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SPATIAL COMPETITION AND CROSS-BORDER SHOPPING: EVIDENCE FROM STATE LOTTERIES

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ABSTRACT

This paper investigates competition between jurisdictions in the context of cross-border shopping for state lottery tickets. We first develop a simple theoretical model in which consumers choose between state lotteries and face a trade-off between travel costs and the price of a fair gamble, which is declining in the size of the jackpot and the odds of winning. Given this trade-off, the model predicts that per-resident sales should be more responsive to prices in small states with densely populated borders, relative to large states with sparsely populated borders. Our empirical analysis focuses on the multi-state games of Powerball and Mega Millions, and the identification strategy is based upon high-frequency variation in prices due to the rollover feature of lottery jackpots. The empirical results support the predictions of the model. The magnitude of these effects is large, suggesting that states do face competitive pressures from neighboring lotteries, but the effects vary significantly across states.

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1 Introduction

This paper examines competition between jurisdictions in the United States. In an analogy to competition in the private sector, the Tiebout model (1956) demonstrates that a greater degree of choice in the public sector enhances efficiency when public goods are financed via benefits taxation. In his model, tax rates serve as prices for accessing the public good, and individuals thus sort into jurisdictions according to their preferences for public services. In a similar vein, Brennan and Buchanan (1980) argued that competition between governments may help to constrain Leviathan governments whose sole objective is to maximize revenue. In this case, competition in the public sector serves to reduce the size of the public sector and hence enhance economic efficiency from the perspective of taxpayers. A key assumption in this literature is that individuals respond to differences in tax and spending policies across jurisdictions when making economic decisions.

In this paper, we examine responses to policy differences across jurisdictions and the associated competition in the context of the market for lottery products in the United States. On the one hand, competition in this market seems non-existent since every state government has established monopoly rights over the provision of lottery games. Perhaps as a result of this monopoly provision, states set payout rates on lottery tickets at relatively low levels, and the implicit tax rates facing consumers are thus very high, especially when considered relative to taxes on other commodities.

On the other hand, while state governments may have monopoly rights over the provision of lottery products within their state boundaries, competition across states boundaries may be significant. In particular, consumers, especially those living near borders, are often willing to cross into other states in order to play lottery games, and the existence of lotteries in nearby states may thus provide an important form of competition in this market. If such competition is economically significant, then the introduction of lotteries in new states may reduce lottery sales in nearby states with existing lotteries.

In theory, state governments may respond to this competition from neighboring state lotteries in a variety of ways. One possibility is that they will respond by decreasing implicit tax rates, a hypothesis supported by Brown and Rork (2005). Alternatively, states may attempt to collude via the coordination of lottery games across states. Recent decades have witnessed an explosion in the sales of these coordinated multi-state games, most prominently Powerball and Mega Millions.

In order to measure the degree of competition facing state lotteries, this paper uses several insights regarding *where* and *when* cross-border shopping should be most prevalent. Regarding where, anecdotal evidence suggests that cross-border shopping is most common along densely populated borders between states that are not coordinating their lottery games. For example, many New Yorkers, who cannot purchase Powerball tickets within their state boundaries, reportedly cross the Connecticut border, which is just outside of the densely populated New York City, in order to purchase Powerball tickets. Regarding when, anecdotal evidence suggests that cross-border shopping is most likely when jackpots are high. That is, the crossing of New Yorkers into Connecticut was particularly salient when the Powerball jackpot reached $250 million in 1998.[1] Put together, this anecdotal evidence suggests that the relationship between lottery sales and lottery jackpots may be stronger in densely populated areas that do not share a multi-state game than in sparsely populated areas or along borders cooperating in the same multi-state lottery.

In this paper, we begin by formalizing these ideas in a simple theoretical model of the choices facing lottery players. In the model, players face a trade-off between travel distance and the price of a fair gamble, which is declining in the size of the jackpot and in the odds of winning. Given this trade-off, the model predicts that, if cross-border shopping is substantial, then the relationship between sales and prices should be stronger in states that have small populations and densely populated border regions, such as Rhode Island and Delaware, than in states that have large populations and more rural border regions, such as California and Texas.

In order to test this hypothesis, our empirical application focuses on the large multi-state games of Powerball and Mega Millions. We combine information from several different datasets. The first dataset consists of weekly lottery sales between 1995 and 2008 for each state and separately for each game. The second dataset represents game characteristics, most notably odds and jackpots on a drawing-by-drawing basis for Powerball and Mega Millions. The fact that jackpots roll over to the next drawing in the event that a winning ticket is not purchased provides a source of variation in jackpots and thus in prices across games and over time. The third dataset includes information on the spatial distribution of the population in the United States in 2000 and is used to create measures of the size of the population living near every state border.

The empirical results support the theoretical predictions. Lottery sales per capita are higher during weeks with large jackpots, which imply low prices. Importantly, this relationship is much stronger in states with small populations and densely populated border regions than in states with large populations and sparsely populated border regions. The results demonstrate that cross-border sales are an economically significant factor in small, densely populated states. In a series of alternative specifications, we then examine the robustness of

[1] New York Times, July 27, 1998.

these results. As predicted by the theory, we also show in a placebo test that these relationships are not present along borders in which both states participate in the same interstate lottery game since there is no incentive to cross state borders in this case. Finally, we use the model to predict how sales would change were Powerball and Mega Millions tickets available in every state.

Our approach offers several contributions to the literature on cross-border shopping for lottery tickets. First, our paper develops a theoretical framework for investigating cross-border shopping that incorporates the spatial distribution of the population. This structure yields two new insights for measuring cross-border shopping: border shopping is more likely in areas with densely populated border regions, and lottery players are more likely to cross borders when jackpots are sizeable. Our other contributions are empirical but are based upon these theoretical insights. In particular, our study is unique in using data on the spatial distribution of the population in order to identify where border shopping is most relevant. Other studies have tended to assume that the effects of lotteries in neighboring states on revenues are homogenous across the United States and have thus ignored these substantial differences in the spatial distribution of the population across states. In addition, we are the first to use high-frequency variation in the jackpot size over time to estimate the degree of cross-border shopping. Other studies have tended to use annual data and thus ignore this source of significant variation in the desirability of lottery products over time and across states.

The paper proceeds as follows. We begin by providing background information on state lotteries. We then discuss the relevant literature. This discussion is followed by the presentation of our theoretical model and its key predictions. After describing the data, we present our baseline empirical results and robustness tests. The final section discusses policy implications and concludes.

2 Background on state lotteries

This section provides a brief background on state lotteries with a focus on those issues that are most relevant to cross-border shopping and competition between states. See Clotfelter et al. (1999) and Kearney (2005) for more complete information on state lotteries.

In 1964, New Hampshire became the first state government in the United States to operate a lottery. Many states followed suit, and, by 2007, 42 state lotteries were in operation. Lottery tickets must be purchased from licensed retailers, which operate only within state boundaries.[2] Thus, individuals wishing to purchase lottery tickets out of state must physi-

[2] Prior to 1985, six states were offering lottery tickets to out-of-state players via mail, a practice that

cally travel to a licensed retailer in that state.

Every state in the continental United States currently either has a lottery or is bordered by at least one state with a lottery. Given this widespread availability, lotteries have become the most common form of gambling. According to a recent Gallup survey, almost one-half of respondents reported that they had purchased a state lottery ticket in the preceding year.[3]

Regarding the overall size of the market, lottery revenues in 2007 totaled \$76 billion nationwide. In terms of the disposition of these revenues, \$56 billion were paid out in prizes, \$18 billion were retained by states as profits, and the remaining \$2 billion were attributed to administrative expenses.[4] With roughly 230 million U.S. residents over the age of 18, which is a typical minimum age for purchasing lottery tickets, this implies per capita annual purchases of \$330. The 24 percent profit margin is consistent with an implicit commodity tax rate of 32 percent, which, while lower than in past years, remains much higher than tax rates on other products (Clotfelter and Cook, 1990).

A variety of games are currently available to lottery players. In the lotto game, which is the focus of this paper, players choose a series of numbers, such as five numbers between 1 and 59 and one number between 1 and 39 in Powerball, and win the jackpot if their numbers match those chosen at the drawing.[5] If there is no winning ticket, the jackpot rolls over to the next drawing, and there are typically two drawings per week. In this type of game, the odds are long but, because of the rollover feature, jackpots can grow very large.

Due in part to demand for games with large jackpots, some states have banded together to form multi-state games. In 1987, the District of Columbia and five relatively small states, Iowa, Kansas, Oregon, Rhode Island, and West Virginia, formed the Multi-State Lottery Association, which offered a lottery game known as LottoAmerica. In 1992, the Association began the Powerball lotto game, which quickly grew in popularity due to its large jackpots. As shown in Table 1, there was significant entry into Powerball during our sample period

was declared illegal by the U.S. Postal Service on May 31, 1985 (Washington Post, June 1, 1985). Similar legal issues apply to potential internet sales of lottery tickets to out-of-state players. Relatedly, the reselling of tickets in out-of-state retail outlets is typically illegal. During a large Powerball jackpot in 1993, some Massachusetts retail outlets were selling Powerball tickets originally purchased in Rhode Island, an act that violated Massachusetts law (Boston Globe, July 8, 1993).

