy variable which represents the change in earmark for Texas Lottery revenue. The dependent variables in the model above were chosen because they are demonstrated components of lottery demand. I test whether the coefficients on the K12 dummy variable and on the interaction terms are significantly different from zero. If this is the case, it is an indication that there is a change in the data generating process for lottery sales at the time the earmark is implemented.

The second model that I use to investigate whether the change in earmark affects lottery sales is based on research by Oster (2004). She uses Powerball sales in Connecticut to demonstrate that as the jackpot increases in size, higher income buyers represent a larger share of total ticket sales. This implies that at higher jackpot levels, the regressivity implied by the lottery decreases. She uses sales by zip code for each Powerball drawing over two years. I will be looking at Lotto Texas, the only lottery game in Texas to run continuously since the Lottery began in 1992. Although it is a much smaller game with lower jackpot levels, it is the only jackpot numbers game to be sold both before and after the earmark change in Texas. I will, first, follow Oster's model:

$$Y_{i,t} = P_t\beta_1 + H_i\beta_2 + P_tH_i\beta_3 + \rho_m + \varepsilon_{it}$$

In this simple model, I regress the log of Lotto Texas sales on the average prize, household income, and an interaction of the two. This allows me to calculate an elasticity of income over the entire population of Texas and, importantly, to know whether that elasticity changes when the prize level changes.

Next, I extend this model by allowing for a possible structural break in demand as of August, 1997. I repeat the model above, but interact each term with the post-earmark dummy variable previously discussed:

$$Y_{i,t} = P_t\beta_1 + H_i\beta_2 + P_tH_i\beta_3 + I_t^{K12}\delta + P_tI_t^{K12}\beta_1 + H_iI_t^{K12}\beta_2 + P_tI_t^{K12}H_i\beta_3 + \rho_m + \varepsilon_{it}$$

This allows me to test whether the relationship between the jackpot size and regressivity changes at the time of the (potential) structural break. In the final specification, I include the socio-economic characteristics. Each characteristic will be interacted with the prize level. This specification ensures that the change in regressivity in the previous model is not attributable to such characteristics. I will also include the dummy variables which allow the introduction of new games to affect lottery play. This equation will allow all of the coefficients to change post-earmark:

$$\begin{aligned} Y_{i,t} = {} & P_t\beta_1 + H_i\beta_2 + P_tH_i\beta_3 + S_i\beta_4 + P_tS_i\beta_5 + N_t\gamma + I_t^{K12}\delta + P_tI_t^{K12}\beta'_1 + H_iI_t^{K12}\beta'_2 \\ & + P_tH_iI_t^{K12}\beta'_3 + S_iI_t^{K12}\beta'_4 + P_tS_iI_t^{K12}\beta'_5 + N_tI_t^{K12}\gamma + \rho_m + \varepsilon_{it} \end{aligned}$$

Ultimately, Oster uses her results to suggest a jackpot level at which a jackpot-driven numbers game may actually become progressive. I will do the same using my sample, although because the jackpots in a one-state numbers game never approach the size of a multi-state numbers game, it is likely that the out-of-sample prediction will not be a feasible prize level.

3.4 Results

The first model is designed to test whether there is a change in the demand for lottery tickets at the time an earmark is imposed. Full regression results are reported in Appendix Table A.24. I find that both games are regressive and that Instant games are more regressive than Lotto Texas. Both findings are consistent with prior research. Furthermore, I find that both games become less regressive after the revenue is earmarked for K12 education. The effect is larger for Lotto Texas, which suggests that higher-income individuals motivated to buy lottery tickets due to the earmark are more likely to choose Lotto Texas that instant games. A larger Lotto Texas Prize increases sales of Lotto Texas and instant games, suggesting that instant games and Lotto Texas are complementary goods. The introduction of new games is invariable correlated with lower sales of Lotto Texas. However, the introduction of new numbers games increases purchases of instant games. This is consistent with numbers games and instant games having a complementary relationship.

However, the relevant question is whether the slope coefficients are different for observations in and after August 1997. The results for the test that the interacted coefficients are equal to zero appear in Table 3.11. For each regression (that is, using either instant game or Lotto Texas as the dependent variable), I use a Chi-sq test on the coefficients of the interacted terms. These tests offer convincing evidence that there is a structural change in the demand for Lotto Texas and Instant game tickets when the earmark goes into effect.