[3] These data were taken from the website http://www.gallup.com/poll/104086/one-six-americans-gamble-sports.aspx (accessed August 5, 2009).

[4] These data are taken from the Census Bureau 2007 Survey of Governments.

[5] Lottery games can be placed into several broad categories (Clotfelter et al., 1999). In addition to the lotto, there are four other categories of games. Instant scratch tickets allow the player to immediately observe and collect any prizes. In the numbers game, players choose their own three-digit or four-digit numbers and win if their numbers match those chosen during the drawing, which are typically held daily. Keno is a similar game but one in which drawings are held more frequently, often hourly. Video lottery terminals are similar to those found in casinos and offer games such as video poker.

1995-2008. By the end of this period, Powerball tickets were sold in D.C. and in 30 states. As also shown in Table 1, six states came together in 1996 to start a competitor multi-state lottery known as The Big Game. In 2002, the name was changed to Mega Millions, and, by the end of 2008, tickets were sold in 12 of the 13 lottery states not currently selling Powerball tickets. Florida entered Mega Millions in 2009, and every lottery state thus currently participates in either Powerball or Mega Millions. Jackpots in the Mega Millions game have also grown large, with the $390 million top prize on March 6, 2007 marking the largest jackpot in U.S. history. While jackpots tend to be large, the odds of winning are very long. The odds of winning the jackpot in Powerball, for example, are currently 1 in 195,249,054.

In order to provide a sense of the spatial distribution of Powerball and Mega Millions states, Figure 1 maps the membership in these two games as of December 31, 2008, the end of our sample period. As shown, two Mega Millions states, Illinois and Washington, are completely surrounded by states participating in the competing Powerball game. At the other extreme, four Powerball states, North Dakota, Minnesota, Kansas, and Maine, are completely surrounded by states cooperating in the Powerball game. Thus, there is significant spatial variation in the degree of competition facing Powerball and Mega Millions states.

A recent agreement between these two multi-state games will allow for the simultaneous sale of both sets of tickets in all Powerball and Mega Millions states.[6] This cross-selling of the two lottery tickets is expected to begin in early 2010. This agreement may also reportedly lay the foundation for the introduction of a new "national lottery" with tickets available in all 42 states currently participating in Powerball or Mega Millions.

3 Existing literature

Our paper is most closely related to several studies that investigate cross-border shopping in the context of lottery tickets. Garrett and Marsh (2002) use lottery sales data for counties in Kansas during 1998 and compare sales in border counties to sales in non-border counties. They find that Kansas counties which border states with lotteries tend to have lower sales, while counties bordering states without lotteries tend to have higher sales.[7] While this study uses only cross-sectional variation across counties, Tosun and Skidmore (2004) use annual lottery sales for counties in West Virginia between 1987 and 2000. Variation across time in the introduction of lottery games in border states allows the authors to control for

[6] Philadelphia Inquirer, October 14, 2009.

[7] They control for both county demographic characteristics and spatial autocorrelation.

county fixed effects. The key findings are that sales in border counties decline following the introduction of new lottery games in bordering states. Mikesell (1991) conducts a telephone survey and estimates the determinants of lottery expenditure in Indiana before the Indiana State Lottery was introduced and thus all expenditures were out of state. The key finding here is that Indiana residents living in border counties were more likely to play the lottery.

Two studies use national data on cross-border lottery shopping. Stover (1990) uses sales data from 1984 and 1985 for the 17 states with lotteries in these years and finds that sales are influenced by lottery status in neighboring states. While this study is limited to just 34 observations, Walker and Jackson (2008) use a longer panel covering the period 1985 to 2000. They thus use variation across time in the introduction of lotteries in bordering states and show that lottery sales are declining in the fraction of bordering states with a lottery. One limitation of these studies involves strategic entry, under which states may choose to adopt lotteries when demand for these products is high. Our study, by contrast, uses variation in jackpots over time for a given configuration of state lotteries and is thus less affected by this issue of strategic entry.

More generally, our paper is related to a literature on the economics of state lotteries. This literature has focused on issues such as the regressivity of the implicit tax on lottery products (Oster, 2004), the budget impact of the earmarking of lottery revenues for education (Evans and Zhang, 2007), the effects of lottery purchases on overall consumption (Kearney, 2002a), and the effect of selling a winning ticket on retailer sales of lottery tickets in subsequent drawings (Guryan and Kearney, 2008). See Clotfelter and Cook (1990) and Kearney (2005) for a more complete review of the literature.

There is also a large related literature on cross-border shopping in other contexts.[8] Using individual-level data and spatial analysis, Lovenheim (2008) finds that price elasticities for cigarettes vary with the distance that individuals must travel to a state with lower prices. Like us, Beard et al. (1997) build a theoretical model of cross-border shopping. They estimate the model using data on alcohol sales and taxes at the state level and find evidence of cross-border shopping for beer but not for liquor. Asplund et al. (2007) examine liquor sales in Swedish municipalities and find that price elasticities are decreasing in the distance to the border with Denmark. Using data from the states of Illinois and Indiana, Doyle and Samphantharak (2008) finds that gasoline taxes are largely incorporated into gasoline prices, but that this relationship between taxes and prices depends upon the distance to the state border. Finally, Goolsbee (2000) shows that consumers are more likely to purchase goods

[8] There is a related literature in industrial organization on spatial competition between firms. For example, Davis (2006) estimates a model in which spatially dispersed consumers choose between products that are characterized by their location. In an empirical application to movie theaters, one interesting finding is that travel costs have an estimated shape that is concave in nature.

via the internet if their state of residence has higher sales tax rates.

Related to this literature on cross-border shopping, there is also a literature on spatial interdependence in policies across jurisdictions. In the context of lotteries, Brown and Rork (2005) find that neighboring states respond to changes in lottery payout rates. Case et al. (1993) show that a one dollar increase in government spending leads to a 70 cent increase in spending by neighboring states. Using data from the Boston metropolitan area, Brueckner and Saavedra (2001) show that municipalities engage in strategic property tax competition. The analysis of Besley and Case (1995) provides empirical support for yardstick competition, under which voters evaluate incumbent governors by comparing tax policy to that in neighboring states. For a more complete review of this literature, see Brueckner (2003).

4 Conceptual framework

In this section, we develop a simple two-state model in order to illustrate our main empirical approach to identifying cross-border shopping. Given our empirical motivation, we keep the model simple and make specific functional form assumptions in some cases. It should be clear, however, that the results are robust to more general economic environments. Also, given our empirical application, we focus on the market for lottery products. The basic trade-off between travel costs and prices, however, is more general and applies to many other forms of commodity taxation.

4.1 Setup

In the model, player i chooses to play one of two possible state lotteries, which are given by West (W) and East (E) and are indexed by s. Conditional on choosing to play lottery s, individual i must choose how many tickets to purchase (x_{is}), each of which returns a jackpot j_s with probability p_s.[9] Players are characterized by their geographic locations (l_i), which are assumed to be distributed on the interval $[0, L]$ according to the distribution function F. The border between the states is located at b, and players with $l_i < b$ are thus residents of state W and players with $l_i > b$ are thus residents of state E. The total number of residents is normalized to one, with a fraction N_E living in state E and a fraction $N_W = 1 - N_E$ living in state W. Thus, we have that $F(b) = N_W$.

[9] Note that this model makes two simplifying assumptions. First, we assume that there is at most one winner of the jackpot. In reality, there are sometimes multiple winners who split the jackpot. Incorporating this factor would significantly complicate the analysis since it would introduce strategic interactions between players. Second, we assume that there is only one prize available, the jackpot. In reality, lotto games tend to have multiple prizes with smaller prizes available for matching a subset of the numbers drawn. This assumption is motivated by our empirical strategy, which focuses on variation in the size of the jackpot over time due to rollovers of previous jackpots without a winning ticket.

In order for individual i to play the lottery in the state where he is not a resident, he must travel a distance to the border equal to $d_i = |l_i - b|$, and the marginal cost of such travel is given by c. Thus, total transportation costs associated with playing the lottery in neighboring states is given by cd_i.[10] Players choosing to play the home lottery are assumed to have immediate access to a retail store and thus face no transportation costs.

Following Kearney (2002b), we also assume that players receive an entertainment value from playing the lottery.[11] We model this entertainment aspect by the function $g(x_{is})$, which is assumed to be homogenous across players and is increasing in the number of tickets purchased but at a decreasing rate. That is, $g'(x_{is}) > 0$ and $g''(x_{is}) < 0$. We normalize this function such that $g(0) = 0$ and also assume that $g'(0) > 1$. The latter assumption guarantees that individuals always prefer to participate in the domestic lottery over not participating in any lottery.[12] Finally, we assume that players are endowed with exogenous income equal to m.

We further assume that players are risk-neutral and that, following Kearney (2002b), utility is separable in the financial and entertainment aspects of the lottery. Under these assumptions, player i receives the following utility from purchasing x_{is} lottery tickets in state s:

$$U_{is} = x_{is}p_s(m + j_s - x_{is} - cd_{is}) + (1 - x_{is}p_s)(m - x_{is} - cd_{is}) + g(x_{is})$$

where $d_{is} = 0$ for the home-state lottery. This can be rewritten as follows:

$$U_{is} = m - cd_{is} - \pi_s x_{is} + g(x_{is})$$

where $\pi_s = 1 - p_s j_s$ can be interpreted as the price of purchasing a fair gamble, defined as one that costs \$1 to play and pays an expected value of \$1. Note that $\pi_s \leq 1$ since jackpots cannot be negative.

[10] Note that this formulation assumes that individuals travel across borders for the sole purpose of playing lotteries. In reality, individuals may travel across the border to purchase bundles of products when tax rates differ substantially across states. In this case, the total travel costs cd_i will be spread across multiple products.

[11] Evidence from Kearney (2002a) suggests that non-financial aspects of games, which can be interpreted as entertainment, are important determinants of sales. For example, games that require players to choose seven digits have higher sales than games that require players to choose four digits, all else equal.

[12] Below we consider the case in which only one state offers a lottery, and residents of the other state must thus travel in order to purchase lottery tickets. In this case, if the travel costs are sufficiently high, players may choose to not participate even under this assumption.

4.2 Individual choices

Conditional on choosing to play the lottery in state s, the number of tickets purchased by individual i is characterized by the following first-order condition:

$$g'(x_{is}) = \pi_s$$

Thus, players equate the marginal entertainment value to the price of a fair gamble. Note that the marginal entertainment value from a ticket must be significant in order to induce sizable sales since prices for playing fair games are typically positive and significant. Inverting this first-order condition, we have that $x_{is} = x_s = h(\pi_s)$ where $h = (g')^{-1}$. Since $h' = 1/g'' < 0$, the number of tickets purchased is decreasing in the price of a fair gamble (π_s). Also, note that the number of tickets is constant across individuals and is independent of the distance traveled.[13] Given these results, the indirect utility for player i choosing lottery s is given by:

$$V_{is} = m - cd_{is} + z(\pi_s)$$

where $z(\pi_s) = g(h(\pi_s)) - \pi_s h(\pi_s)$ represents the non-travel, financial benefits from playing lottery s. Applying the envelope theorem, we have that $z'(\pi_s) = -h(\pi_s)$ and thus the non-travel, financial benefits are decreasing in the price of a fair gamble (π_s).

Given these results, there exists a cutoff location ($\widetilde{l}$) at which residents are indifferent between playing the lotteries in states E and W. This cutoff is given by:

$$\widetilde{l} = b + (z(\pi_W) - z(\pi_E))/c$$

Players west of this location ($l_i < \widetilde{l}$) thus play lottery W, and those east of this location ($l_i > \widetilde{l}$) thus play lottery E.

4.3 Lottery revenues

Lottery revenue for state W, which is the product of sales per player (x_W) and the number of players $F(\widetilde{l})$, can be written as:

$$R_W = h(\pi_W) F\left[b + (z(\pi_W) - z(\pi_E))/c\right]$$

Recalling that $F(b) = N_W$, the log of per capita revenues ($r_W = R_W/N_W$) is then given by:

$$\ln(r_W) = \ln[h(\pi_W)] + \underbrace{\ln F\left[b + (z(\pi_W) - z(\pi_E))/c\right] - \ln\left[F(b)\right]}_{\text{cross-border adjustment factor}}$$

[13] Note that optimal spending on lottery tickets is independent of income. While this is driven by the fuctional form assumptions made above, it is consistent with evidence from Kearney (2005), who shows that average spending levels are similar across different income groups.

The first term represents log sales per player, and the second term is the cross-border adjustment factor. If the price of a fair game in E is higher than that in W ($\pi_E > \pi_W$), then this cross-border adjustment factor is positive since residents from state E will cross the border and play lottery W. Similarly, if prices are higher in state W, then this factor is negative since residents from state W will cross the border and play lottery E.[14]

This model yields a number of testable hypotheses related to cross-border shopping. To generate an empirical specification, we first take a first-order linear approximation to the above revenues equation at the point $\pi_W = \pi$ and $\pi_E = \pi$.[15] This yields:

$$\ln(r_W) \approx \alpha + \frac{h'(\pi)}{h(\pi)}\pi_W - \frac{h(\pi)}{c}\lambda(b)\pi_W + \frac{h(\pi)}{c}\lambda(b)\pi_E$$

where $\alpha = \ln[h(\pi)] - \frac{h'(\pi)}{h(\pi)}\pi$ is a constant and $\lambda(b) = f(b)/F(b)$ represents the Mills ratio, the population density function divided by the distribution function, both of which are evaluated at the border.

Using the fact that $f(b) \approx F(b+\varepsilon) - F(b-\varepsilon)$ for small values of ε, the numerator of the Mills ratio can be interpreted as the size of the population near the border, regardless of which side. Since the denominator $F(b)$ represents state population, the model thus predicts that sales in state W are more responsive to the price of the affiliated lottery (π_W) in states with small populations and densely populated border regions and less responsive in states with large populations and sparsely populated border regions. Finally, note that the magnitude of the effect is decreasing in the cost of travel (c), which makes players less willing to cross borders.

Similarly, the model demonstrates that the relationship between sales and the price of the rival lottery (π_E) also depends upon the Mills ratio $\lambda(b)$. Thus, sales should also be more responsive to the price of the rival lottery in states with small populations and densely populated border regions. Comparing the strength of the affiliated price effect and rival price effect, the former effect is the stronger of the two since it also includes the term $h'(\pi)/h(\pi)$, which reflects the intensive margin, defined as the increased sales per player induced by lower prices. This intensive margin is not relevant for consumers who choose to play the lottery in the competing state.

The model can also be used to consider the effects of states cooperating in multi-state games, such as Powerball and Mega Millions. In particular, if the two states are part of the

[14] Analogous results can be demonstrated for revenues from state E.

[15] We evaluate this function at the same prices ($\pi_W = \pi_E = \pi$) for two reasons. First, it generates a tractable empirical specification since the terms $z(\pi_W)$ and $z(\pi_E)$ cancel out in the key spatial expressions $f(b)$ and $F(b)$. Second, equal prices will occur on average in our empirical application to follow since the two lotteries under examination, Powerball and Mega Millions, have similar odds and both allow jackpots to roll over to the next drawing.

same multi-state game, then jackpots, odds, and thus prices are always identical ($\pi_E = \pi_W$), and the cross-border shopping adjustment factor vanishes since there is no incentive to travel to neighboring states when purchasing lottery tickets. In this case, revenues are given by $\ln(r_W) = \ln[h(\pi_W)]$ and thus increases in affiliated prices yield decreases in sales but only due to the decrease in sales per player for the domestic population. In particular, the relationship between sales and both affiliated and rival prices should not depend upon the population density in border regions. We use this prediction to provide a placebo test of our main results in the empirical application to follow.

Finally, we use the model to consider a scenario in which the bordering state E does not have a lottery since this is relevant to our empirical application, in which some states do not have lotteries. In this case, it is possible that some players in state E will prefer to not purchase any lottery tickets if the associated travel costs are sufficiently high. It can then be shown that the linear approximation to revenues is given by:

$$\ln(r_W) \approx \alpha + \frac{h'(\pi)}{h(\pi)}\pi_W - \frac{h(\pi)}{c}\lambda(b + (z(\pi)/c))\pi_W$$

where $\alpha = \ln[h(\pi)] - \frac{h'(\pi)}{h(\pi)}\pi + \ln F\left[b + (z(\pi)/c)\right] - \ln\left[F(b)\right]$.[16] Thus, there are two important differences between the above case with competing lotteries and this case in which the bordering state has no lottery. First, in this case, lottery revenues in state W depend only upon the price of lottery W and thus do not depend upon the price of the rival lottery. Second, the marginal resident is always located in state E, and thus only the population on the foreign side of the border is relevant for cross-border shopping.

In summary, the model yields a number of testable predictions. First, lottery sales are declining in the price of the affiliated lottery. More importantly, this relationship is stronger in small states, in states with densely populated borders with competing neighbors, and in states with densely populated borders with neighbors without a lottery. Second, the positive relationship between sales and prices of rival lotteries is stronger in small states and in those states with densely populated borders with competing states. Third, these relationships

[16] To generate this, note that there exists a cutoff point located in state E where players are indifferent between playing the lottery in state E and not purchasing any tickets, which yields a utility level of $V = m$. This cutoff is given by:

$$\widetilde{l} = b + z(\pi_W)/c$$

Given this cutoff, the log of per capita revenues are thus given by:

$$\ln(r_W) = \ln[h(\pi_W)] + \underbrace{\ln F\left[b + (z(\pi_W)/c)\right] - \ln\left[F(b)\right]}_{\text{cross-border adjustment factor}}$$

Thus, the cross-border adjustment factor is always positive in this case.

between sales and prices should be independent of population density along cooperating borders, defined as those in which both states participate in the same multi-state lottery.