Table 3.11 Test Statistics for Structural Change

	Instant	Lotto Texas
Chi-sq test statistic	8516.85	10757.64
Prob>Chi-sq	0.0000	0.000

The presence of this structural break suggests that researchers seeking to model the demand for lottery tickets must take into account revenue earmarks in order to accurately model behavior. The next model replicates Oster's (2004) analysis, extending it to take into account the structural break. Her paper showed that when the advertised Powerball jackpot was larger, the regressivity of the lottery decreased. Table 3.12 contains the main regression results for this model. In the left column, I replicate Oster's model as closely as possible with my data. In the right column, I have included dummy variables which allow the intercept and slopes to vary before and after the break.

In Table 3.13 I have summarized the coefficients of interest. The first column reports the coefficients from the pooled model in Table 3.12. The second and third columns take into account the structural break in sales and report the coefficients before and after the earmark for K12 education. The third column is calculated by adding the coefficient on each variable to the coefficient of the same variable interacted with the K12 indicator. Finally, the fourth column tests the pre-break and post-break coefficients against one another.

The most important coefficient is that on (Median HH Income (ln) * Average Jackpot). This coefficient defines the extent to which the regressivity of the lottery changes when the prize level changes. In each of the three sets of coefficients, my findings are consistent with Oster, in that as the advertised jackpot increases, the implied regressivity of the lottery decreases. The size of this coefficient is slightly smaller after the earmark is implemented. However, the regressivity of the tax implied by lottery sales is much less once revenue is earmarked for K-12 education. This, along with the structural break in the sales equation, is further evidence in support of the theory described in Chapter 1. Not surprisingly, there is not a significant difference in the relationship between the advertised prize and sales before and after the break independent of income.

Table 3.12 Basic Model for Income Elasticity versus Prize

Variable	Pooled Model		With Break	
Median Household Income (ln)	-0.245	*	-0.425	*
	(0.049)		(0.05)	
Average Texas Lotto Advertised Jackpot	-0.086	*	-0.062	*
	(0.003)		(0.01)	
Median HH Income (ln) * Average Jackpot	0.009	*	0.010	*
	(0)		(0.001)	
K12 Earmark Indicator			-3.697	*
			(0.152)	
K12*Median Household Income (ln)			0.330	*
			(0.014)	
K12*Average Texas Lotto Advertised Jackpot			0.005	
			(0.011)	
K12*Median Household Income (ln)*Average Jackpot			-0.004	*
			(0.001)	
_cons	3.527	*	5.382	*
	(0.509)		(0.525)	
Overall R-sq	0.0128		0.1752	
N	244873		244873	

*Indicates significantly different from 0 at the 5% level.
Season fixed effects were included in each of the above regressions.

Table 3.13 Basic Model for Income Elasticity versus Prize - Coefficients of Interest

Variable	Pooled Model		With Break				
			Pre-Earmark		Post-Earmark		***P-value for H_o: β_{Pre}=β_{Post}***
Median Household Income (ln)	-0.245	*	-0.425	*	-0.095	*	0.0000
	(0.049)		(0.05)		(0.048)		
Average Texas Lotto Advertised Jackpot	-0.086	*	-0.062	*	-0.058	*	0.6568
	(0.003)		(0.01)		(0.003)		
Median HH Income (ln) * Average Jackpot	0.009	*	0.010	*	0.006	*	0.0001
	(0)		(0.001)		(0.000)		

The final model includes socioeconomic characteristics, each of which is interacted with the average advertised prize. This interaction allows me to test whether the change in regressivity which has been attributed to the prize level isn't actually due to non-income population characteristics. It also includes indicator variables which control for the introduction of new games. Finally, each variable I have described for this model is interacted with the K12 indicator variable to allow the coefficients to take on different values after the structural break.

The results are shown in Table 3.14. The left column includes each of the variables that are not interacted with the K12 indicator, thereby representing the entire model before August 1997. The right column shows the coefficient values for August 1997 and after. There is very little significance among the set of coefficients on socioeconomic characteristics. Interestingly, it appears that a larger share of the population having at least a High School degree is correlated with more lottery purchases. However, because this particular variable is expressed on a 0-1 scale, the correlation here is actually very small. Not surprisingly, the introduction of a new game to the Texas Lottery portfolio is always correlated with fewer Texas Lotto purchases.

Most importantly, the coefficient on the Income-Jackpot interaction term remains positive, suggesting that even with the addition of several control variables, it is still the case that a higher jackpot draws in higher income players. This effect is slightly larger once the earmark for K-12 schools goes into effect. Finally, with this full specification, it still appears that, post-earmark, the game become less regressive overall.