5 Data and Empirical Framework

Since our hypotheses relate lottery sales to prices and the spatial distribution of the population, we combine data from three different sources. In order to focus on games in which we would expect significant cross-border shopping, we use sales data from Powerball and Mega Millions, the two lotteries with the largest jackpots. Our data on lottery sales were provided by La Fleur's and include weekly sales data from 1995 to 2008 separately by game and state. Note that states enter Powerball and Mega Millions at different points in time and thus the panel data are unbalanced in this case.

Data on the size of the jackpot by drawing in Mega Millions between its introduction on September 6, 1996 and the end of 2008 were downloaded from the Massachusetts Lottery website. Drawings in this game are held every Tuesday and Friday. Similar data on the size of the jackpot by drawing in Powerball were provided by the Multi-State Lottery Association and begin in 1992. Drawings for this game are held every Wednesday and Saturday. Both of these measures represent advertised jackpots, defined as the forecast of the jackpot that is communicated to potential players on the days leading up to the drawing.[17]

In order to measure prices, we have also collected data on the odds of winning the jackpot in both Powerball and Mega Millions. These odds have changed somewhat over our sample period, tending to become longer. In calculating prices, we also discounted the stream of payments associated with winning the jackpot since the advertised jackpot is not adjusted to reflect present value considerations. Finally, we incorporate federal taxes on lottery winnings under the assumption that winning the jackpot will put the taxpayer in the highest marginal tax bracket. The rate associated with this tax bracket has also increased somewhat over our sample period.

Since we have two observations per week on jackpots but only one observation on sales, we use the maximum jackpot during the week as our key measure. This follows the approach used by Kearney (2002a). We have also experimented with using the average jackpot, and our results are qualitatively similar to those presented here.

To measure the size of the population along state borders, we used spatial software and 2000 Census data.[18] We first compute the distance from the center of every census

[17] The actual jackpot will differ if actual sales during the days leading up to the drawing are not equal to projected sales.

[18] Ideally, we would measure population on an annual basis during our sample period 1995-2008. The

tract to every state border.[19] This then allows us to compute measures of the size of the population near the border for different definitions of proximity. We use three such measures of proximity, the number of residents within 25 kilometers of either side of the state border, the number within 50 kilometers of either side of the border, and the number within 100 kilometers of either side of the border. Assuming that travel occurs on highways at a rate of 65 miles per hour and that retail stores are available directly on the border, these distances represent one-way travel times of 14, 28, and 56 minutes, respectively. While these distances do represent significant travel times, we have found accounts of some individuals travelling well in excess of these three assumed distances in order to purchase lottery tickets.[20]

As noted above, there are three types of borders. For a state selling Powerball tickets, for example, there are potential borders with states also selling Powerball tickets (cooperating), with states selling Mega Millions tickets (competing), and with states selling neither type of ticket (neither). We expect the responsiveness of sales in a given state to the price of the affiliated lottery to depend upon the population along both sides of the border with a competing lottery and along the foreign side of the border for states with neither lottery. We refer to this combined population divided by state population as the inflow ratio. We expect the responsiveness of sales in a given state to the price of the rival lottery to depend upon the population along both sides of the border with a competing lottery. We refer to this population measure divided by state population as the outflow ratio.[21] Thus, the difference between the inflow and the outflow ratios is due to borders with states that participate in neither Powerball nor Mega Millions. Note that the inflow and the outflow ratios will necessarily change as states enter and exit multi-state games, and we thus calculate these for each of the 21 combinations of multi-state game members, as shown in Table 1, between 1995 and 2008.

Census Bureau releases annual population estimates for each state and county. These estimates, however, are not provided for smaller census areas, such as zip codes, census tracts, block groups, and blocks. Note that our key spatial measures, the inflow and outflow ratios, are based upon the size of the population living near borders divided by the number of state residents. Thus, these measures are unaffected by population growth so long as the growth is similar in both non-border and border regions.

[19] More specifically, we discretize every state border into 2,500 points and then calculate the great circle distance from the census tract centroid to the closest border point.

[20] On the lottery blog http://www.lotterypost.com/topic/196525 (accessed October 28, 2009), an individual reports traveling from Dallas, Texas to Shreveport, Louisiana, a distance of 301 kilometers, in order to purchase Powerball tickets.

[21] We calculate these populations as follows. For the domestic population in a given state, say x, we simply compute the minimum distance to a Powerball or Mega Millions state, which could be zero for affiliated states, and then determine whether or not this is below the cutoff distance. For every tract in states other than x, we first determine whether state x is the closest Powerball or Mega Millions state to that tract, and, if so, whether the distance is below the cutoff. We also record the lottery status (Mega Millions, Powerball, or neither) of the state in which the tract is located.

Using these measures of sales, prices, inflow ratios, and outflow ratios, we estimate regressions of the following form:

$$\ln(r_{st}) = \beta_1 \pi_{st}^{AFF} + \beta_2 \pi_{st}^{RIV} + \beta_3 \lambda_{st}^{IN} + \beta_4 \lambda_{st}^{OUT} + \beta_5 \lambda_{st}^{IN} \times \pi_{st}^{AFF} + \beta_6 \lambda_{st}^{OUT} \times \pi_{st}^{RIV} + \alpha_s + \alpha_t + u_{st}$$

where t indexes time, α_s and α_t represent state and time fixed effects, and u_{st} represents unobserved determinants of sales in state s in time t.[22] The variable π_{st}^{AFF} reflects prices for the affiliated lottery (e.g., Powerball prices for Powerball states) and π_{st}^{RIV} reflects the price of the rival lottery (e.g., Mega Millions prices for Powerball states). Finally, as motivated by the theoretical model, λ_{st}^{IN} is the inflow ratio, as defined above, and λ_{st}^{OUT} is the outflow ratio.

Our identification strategy is thus based upon cross-state differences in the response of sales to prices. The parameters β_1 and β_2 capture the part of the response of sales to affiliated and rival prices that is common across all states.[23] Similarly, the parameters β_3 and β_4 capture any relationships between sales and the spatial distribution of the population that are independent of variation in prices.[24] Finally, the key parameters β_5 and β_6 capture differences in the responsiveness of sales to prices according to state population and the spatial distribution of the population near state borders. In particular, according to our hypotheses regarding the effect of border density on the relationship between sales and jackpots, we expect that $\beta_5 < 0$ and $\beta_6 > 0$.

Table 2 provides summary statistics for our key measures. As shown, we have a large sample size, with 22,960 observations, where the unit of observation is the week-state. There is significant variation in prices over time, averaging around 83 cents and ranging from negative to prices that are close to 1. This variation is in turn driven largely by variation in jackpots, which range in our sample from \$2 million to \$390 million. There is also significant variation in the inflow and outflow ratios, averaging 0.675 and 0.543 respectively and ranging from 0 to 6.235 in the case of Washington, D.C. for the 25-kilometer definition. Washington, D.C. turns out to be a significant outlier in this dimension with no other states having a value in excess of 2. Given this, we exclude Washington, D.C. from the baseline analysis but, as a robustness check, do report results including Washington, D.C. in Table 5.

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[22] Since states often use different definitions of a week in the La Fleur's data, we incorporate monthly, rather than weekly, time fixed effects. Some states may report sales on a Saturday-Friday basis, for example, whereas others may report sales on a Monday-Sunday basis.

[23] In addition to the parameter β_1 capturing the intensive margin discussed in the theoretical model above, it also captures the decision to not play the lottery, a margin that was not incorporated into our theoretical model.

[24] For example, if small states with densely populated borders tend to build casinos along borders, then the effect of this factor on sales will be incorporated into these measures λ_{st}^{IN} and λ_{st}^{OUT}.

6 Results

In this section, we first provide graphical evidence supporting our main hypothesis. We then turn to the baseline regression results and present a variety of alternative specifications. Finally, we provide a policy simulation regarding the change in sales were both Powerball and Mega Millions tickets to be sold in all states.

We first provide a graphical analysis that is designed to highlight our identification strategy. In particular, Figures 2 and 3 depict the relationship between Powerball sales in Delaware and Rhode Island, respectively, and prices in the affiliated game of Powerball before and after Pennsylvania's entry into Powerball in 2002. Pennsylvania has a large population located near Delaware's border: the northern part of Delaware is included in the definition of the Philadelphia MSA, and the city center of Philadelphia is less than 25 miles from the Delaware border. Thus, in addition to having a small population, Delaware also has densely populated border regions.[25] The state of Rhode Island also has a small number of residents and densely populated areas near the border with Massachusetts, a state that participates in Mega Millions and thus did not enter Powerball during this period. Given that Rhode Island does not border Pennsylvania, we thus expect sales to be more responsive to prices in Delaware prior to Pennsylvania's entry into Powerball when compared to a similar relationship between sales and prices in Rhode Island.

As shown in Figure 2, the relationship between sales and prices was indeed very strong in Delaware prior to the entry of Pennsylvania into Powerball. After Pennsylvania's entry, however, the spikes in sales when jackpots are high remain visible but these spikes are now much less pronounced. In Rhode Island, by contrast, the relationship between sales and prices, as depicted in Figure 3, remains fairly stable over this period. Thus, the graphical evidence supports our key hypothesis regarding the relationship between sales, prices of affiliated lotteries, and the size of the population along state borders.

6.1 Baseline Results

Table 3 presents results from our key regressions for border proximity definitions of 25 kilometers, 50 kilometers, and 100 kilometers. As shown in column 1, there is a strong response of sales to the price of the affiliated lottery when using the 25 kilometer measure. In particular, sales fall 230 percent when the price increases from zero to one. As expected, this effect is stronger in areas with high measures of the inflow ratio λ_{st}^{IN}. This supports our main

[25] Consistent with our hypothesis, lottery officials in Delaware were concerned that Pennsylvania's entry into Powerball would severely depress sales of Powerball tickets in Delaware (Philadelphia Inquirer, December 19, 2001).

hypothesis regarding the relationship between sales and affiliated prices.

To provide a sense of the quantitative magnitude of these effects, consider a reduction in the price of the affiliated lottery of one standard deviation, or 16 cents. In cases with no border pressure, such as Powerball sales in North Dakota, whose neighbors are all currently participating in Powerball, sales are predicted to rise by 37 percent. In the opposite extreme, consider the case of Rhode Island, which has an inflow ratio of 1.72. In this case, our model predicts that sales rise by a significantly larger 47 percent. Expressed in terms of elasticities, the affiliated price elasticity is 2.78 in North Dakota and 3.53 in Rhode Island.[26]

Returning to column 1, the coefficient on the interaction between the price of the rival lottery and the outflow ratio is positive and statistically significant at conventional levels. Thus, these results also support the key prediction that the relationship between sales and the price of the rival lottery is stronger in states with small populations and densely populated border regions. This effect, however, is somewhat weaker in magnitude than the relationship between sales and affiliated prices.

As further evidence regarding the magnitude of these effects, we present results from a counterfactual experiment in Table 4. Using the membership of states in multi-state games between June 2006 and December 2008, the final month of our sample, we predict the fraction of sales in each state due to cross-border shopping. In particular, we set both the inflow and the outflow ratios to zero for each state and predict what sales would have been in the absence of cross-border shopping. We then compare this to the sales predicted by our baseline model, and the difference between these two measures over time reflects the fraction of sales due to cross-border shopping. Finally, we average this difference across weeks over the period June 2006-December 2008.

In principle, sales could be higher or lower in the absence of cross-border shopping since states benefit from the inflow of the population from nearby states but lose revenues from the outflow of residents to nearby states. As shown in Table 4, however, the former effect dominates, and sales are higher due to cross-border shopping in all states. While the boost to sales is small on average, there are significant differences across states. The increase in sales due to cross-border shopping is close to zero in large states with sparsely populated borders, such as California and Texas, and has a maximal value of 9 percent in Rhode Island. That is, sales in Rhode Island, a state with densely populated borders and a small number of residents, are 9 percent higher than what they would be in the absence of cross-border shopping.

[26] These elasticities are evaluated at the mean affiliated price of 83 cents.

6.2 Alternative specifications

Returning to Table 3, column 2 provides results using a somewhat more generous 50 kilometer border proximity definition. As shown, the key coefficients are similar in magnitude. Again, considering a 16 cent decrease in the price of the affiliated lottery, Powerball sales in North Dakota are predicted to rise by 37 percent, whereas in Rhode Island, which at 50 kilometers has an inflow ratio of 3.22, sales are predicted to rise by 46 percent. The similarity of these predictions to those associated with the results using the 25 kilometer measure suggests that our results are robust to different distance measures. Again, the coefficient on the interaction between the price of the other lottery and the outflow ratio has the expected positive sign. The rival price effect is again weaker in magnitude than the affiliated price effect. Column 3 presents results using a border proximity definition of 100 kilometers, and the coefficients again have the expected signs. Considering the hypothetical 16 cent decrease in the price of the affiliated lottery, Powerball sales in North Dakota are predicted to rise by 36 percent, whereas in Rhode Island, which at 100 kilometers has an inflow ratio of 3.49, sales are predicted to rise by 44 percent.

Comparing across the three specifications in Table 3, the coefficient on the price of the affiliated lottery is quite stable. The two coefficients on the key interactions between prices and the key ratios, by contrast, have the expected downward pattern. By measuring the geographic area near the border in a more liberal manner, the fraction of residents in these areas who are willing to cross the border in order to purchase lottery tickets will necessarily fall. That is, those within 25 kilometers of the border may be more willing to travel than those between 50 and 100 kilometers, and this difference would explain the downward pattern in these key coefficients. This also helps to explain why the magnitudes of the changes in sales associated with the hypothetical one standard deviation price reductions are similar across the three specifications.

In Table 5, we present results including Washington, D.C., which as noted above, is a significant outlier. As shown, the coefficients on the key interaction terms are somewhat weaker in magnitude, and the key coefficient on the interaction between the price of the affiliated lottery and the inflow ratio is now statistically insignificant for the 25 kilometer measure at conventional levels. The other five key coefficients, however, remain statistically significant at conventional levels. Also, the key coefficients display the same downward pattern when moving to more generous border definitions.

Our interpretation of the baseline results in Table 3 is that individuals living near borders respond to prices when deciding between playing the home-state lottery and crossing the border and purchasing tickets in neighboring states. An alternative interpretation is that residents of small states with densely populated border regions, relative to residents of other states, are more responsive to prices for reasons unrelated to cross-border shopping. When prices are low, residents of these small states with densely populated borders may be more likely, for example, to play the lottery (as opposed to not purchasing any tickets) or to purchase more tickets.

To address this alternative interpretation, we next provide results from a placebo test in which we examine border regions between cooperating states. As noted in our theoretical model, there is no incentive to cross borders between two states participating in the same multi-state lottery game. Thus, in these cases, we would not expect the size of border populations, relative to the number of residents, to affect the price responsiveness of sales. Under the alternative interpretation outlined above, however, we would expect the size of border populations, relative to the number of residents, to affect the price responsiveness of sales.

As shown in Table 6, these measures indeed have no explanatory power, as the coefficient on the interaction between the cooperating ratio and the price of the affiliated lottery is small and statistically insignificant in all three measures of border regions (within 25 kilometers of the border, within 50 kilometers, and within 100 kilometers). In addition, after controlling for these measures of the cooperating ratio, the key coefficients on the interactions between affiliated prices and the inflow ratio and between rival prices and the outflow ratio are similar to those in Table 3. Thus, this placebo test also supports our hypotheses related to cross-border shopping.

In Table 7, we examine an alternative measure of the attractiveness of lottery games, the jackpot. Cook and Clotfelter (1993) argue that players may respond more to the jackpot than to the odds. If players do condition only on the jackpot, then our price measure may be noisy since it also includes information on odds, which change during our sample period. Given this, we thus present results using the jackpot as a key explanatory variable. As shown, we find that players do respond strongly to the jackpot. A one standard deviation, or \$57 million, increase in the jackpot of the affiliated lottery is associated with an increase in sales of 36 percent in North Dakota, and this effect is again much stronger in states with large inflow ratios. In Rhode Island, for example, a one standard deviation, or \$57 million, increase in the lottery is associated with an increase in sales of 50 percent.

We next relax the assumption that non-residents from states with a competing lottery are as responsive to prices as non-residents from states with neither Powerball nor Mega Millions. In particular, we separate the inflow ratio into two pieces, the competing ratio, which includes in the numerator only those individuals on both sides of the border with competing games, and the neither ratio, which includes in the numerator only those individuals on the foreign side of the border with states participating in neither Powerball nor Mega Millions. Note that the competing ratio is identical to our definition of the outflow ratio since the latter also excludes borders with neighboring states that have neither Powerball nor Mega Millions. As shown in Table 8, the coefficients on the interactions between the competing ratio and the price of the affiliated lottery and between the competing ratio and the price of the rival lottery are similar to the corresponding coefficients in Table 3. The coefficient on the interaction between the neither ratio and the price of the affiliated lottery, by contrast, is much larger in magnitude than the coefficient on the competing ratio. Thus, residents from states that participate in neither Powerball nor Mega Millions but who live close to borders of participating states are quite responsive to prices. Again, all three sets of coefficients are decreasing in magnitude as the definition of distance increases.

Finally, in Table 9, we present results using a linear, rather than logarithmic, measure of sales per capita. As shown, the coefficients on the price of the affiliated lottery and its interaction with the inflow ratio have the expected negative signs. The coefficient on the interaction between the price of the rival lottery and the outflow ratio, however, has the expected positive sign only in column 1 and is statistically insignificant across all three specifications.