The results in Table 3.14 can be used to extrapolate the prize at which the lottery becomes progressive, which is to say that the following equation is equal to one:

$$\begin{aligned} &Income\ Elasticity \\ &\qquad = \beta(Median\ Household\ Income) \\ &\qquad + \beta(Median\ Household\ Income * Advertised\ Prize) \\ &\qquad * (Advertised\ Prize) \end{aligned}$$

The average advertised prize is equal to \$14.9 million. For the equation above to be equal to one, the prize would have to reach \$371 million pre-earmark and \$254 million post-earmark. That the necessary prize is smaller post-earmark is consistent with theory. However, both prize levels are highly unlikely in Texas Lotto.

3.5 Conclusions

This essay has used data on the Texas Lottery over a 14 year period to investigate whether there is a structural break in demand at the time that Texas began earmarking lottery revenue for the Foundation School Fund, which serves as the primary source of state funds for local K-12 districts. I have found there is a structural break at the time of the change in revenue allocation. Because this break exists, I have used the data to extend a model by Oster (2004) to take this break into account.

Oster's model demonstrates that as the jackpot size increases, the regressivity of the lottery decreases. However, my research suggests that this is not the only lottery characteristic which will reduce regressivity. So, I estimate her model, but allow the coefficients and intercept to vary before and after the break point. I find that, consistent with theory, the lottery is less regressive after the earmark takes place. I further find that when the model is fully specified, the regressivity decreases slightly faster with an increase in the prize when revenue is earmarked for K-12 education.

There are limitations to this analysis. Primarily, some of the effect of an advertised lottery prize on sales has been muted due to the use of monthly averages. Sales tend to drop immediately after a large jackpot has been won, which will offset the preceding spike in sales to some degree. Another drawback of this paper is that I am modeling an individual decision process and testing it with data that is aggregated geographically.

Despite these shortcomings, the results presented here suggest that the regressivity of the implicit tax of a state lottery is not beyond the control of legislatures that create them and the quasi-governmental agencies that execute them. Players appear to respond to statutory earmarks on revenue. Furthermore, games with large jackpots draw in higher income players. While lotteries are not likely to become a form of progressive taxation, the policies discussed here may provide some mitigation to the common critique that lotteries merely tax the poor.

Table 3.14 Income Elasticity versus Prize with Socioeconomic Characteristics and Indicators for New Games

Variable	Pre-Earmark		Post-Earmark		*P-value for H_o: $\beta_{Pre}=\beta_{Post}$*
Median Household Income (ln)	-0.856	*	-0.520	*	0.0000
	(0.069)		(0.068)		
Average Texas Lotto Advertised Jackpot	-0.024	*	-0.043	*	0.0924
	(0.011)		(0.003)		
Median HH Income (ln) * Average Jackpot	0.005	*	0.006	*	0.1930
	(0.001)		(0.000)		
Percent Urban	-0.052		-0.096	*	0.0000
	(0.048)		(0.047)		
Percent Black	-0.121		-0.169		0.1274
	(0.146)		(0.014)		
Percent Hispanic	0.143		0.367	*	0.0000
	(0.115)		(0.113)		
Percent High School and Above	2.308	*	2.913	*	0.0000
	(0.27)		(0.266)		
Unemployment Rate	-0.097		0.780		0.0000
	(0.536)		(0.526)		
Percent Urban*Average Prize	0.003	*	0.001	*	0.0094
	(0.001)		(0.000)		
Percent Black *Average Prize	-0.003		0.000		0.1266
	(0.002)		(0.001)		
Percent Hispanic*Average Prize	0.002		0.000		0.5138
	(0.002)		(0.000)		
Unemployment Rate*Average Prize	0.015		0.011	*	0.6476
	(0.008)		(0.002)		
Percent High School and Above*Average Prize	0.03	*	0.004	*	0.0000
	(0.004)		(0.001)		
Pick3 Indicator	-0.035	*			
	(0.004)				
Cash5 Indicator	-0.201	*			
	(0.003)				
Texas Millionaire Indicator	-0.216	*			
	(0.003)				
Mega Millions Indicator	-0.733	*			
	(0.002)				
Texas2Step Indicator	-0.229	*			
	(0.002)				

Table 3.14 continued Income Elasticity versus Prize with Socioeconomic Characteristics and Indicators for New Games

Variable	Pre-Earmark		Post-Earmark		*P-value for H_o: $\beta_{Pre}=\beta_{Post}$*
Constant	8.866	*	-2.75	*	0.0000
	(0.699)		(0.158)		
Overall R-sq	0.3796				
N	244873				

*Indicates significantly different from 0 at the 5% level.

Season fixed effects were included in each of the above regressions.