6.3 Policy simulation

As noted above, these two key multi-state games, Powerball and Mega Millions, are expected to begin cross-selling their products in 2010, and we next use our analysis to predict the level of sales under this counterfactual scenario. Sales in our theoretical model have a simple form in this case since consumers would have no incentive to cross borders in order to purchase tickets. In particular, the two games become perfect substitutes, and players thus purchase tickets from the game with the lower price. Under the assumption that these tickets are available in all fifty states, sales, in the context of our empirical specification, are predicted to have the following form:

$$\ln(r_{st}) = \beta_1 \min(\pi_{st}^{RIV}, \pi_{st}^{AFF}) + \alpha_s + \alpha_t + u_{st}$$

There are two offsetting effects associated with this change, and thus sales could either increase or decrease following the cross-selling arrangement. On the one hand, state revenues will increase due to the fact that residents can choose to purchase tickets from the game with lower prices. On the other hand, state revenues will tend to fall, since, as shown in Table 4, cross-border shopping tends to increase sales in all states, and, as noted above, the cross-selling of Powerball and Mega Millions tickets will eliminate incentives to cross borders in order to purchase lottery tickets.

As shown in Table 10, the former effect dominates as we predict that sales would rise by a large percentage in all states. The variation in this increase is significant, ranging from 10 percent in Delaware and 11 percent in Rhode Island to 21 percent in Michigan. The lower predicted increases in these small densely populated states reflect the fact that both games were already more easily accessible in these states and their bordering states since travel distances are relatively short. Thus, having both sets of tickets sold in every state represents a less dramatic change in these states.

There are two important caveats associated with this policy simulation. First, our analysis does not account for the fact that multiple winners would be more common in this counterfactual scenario since sales would be significantly boosted. Increased prevalence of multiple winners would tend to increase prices and, if players account for multiple winners when making lottery choices, thus dampen these predicted increases in sales. Second, and perhaps more importantly, our analysis assumes that jackpots would be unchanged over this period. With all players purchasing tickets for the game with the lower price, one jackpot would tend to rise briskly until a winning ticket is purchased. The other jackpot, by contrast, would remain at low levels during this period. Given this, our results can best be interpreted as the short-run effects associated with the cross-selling of Powerball and Mega Millions tickets. An investigation of the long-run effects of this agreement would require a simulation of the dynamics of jackpots in this counterfactual scenario.

7 Conclusion

This paper has investigated competition between state lotteries with a specific focus on competitive forces associated with cross-border shopping. Our theoretical model predicts, and the empirical analysis confirms, that if cross-border shopping is significant, the relationship between sales and prices should be stronger in states with small populations and densely populated border regions. The magnitude of the estimated effects is large in general, suggesting that states do face significant competitive pressures from neighboring states. The effects also vary significantly across regions, with much stronger effects in small states with densely populated border regions.

The findings have important implications for the recent agreement to sell Powerball and Mega Millions tickets in the 42 states currently selling tickets for one of the two games. First, subject to the two important caveats discussed above, our policy simulations suggest that sales in all states will rise significantly following this cross-selling since consumers have access to a greater variety of products. Second, our findings suggest that this cooperation may reduce the competitive pressures facing states since consumers will no longer have incentives to cross borders in order to purchase tickets. If states respond to these competitive pressures when setting prices, as documented by Brown and Rork (2005), this agreement may lead to even higher prices and lower payout rates for consumers.

These findings also have broader implications for state taxation of lottery tickets and related products. The findings are consistent with the view that consumers have a limited budget for gambling, and the offering of new products may reduce sales of related products. In particular, the introduction of lotteries in new states may reduce sales in neighboring states. Under the additional assumption that these results apply to other forms of gambling, the introduction of new casinos, which have been recently proposed in many cash-strapped states, may reduce casino revenues in neighboring states or even reduce lottery sales within the state borders.

Even more generally, our results have important implications for the taxation of other products with low transportation costs and significant variation in tax burdens across states. As noted in the literature review, this set of products includes gasoline, cigarettes, and alcohol. In these cases, our analysis suggests that tax bases are linked across states and thus changes in tax rates in one state may affect tax revenues in neighboring states.

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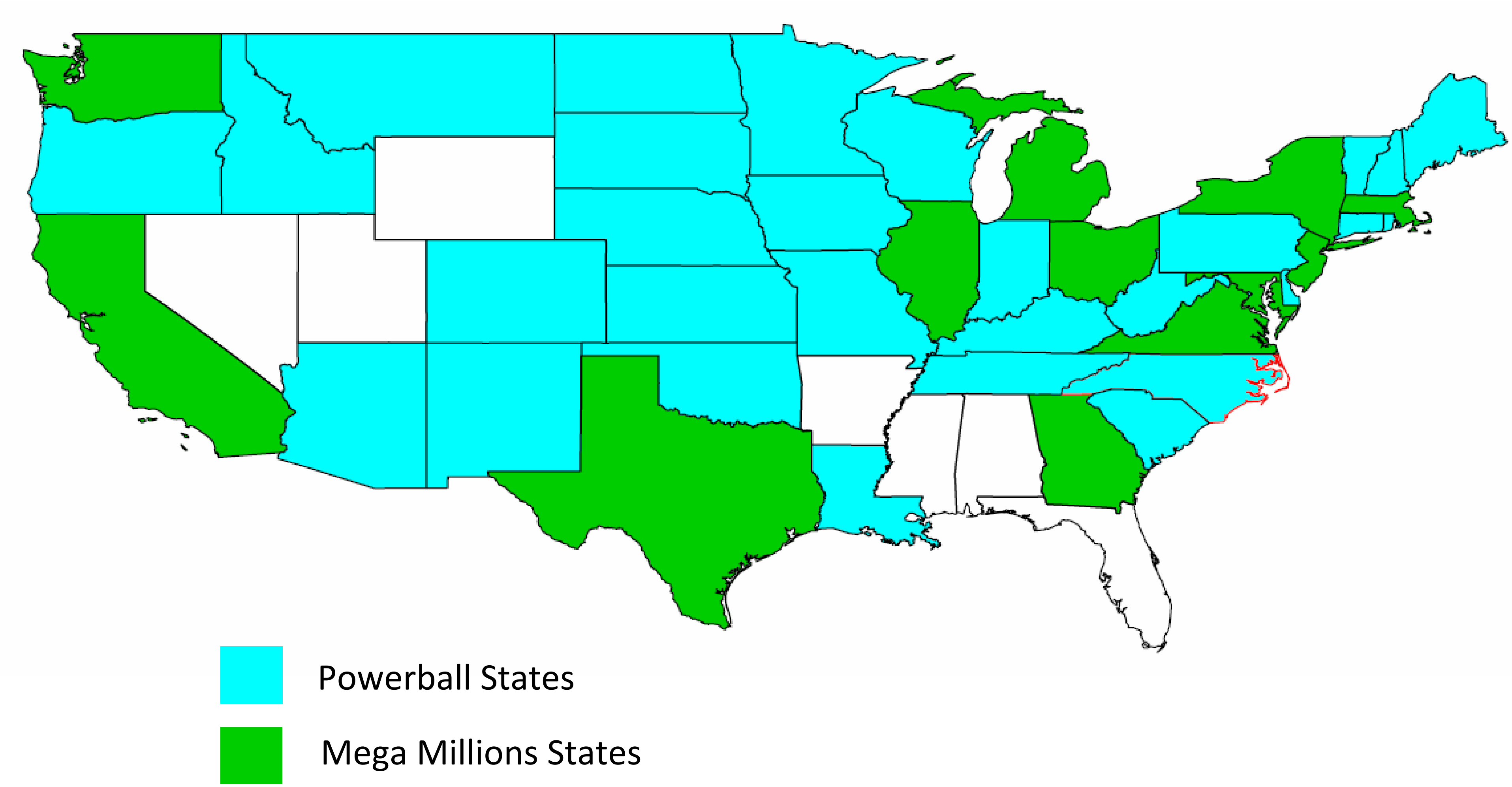
Figure 1: Powerball and Mega Millions states as of 12/31/2008



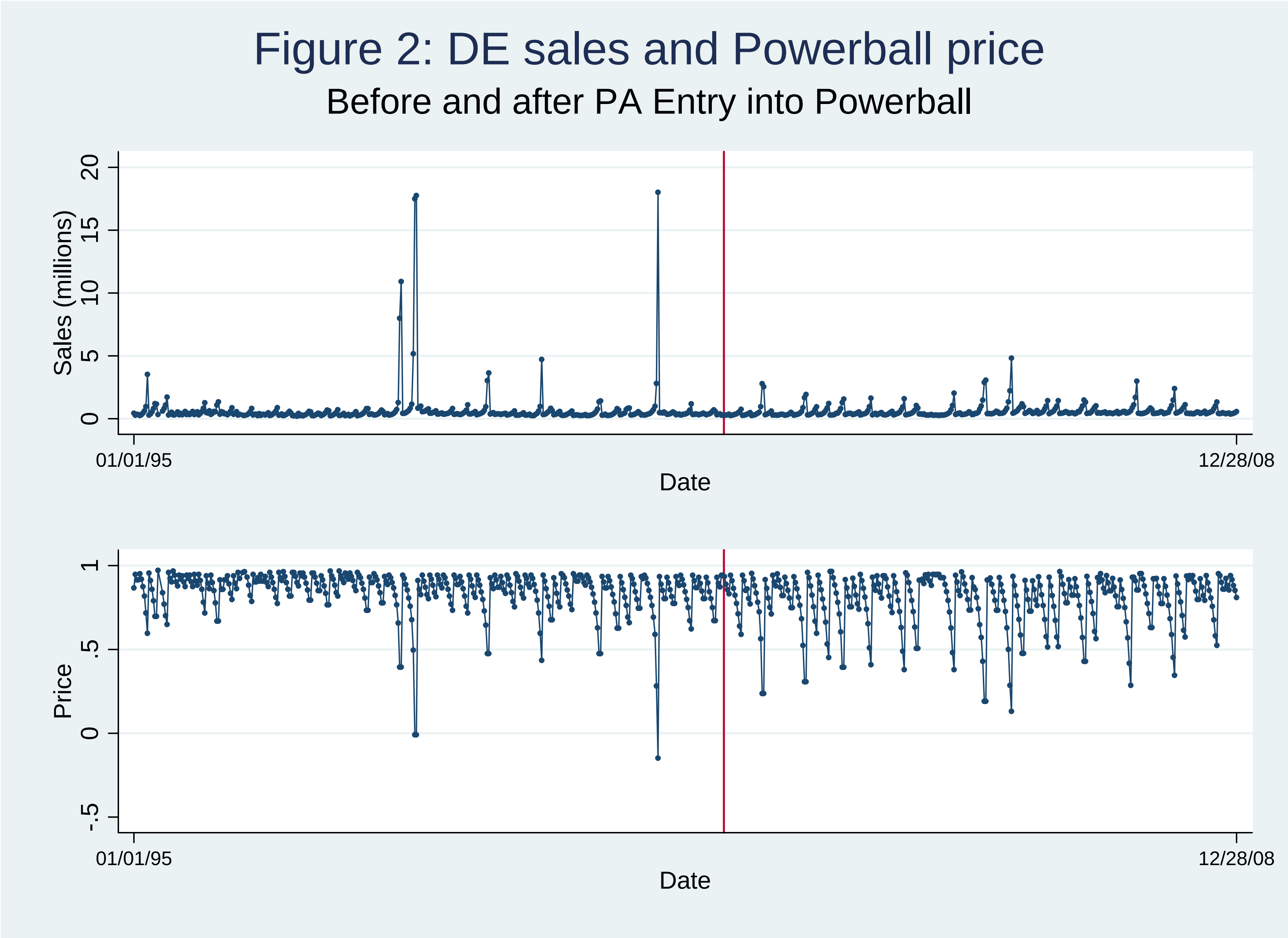


Figure 2: DE sales and Powerball price
Before and after PA Entry into Powerball
Sales (millions)
0
5
10
15
20
01/01/95
12/28/08
Date
Price
-.5
0
.5
1
01/01/95
12/28/08
Date

Figure 3: RI sales and Powerball price

Before and after PA Entry into Powerball

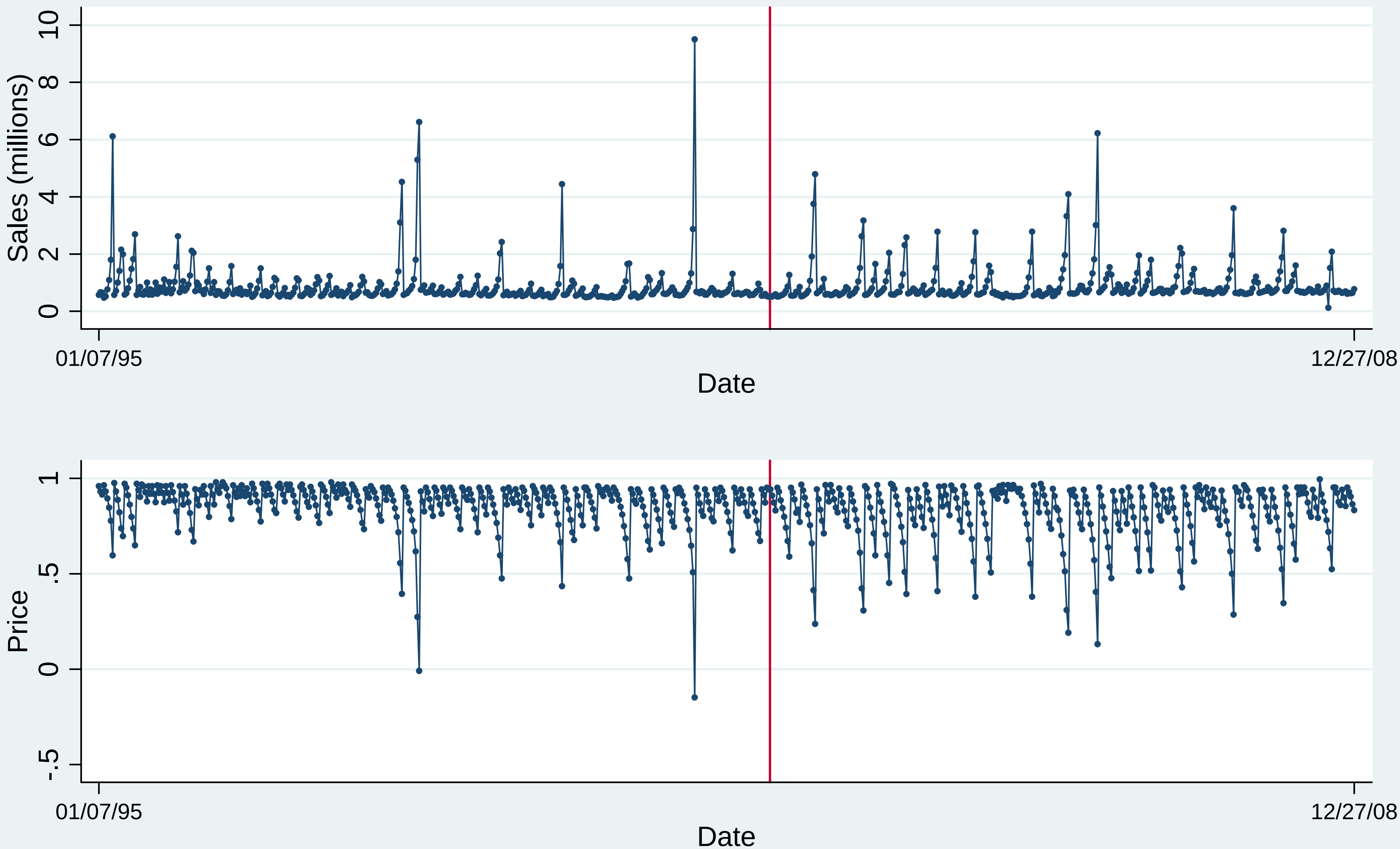


Table 1: Date of Entry into Powerball (P) and Mega Millions (M) by State

Date	1/1/1995	3/5/1995	7/1/1995	11/5/1995	11/28/1995	8/31/1996	10/20/1996	5/27/1999	8/2/2001	5/15/2002	6/27/2002	9/1/2002	10/6/2002	6/29/2003	11/30/2003	3/25/2004	4/18/2004	7/31/2004	6/19/2005	1/12/2006	5/28/2006
AZ	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
CA																			M	M	M
CO									P	P	P	P	P	P	P	P	P	P	P	P	P
CT					P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
DE	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
DC	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
GA			P	P	P	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
ID	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
IL						M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
IN	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
IA	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
KS	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
KY	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
LA		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
ME																		P	P	P	P
MD						M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
MA						M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
MI						M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
MN	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
MO	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
MT	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
NE	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
NH				P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
NJ								M	M	M	M	M	M	M	M	M	M	M	M	M	M
NM							P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
NY										M	M	M	M	M	M	M	M	M	M	M	M
NC																					P
ND																P	P	P	P	P	P
OH										M	M	M	M	M	M	M	M	M	M	M	M
OK																				P	P
OR	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
PA											P	P	P	P	P	P	P	P	P	P	P
RI	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
SC													P	P	P	P	P	P	P	P	P
SD	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
TN																	P	P	P	P	P
TX															M	M	M	M	M	M	M
VT														P	P	P	P	P	P	P	P
VA						M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
WA												M	M	M	M	M	M	M	M	M	M
WV	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
WI	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P