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Works Cited

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Appendix

Appendix

Table A.15 Variable Descriptions and Source Notes

Data	Source
Instant Game Sales by county and month, January 2004 - December 2008	Tennessee Education Lottery Corporation
Powerball Sales by county and month, January 2004 - December 2008	Tennessee Education Lottery Corporation
Nominal Per Capita Personal Income, by county and year, 2004-2008	Bureau of Economic Analysis
Weekly Wages	Bureau of Labor Statistics
Scholarship recipients, Fall 2004 - Fall 2008	Tennessee Higher Education Commission
Maximum advertised Powerball prize for all drawings in a given month, scaled by ten million	Tennessee Education Lottery Corporation
Population, by county and year	U.S. Census Population Division
Percent of the Population that is male	Bureau of Economic Analysis
Percent of the Population that is black	Bureau of Economic Analysis
Percent of the Population that is Hispanic	Bureau of Economic Analysis
Percent of the Population that is 65 years of age and older	Bureau of Economic Analysis
Unemployment rate, by county and month, January 2004 - December 2008	Tennessee Department of Labor and Workforce Development

Table A.16 Model 1 - Baseline Model with Top 10 and Bottom 10 Counties by Income

	Personal Income				Weekly Wage			
Variable	**Powerball (ln)**		**Instant (ln)**		**Powerball (ln)**		**Instant (ln)**	
Per Capita Personal Income (ln)	0.102	+	0.466	*+				
	(0.088)		(0.121)					
Top 10*Per Capita Personal Income (ln)	0.175	*+	0.27	*+				
	(0.077)		(0.106)					
Bottom 10*Per Capita Personal Income (ln)	0.004	*+	0	*+				
	(0.001)		(0.002)					
Weekly Wage (ln)					0.046	+	0.087	*+
					(0.027)		(0.037)	
Top 10*Weekly Wage (ln)					0.002	+	0.005	*+
					(0.001)		(0.002)	
Bottom 10*Weekly Wage (ln)					0	+	0.005	*+
					(0.001)		(0.002)	
Max Powerball Prize ($10 million)	0.036	*	0.002	*	0.036	*	0.002	*
	(0)		(0.001)		(0)		(0.001)	
Percent age 65 and up	0.672		0.883		0.784		1.154	
	(0.431)		(0.595)		(0.431)		(0.594)	
Percent male	-1.753	*	-3.495	*	-1.545	*	-3.51	*
	(0.785)		(1.083)		(0.786)		(1.085)	
Percent black	-0.184		0.561		-0.125		0.355	
	(0.504)		(0.696)		(0.503)		(0.693)	
Percent Hispanic	0.207		2.687	*	0.401		2.622	*
	(0.504)		(0.695)		(0.489)		(0.674)	
Unemployment Rate	-0.009	*	-0.007	*	-0.009	*	-0.008	*
	(0.001)		(0.002)		(0.001)		(0.002)	
Overall R-sq	0.0891		0.000		0.2572		0.0837	
N	5130		5130		5130		5130	
F(94,4974)	1371.92		625.95		1363.29		595.91	

*Indicates significantly different from 0 at the 5% level.

+Indicates significantly different from 1 at the 5% level.

Standard errors shown in parentheses.

County, month, and season fixed effects were included in each of the above regressions.

Table A.17 Model 2 - Scholarship Variable and Top 10 and Bottom 10 Counties by Income

	Personal Income				Weekly Wage			
Variable	Powerball (ln)		Instant (ln)		Powerball (ln)		Instant (ln)	
Per Capita Personal Income (ln)	0.112	+	0.538	*+				
	(0.088)		(0.122)					
Top 10*Per Capita Personal Income (ln)	-0.003	+	0.058	+				
	(0.106)		(0.147)					
Bottom 10*Per Capita Personal Income (ln)	-0.019	*+	-0.029	*+				
	(0.006)		(0.008)					
Weekly Wage (ln)					0.052	*+	0.076	*+
					(0.026)		(0.036)	
Top 10*Weekly Wage (ln)					0.020	*+	0.028	*+
					(0.008)		(0.011)	
Bottom 10*Weekly Wage (ln)					0.060	*+	-0.041	*+
					(0.008)		(0.011)	
Per Capita Scholarships (ln)	-0.036	*+	0.034	*+	-0.050	*+	0.026	+
	(0.010)		(0.013)		(0.009)		(0.013)	
Top 10*Per Capita Scholarships (ln)	0.028	+	0.053	*+				
	(0.018)		(0.024)					
Bottom 10*Per Capita Scholarships (ln)	-0.043	*+	-0.057	*+				
	(0.011)		(0.015)					
Top 10*Per Capita Scholarships (ln)					0.004	*+	0.005	*+
					(0.002)		(0.002)	
Bottom 10*Per Capita Scholarships (ln)					0.090	*+	-0.068	*+
					(0.012)		(0.017)	
Max Powerball Prize ($10 million)	0.036	*	0.002	*	0.036	*	0.002	*
	(0.000)		(0.001)		(0.000)		(0.001)	
Percent age 65 and up	0.664		0.948		0.737		1.396	*
	(0.429)		(0.593)		(0.430)		(0.597)	
Percent male	-1.608	*	-3.273	*	-1.337		-3.349	*
	(0.783)		(1.083)		(0.782)		(1.086)	

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Table A.17 continued Model 2 - Scholarship Variable and Top 10 and Bottom 10 Counties by Income

	Personal Income				Weekly Wage			
Variable	Powerball (ln)		Instant (ln)		Powerball (ln)		Instant (ln)	
Percent black	0.150		0.830		-0.471		0.561	
	(0.510)		(0.704)		(0.510)		(0.708)	
Percent Hispanic	0.306		2.608	*	0.774		2.253	*
	(0.503)		(0.696)		(0.489)		(0.680)	
Unemployment Rate	-0.010	*	-0.007	*	-0.008	*	-0.008	*
	(0).001		(0.002)		(0.001)		(0.002)	
Overall R-sq	0.2592		0.0297		0.2313		0.0881	
N	5035		5035		5035		5035	
F(94,4877)	1405.25		635.60		1409.10		605.64	

*Indicates significantly different from 0 at the 5% level.

+Indicates significantly different from 1 at the 5% level.

Standard errors shown in parentheses.

County, month, and season fixed effects were included in each of the above regressions.

Table A.18 Model with Scholarship Variable, Scholarship-Income Interaction and Top 10 and Bottom 10 Counties by Income

	Personal Income				Weekly Wage			
Variable	**Powerball (ln)**		**Instant (ln)**		**Powerball (ln)**		**Instant (ln)**	
Per Capita Personal Income (ln)	-0.000	+	1.843	*+				
	(0.200)		(0.277)					
Top 10*Per Capita Personal Income (ln)	-0.558	+	-3.146	*+				
	(0.416)		(0.576)					
Bottom 10*Per Capita Personal Income (ln)	0.007	+	0.006	+				
	(0.009)		(0.012)					
Weekly Wage (ln)					-0.023	+	0.398	+
					(0.148)		(0.205)	
Top 10*Weekly Wage (ln)					0.033	*+	0.024	+
					(0.011)		(0.015)	
Bottom 10*Weekly Wage (ln)					0.049	*+	-0.038	*+
					(0.010)		(0.014)	
Per Capita Scholarships (ln)	0.435		-2.720	*+	0.074	+	-0.467	+
	(0.376)		(0.520)		(0.227)		(0.315)	
Top 10*Per Capita Scholarships (ln)	1.018		6.736	*+				
	(0.841)		(1.163)					
Bottom 10*Per Capita Scholarships (ln)	-1.210	*+	0.079	+				
	(0.185)		(0.255)					
Top 10*Per Capita Scholarships (ln)					-0.021	+	-0.022	+
					(0.011)		(0.016)	
Bottom 10*Per Capita Scholarships (ln)					0.254	*+	0.074	+
					(0.084)		(0.117)	
Per Capita Scholarships (ln)* Per Capita Personal Income (ln)	-0.047	+	0.271	*+				
	(0.037)		(0.051)					
Top 10*Per Capita Scholarships (ln)* Per Capita Personal Income (ln)	-0.092	+	-0.644	*+				
	(0.080)		(0.111)					
Bottom 10*Per Capita Scholarships (ln)* Per Capita Personal Income (ln)	0.122	+	-0.007	+				
	(0.019)		(0.027)					

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Table A.18 continued - Model with Scholarship Variable, Scholarship-Income Interaction and Top 10 and Bottom 10 Counties by Income

	Personal Income				Weekly Wage			
Variable	Powerball (ln)		Instant (ln)		Powerball (ln)		Instant (ln)	
Top 10*Per Capita Scholarships (ln)* Weekly Wage (ln)					0.003	*+	0.003	+
					(0.001)		(0.002)	
Bottom 10*Per Capita Scholarships (ln)* Weekly Wage (ln)					-0.024	*+	-0.018	+
					(0.012)		(0.016)	
Per Capita Scholarships (ln)* Weekly Wage (ln)					-0.016	+	0.063	+
					(0.029)		(0.040)	
Max Powerball Prize ($10 million)	0.036	*	0.002	*	0.036	*	0.002	*
	(0.000)		(0.001)		(0.000)		(0.001)	
Percent age 65 and up	0.802		1.055		0.705		1.389	*
	(0.430)		(0.595)		(0.430)		(0.597)	
Percent male	-1.096		-3.232	*	-1.315		-3.434	*
	(0.786)		(1.087)		(0.783)		(1.087)	
Percent black	0.561		1.466	*	-0.386		0.685	
	(0.519)		(0.717)		(0.511)		(0.709)	
Percent Hispanic	0.243		2.142	*	0.816		2.219	*
	(0.510)		(0.705)		(0.490)		(0.681)	
Unemployment Rate	-0.010	*	-0.007	*	-0.008	*	-0.008	*
	(0.001)		(0.002)		(0.001)		(0.002)	
Overall R-sq	0.000		0.0042		0.2399		0.0946	
N	5035		5035		5035		5035	
F(94,4874)	1403.16		616.73		1386.36		588.89	

*Indicates significantly different from 0 at the 5% level.

+Indicates significantly different from 1 at the 5% level.

Standard errors shown in parentheses.

County, month, and season fixed effects were included in each of the above regressions.

Table A.19 Fully-Specified Model, Limited to Hope and Merit Scholarships

	Personal Income				Weekly Wage			
Variable	**Powerball (ln)**		**Instant (ln)**		**Powerball (ln)**		**Instant (ln)**	
Per Capita (ln) Personal Income	0.338	*+	1.612	*+				
	(0.134)		(0.184)					
Weekly Wage (ln)					-0.304	*+	0.792	*
					(0.110)		(0.152)	
Per Capita Scholarships(ln)	-0.519	*+	-1.977	*+	0.512	*+	-0.989	*+
	(0.201)		(0.276)		(0.153)		(0.211)	
Per Capita Personal Income (ln) * Per Capita Scholarships (ln)	0.051	*+	0.199	*+				
	(0.02)		(0.027)					
Weekly Wage (ln) * Per Capita Scholarships (ln)					-0.066	*+	0.131	*+
					(0.020)		(0.027)	
Max Powerball Prize ($10 million)	0.036	*	0.002	*	0.036	*	0.002	*
	(0)		(0.001)		(0)		(0.001)	
Percent age 65 and up	0.836		1.169	*	0.656		1.424	*
	(0.432)		(0.592)		(0.428)		(0.591)	
Percent male	-1.329		-3.04		-1.336		-3.488	*
	(0.786)		(1.079)		(0.786)		(1.085)	
Percent black	0.014		0.458		0.048		0.334	
	(0.507)		(0.696)		(0.507)		(0.700)	
Percent Hispanic	0.264		2.005	*	0.709		2.108	*
	(0.506)		(0.695)		(0.493)		(0.681)	
Unemployment Rate	-0.009	*	-0.007	*	-0.009	*	-0.008	*
	(0.001)		(0.002)		(0.001)		(0.002)	
Overall R-sq	0.2679		0.0507		0.2723		0.0787	
N	5035		5035		5035		5035	
F(94,4880)	1398.77		654.25		1399.19		626.22	

*Indicates significantly different from 0 at the 5% level.

+Indicates significantly different from 1 at the 5% level.

Standard errors shown in parentheses.

County, month, and season fixed effects were included in each of the above regressions.

Table A.20 Fully-Specified Model, Limited to Access and Aspire Scholarships

	Personal Income				Weekly Wage			
Variable	**Powerball (ln)**		**Instant (ln)**		**Powerball (ln)**		**Instant (ln)**	
Per Capita (ln)	0.483	*+	1.291	*				
Personal Income	(0.141)		(0.197)					
Weekly Wage (ln)					-0.007	+	0.357	+
					(0.119)		(0.167)	
Per Capita	-0.763	*+	-1.230	*+	-0.009	+	-0.380	*+
Scholarships(ln)	(0.195)		(0.272)		(0.150)		(0.210)	
Per Capita Personal	0.067	*+	0.119	*+				
Income (ln) * Per	(0.019)		(0.027)					
Capita Scholarships (ln)								
Weekly Wage (ln) * Per					-0.009	+	0.046	+
Capita Scholarships (ln)					(0.019)		(0.027)	
Max Powerball Prize	0.038	*	0.002	*	0.038	*	0.003	*
($10 million)	(0.000)		(0.001)		(0.000)		(0.001)	
Percent age 65 and up	0.463		0.936		0.362		1.187	*
	(0.427)		(0.597)		(0.425)		(0.596)	
Percent male	-1.897	*	-3.502	*	-1.851	*	-3.649	*
	(0.775)		(1.083)		(0.778)		(1.089)	
Percent black	-0.349		0.501		-0.361		0.381	
	(0.501)		(0.699)		(0.501)		(0.701)	
Percent Hispanic	0.596		2.777	*	0.754		2.571	*
	(0.492)		(0.687)		(0.484)		(0.677)	
Unemployment Rate	-0.010	*	-0.007	*	-0.009	*	-0.008	*
	(0.001)		(0.002)		(0.001)		(0.002)	
Overall R-sq	0.2550		0.0624		0.2535		0.0906	
N	5035		5035		5035		5035	
F(94,4880)	1428.48		644.64		1434.88		630.86	

*Indicates significantly different from 0 at the 5% level.

+Indicates significantly different from 1 at the 5% level.

Standard errors shown in parentheses.

County, month, and season fixed effects were included in each of the above regressions.

Table A.21 Fully-Specified Model, Excluding Metropolitan Counties: Davidson, Hamilton, Knox, Shelby

	Personal Income				Weekly Wage			
Variable	**Powerball (ln)**		**Instant (ln)**		**Powerball (ln)**		**Instant (ln)**	
Per Capita (ln) Personal Income	0.381	*+	1.387	*+				
	(0.136)		(0.191)					
Weekly Wage (ln)					-0.2	+	0.607	*+
					(0.112)		(0.158)	
Per Capita Scholarships(ln)	-0.765	*+	-1.726	*+	0.352	*+	-0.799	*+
	(0.226)		(0.316)		(0.172)		(0.242)	
Per Capita Personal Income (ln) * Per Capita Scholarships (ln)	0.072	*+	0.173	*+				
	(0.022)		(0.031)					
Weekly Wage (ln) * Per Capita Scholarships (ln)					-0.051	*+	0.106	*+
					(0.022)		(0.031)	
Max Powerball Prize ($10 million)	0.036	*	0.002	*	0.036	*	0.002	*
	(0)		(0.001)		(0)		(0.001)	
Percent age 65 and up	0.796		1.479	*	0.722		1.844	*
	(0.438)		(0.615)		(0.436)		(0.613)	
Percent male	-1.246		-2.954	*	-1.241		-3.299	*
	(0.8)		(1.122)		(0.801)		(1.127)	
Percent black	0.514		0.102		0.286		-0.173	
	(0.537)		(0.753)		(0.536)		(0.755)	
Percent Hispanic	-0.137		2.111	*	0.321		2.07	*
	(0.523)		(0.734)		(0.509)		(0.717)	
Unemployment Rate	-0.01	*	-0.007	*	-0.009	*	-0.008	*
	(0.001)		(0.002)		(0.001)		(0.002)	
Overall R-sq	0.2724		0.0443		0.2698		0.0431	
N	4823		4823		4823		4823	
F(90,4672)	1460.15		642.56		1471.25		613.40	

*Indicates significantly different from 0 at the 5% level.

+Indicates significantly different from 1 at the 5% level.

Standard errors shown in parentheses.

County, month, and season fixed effects were included in each of the above regressions.

Table A.22 Fully-Specified Model, Excluding Counties that Border States without a Lottery (Alabama, Arkansas, Mississippi)

	Personal Income				Weekly Wage			
Variable	**Powerball (ln)**		**Instant (ln)**		**Powerball (ln)**		**Instant (ln)**	
Per Capita (ln) Personal Income	0.515	*+	1.118	*				
	0.139		0.198					
Weekly Wage (ln)					-0.05	+	0.54	*+
					0.112		0.159	
Per Capita Scholarships(ln)	-1.242	*+	-1.553	*+	0.102	+	-0.713	*+
	0.23		0.328		0.172		0.245	
Per Capita Personal Income (ln) * Per Capita Scholarships (ln)	0.117	*+	0.156	*+				
	0.023		0.032					
Weekly Wage (ln) * Per Capita Scholarships (ln)					-0.02	+	0.095	*+
					0.022		0.031	
Max Powerball Prize ($10 million)	0.037	*	0.002	*	0.037	*	0.003	*
	0		0.001		0		0.001	
Percent age 65 and up	1.134	*	1.151		0.883		1.382	*
	0.465		0.663		0.461		0.657	
Percent male	-0.869		-3.648	*	-0.906		-3.912	*
	0.799		1.138		0.802		1.142	
Percent black	-0.004		-1.915		-0.23		-1.933	
	0.705		1.004		0.706		1.005	
Percent Hispanic	0.463		2.271	*	1.098	*	2.415	*
	0.522		0.743		0.512		0.729	
Unemployment Rate	-0.009	*	-0.008	*	-0.009	*	-0.009	*
	0.002		0.002		0.002		0.002	
Overall R-sq	0.3746		0.0183		0.4039		0.0153	
N	4293		4293		4293		4293	
F(80,4152)	621.14		469.86		606.01		440.76	

*Indicates significantly different from 0 at the 5% level.

+Indicates significantly different from 1 at the 5% level.

Standard errors shown in parentheses.

County, month, and season fixed effects were included in each of the above regressions.

Table A.23 Variable Descriptions and Source Notes

Data	Source
Instant Game Sales by zip code and month, January 1993 - December 2006	Texas Lottery Commission
Texas Lotto Sales by zip code and month, January 1993 - December 2006	Texas Lottery Commission
Average advertised prize for Texas Lotto drawings, January 1993 - December 2006	Texas Lottery Commission
Median Household Income	Census 2000, Zip Code Tabulation Area Statistics
Total Population	Census 2000, Zip Code Tabulation Area Statistics
Percent of the Population that lives in an urban environment	Census 2000, Zip Code Tabulation Area Statistics
Percent of the Population that is black	Census 2000, Zip Code Tabulation Area Statistics
Percent of the Population that is Hispanic	Census 2000, Zip Code Tabulation Area Statistics
Percent of the Population that has completed at least a High School diploma or equivalency degree	Census 2000, Zip Code Tabulation Area Statistics
Unemployment rate	Census 2000, Zip Code Tabulation Area Statistics

Table A.24 Testing for a Structural Break

Variable	PerCapita Instant (ln)		PerCapita Lotto Texas (ln)	
Median Household Income (ln)	-1.293	*	-0.797	*
	(0.072)		(0.069)	
Average Texas Lotto Advertised Jackpot	0.007	*	0.041	*
	(0)		(0)	
Percent Urban	-0.229	*	-0.019	
	(0.05)		(0.047)	
Percent Black	0.298		-0.161	
	(0.153)		(0.145)	
Percent Hispanic	0.185		0.165	
	(0.12)		(0.115)	
Percent High School and Above	1.682	*	2.683	*
	(0.28)		(0.269)	
Unemployment Rate	-0.593		0.097	
	(0.533)		(0.532)	
Pick3 Control	0.367	*	-0.035	*
	(0.004)		(0.004)	
Cash5 Control	0.344	*	-0.201	*
	(0.003)		(0.003)	
Texas Millionaire Control	-0.156	*	-0.216	*
	(0.003)		(0.003)	
Mega Millions Control	0.277	*	-0.733	*
	(0.002)		(0.002)	
Texas2Step Control	0.235	*	-0.229	*
	(0.002)		(0.002)	
K12 Earmark Control	-3.9	*	-4.011	*
	(0.063)		(0.063)	
K12*Median Household Income (ln)	0.37	*	0.375	*
	(0.006)		(0.006)	
K12*Average Texas Lotto Advertised Jackpot	-0.005	*	-0.017	*
	(0)		(0)	
K12*Percent Urban	-0.016	*	-0.066	*
	(0.004)		(0.004)	
K12*Percent Black	0.078	*	-0.004	*
	(0.013)		(0.013)	

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Table A.24 continued Testing for a Structural Break

Variable	PerCapita Instant (ln)		PerCapita Texas Lotto (ln)	
K12*Percent Hispanic	-0.012	*	0.21	*
	(0.01)		(0.01)	
K12*Percent High School and Above	-0.222	*	0.293	*
	(0.024)		(0.024)	
K12*Unemployment Rate	0.231	*	0.866	*
	(0.048)		(0.048)	
K12*Pick3 Control	(omitted)		(omitted)	
K12*Cash5 Control	(omitted)		(omitted)	
K12*Texas Millionaire Control	(omitted)		(omitted)	
K12*Mega Millions Control	(omitted)		(omitted)	
K12*Texas2Step Control	(omitted)		(omitted)	
Constant	14.281	*	8.046	*
	(0.727)		(0.694)	
Overall R-sq	0.3789		0.2532	
N	244873		249605	

*Indicates significantly different from 0 at the 5% level.

Season fixed effects were included in each of the above regressions.

Vita

Kara Mitchell is a native of Tennessee and a 2004 graduate of Carson-Newman College with degrees in Economics and Spanish. She earned a Master of Arts in Economics degree from the University of Tennessee in 2006 and then began working for the State of Tennessee in the Department of Finance and Administration. She returned to UT in 2008 to complete her Doctoral degree. In the three years that followed, she worked at the Center for Business and Economic Research and taught several classes. In the fall of 2011, she will be joining the faculty of Belmont University in Nashville where she will teach in the College of Business Administration and continue her research in public finance and environmental economics.