Table 2: Summary Statistics						
Variable	*Distance (km)*	Obs	Mean	Std. Dev.	Min	Max
ln(salespc)		22960	-1.042	0.606	-3.970	3.135
affiliated price		22960	0.827	0.157	-0.768	0.995
rival price		22960	0.827	0.180	-0.768	1.000
inflow ratio	*25*	22960	0.675	1.118	0.000	6.235
inflow ratio	*50*	22960	1.324	1.959	0.000	9.474
inflow ratio	*100*	22960	1.872	2.540	0.000	12.383
outflow ratio	*25*	22960	0.543	1.063	0.000	6.235
outflow ratio	*50*	22960	0.986	1.717	0.000	9.474
outflow ratio	*100*	22960	1.277	1.975	0.000	11.507
cooperating ratio	*25*	22960	0.271	0.314	0.000	1.653
cooperating ratio	*50*	22960	0.444	0.578	0.000	4.147
cooperating ratio	*100*	22960	0.789	0.992	0.000	7.216
competing ratio	*25*	22960	0.543	1.063	0.000	6.235
competing ratio	*50*	22960	0.986	1.717	0.000	9.474
competing ratio	*100*	22960	1.277	1.975	0.000	11.507
neither ratio	*25*	22960	0.132	0.419	0.000	5.235
neither ratio	*50*	22960	0.338	1.000	0.000	8.474
neither ratio	*100*	22960	0.595	1.593	0.000	11.383
affiliated jackpot (b)		22960	57.593	56.802	2.000	390.000
rival jackpot (b)		22960	56.112	61.040	0.000	390.000

Notes: Sample includes DC. Inflow ratio is the size of the population near borders with competing states plus the size of the foreign population near borders with non-lottery states divided by the number of residents. Outflow ratio is the size of the population near borders with competing states divided by the number of residents. Cooperating ratio is the size of the population near borders with cooperating states divided by the number of residents. Competing ratio is the size of the population near borders with competing states divided by the number of residents. Neither ratio is the size of the foreign population near borders with non-lottery states divided by the number of residents.

Table 3: Baseline measures of cross-border shopping			
VARIABLES	ln(salespc) *(dist=25km)*	ln(salespc) *(dist=50km)*	ln(salespc) *(dist=100km)*
affiliated price	-2.298***	-2.303***	-2.280***
	[0.073]	[0.062]	[0.059]
rival price	-0.037***	-0.029**	-0.031**
	[0.012]	[0.011]	[0.011]
inflow ratio	0.433***	0.199***	0.140***
	[0.137]	[0.029]	[0.016]
outflow ratio	-0.125*	-0.032	-0.028
	[0.067]	[0.020]	[0.018]
affiliated price*inflow ratio	-0.368***	-0.177***	-0.135***
	[0.100]	[0.034]	[0.017]
rival price*outflow ratio	0.055***	0.019**	0.015**
	[0.013]	[0.007]	[0.006]
month by year fixed effects	YES	YES	YES
Observations	22231	22231	22231
R-squared	0.884	0.885	0.886

*Notes: Sample excludes DC. Robust standard errors in brackets, clustered by state (40 clusters). *** p<0.01, ** p<0.05, * p<0.1. Inflow ratio is the size of the population near borders with competing states plus the size of the foreign population near borders with non-lottery states divided by the number of residents. Outflow ratio is the size of the population near borders with competing states divided by the number of residents.*

Table 4: Percent change in sales per capita from border shopping			
state	Δsalespc	state	Δsalespc
AZ	0.76%	NC	0.64%
CA	0.23%	ND	0.00%
CO	0.23%	NE	0.11%
CT	6.02%	NH	6.13%
DE	7.78%	NJ	3.75%
GA	2.12%	NM	1.99%
IA	1.14%	NY	1.18%
ID	2.02%	OH	1.83%
IL	3.32%	OK	1.73%
IN	4.20%	OR	2.93%
KS	0.00%	PA	3.91%
KY	2.51%	RI	8.54%
LA	1.55%	SC	1.56%
MA	3.69%	SD	0.10%
MD	3.85%	TX	0.47%
ME	0.00%	VA	2.67%
MI	0.48%	VT	4.69%
MN	0.00%	WA	2.01%
MO	3.05%	WI	1.28%
MT	0.31%	WV	4.93%

Note: Sample excludes DC, calculations for 25km distance.

Table 5: Measures of cross-border shopping (including DC)

VARIABLES	ln(salespc) *(dist=25km)*	ln(salespc) *(dist=50km)*	ln(salespc) *(dist=100km)*
affiliated price	-2.431***	-2.386***	-2.347***
	[0.065]	[0.069]	[0.072]
rival price	-0.030***	-0.029***	-0.031***
	[0.009]	[0.010]	[0.010]
inflow ratio	0.190*	0.124***	0.099***
	[0.099]	[0.038]	[0.028]
outflow ratio	-0.091***	-0.037***	-0.027**
	[0.023]	[0.014]	[0.010]
affiliated price*inflow ratio	-0.093	-0.086*	-0.084**
	[0.068]	[0.048]	[0.036]
rival price*outflow ratio	0.028***	0.015***	0.013***
	[0.008]	[0.004]	[0.003]
month by year fixed effects	YES	YES	YES
Observations (includes DC)	22960	22960	22960
R-squared	0.892	0.893	0.894

*Notes: Sample includes DC. Robust standard errors in brackets, clustered by state (40 clusters). *** p<0.01, ** p<0.05, * p<0.1. Inflow ratio is the size of the population near borders with competing states plus the size of the foreign population near borders with non-lottery states divided by the number of residents. Outflow ratio is the size of the population near borders with competing states divided by the number of residents.*

Table 6: Measures of cross-border shopping including cooperating borders

VARIABLES	ln(salespc) *(dist=25km)*	ln(salespc) *(dist=50km)*	ln(salespc) *(dist=100km)*
affiliated price	-2.307***	-2.305***	-2.294***
	[0.073]	[0.062]	[0.065]
rival price	-0.037***	-0.029**	-0.033***
	[0.012]	[0.011]	[0.011]
inflow ratio	0.533**	0.151	0.037
	[0.201]	[0.097]	[0.063]
outflow ratio	-0.171	-0.025	-0.037***
	[0.104]	[0.024]	[0.013]
cooperating ratio	0.060	-0.066	-0.162*
	[0.311]	[0.150]	[0.092]
affiliated price*inflow ratio	-0.372***	-0.176***	-0.133***
	[0.102]	[0.034]	[0.017]
rival price*outflow ratio	0.054***	0.019***	0.017***
	[0.012]	[0.007]	[0.006]
affiliated price*cooperating ratio	0.043	0.004	0.016
	[0.161]	[0.047]	[0.026]
month by year fixed effects	YES	YES	YES
Notes: Sample excludes DC	22231	22231	22231
R-squared	0.884	0.885	0.887

*Notes: Sample excludes DC. Robust standard errors in brackets, clustered by state (40 clusters). *** p<0.01, ** p<0.05, * p<0.1. Inflow ratio is the size of the population near borders with competing states plus the size of the foreign population near borders with non-lottery states divided by the number of residents. Outflow ratio is the size of the population near borders with competing states divided by the number of residents. Cooperating ratio is the size of the population near borders with cooperating states divided by the number of residents.*

Table 7: Measures of cross-border shopping using jackpot sizes

VARIABLES	ln(salespc) *(dist=25km)*	ln(salespc) *(dist=50km)*	ln(salespc) *(dist=100km)*
affiliated jackpot	6.446***	6.503***	6.311***
	[0.268]	[0.240]	[0.224]
rival jackpot	0.033	-0.029	-0.018
	[0.092]	[0.083]	[0.092]
inflow ratio	0.094	0.028*	0.006
	[0.061]	[0.016]	[0.007]
outflow ratio	-0.086	-0.020	-0.019
	[0.052]	[0.014]	[0.013]
affiliated jackpot*inflow ratio	1.414***	0.640***	0.585***
	[0.429]	[0.187]	[0.110]
rival jackpot*outflow ratio	-0.277*	-0.069	-0.059
	[0.164]	[0.081]	[0.069]
month by year fixed effects	YES	YES	YES
Observations	22231	22231	22231
R-squared	0.862	0.863	0.865

*Notes: Sample excludes DC. Robust standard errors in brackets, clustered by state (40 clusters). *** p<0.01, ** p<0.05, * p<0.1. Inflow ratio is the size of the population near borders with competing states plus the size of the foreign population near borders with non-lottery states divided by the number of residents. Outflow ratio is the size of the population near borders with competing states divided by the number of residents.*

Table 8: Measures of cross-border shopping, separating competing and neither populations			
VARIABLES	ln(salespc) *(dist=25km)*	ln(salespc) *(dist=50km)*	ln(salespc) *(dist=100km)*
affiliated price	-2.315***	-2.330***	-2.318***
	[0.030]	[0.029]	[0.030]
rival price	-0.039***	-0.029***	-0.030***
	[0.012]	[0.011]	[0.011]
competing ratio	0.197***	0.099***	0.060***
	[0.038]	[0.013]	[0.012]
neither ratio	0.681***	0.321***	0.191***
	[0.139]	[0.024]	[0.013]
affiliated price*competing ratio	-0.248***	-0.097***	-0.074***
	[0.039]	[0.015]	[0.013]
rival price*competing ratio	0.054***	0.018***	0.015***
	[0.015]	[0.006]	[0.005]
affiliated price*neither ratio	-0.671***	-0.321***	-0.195***
	[0.162]	[0.028]	[0.015]
month by year fixed effects	YES	YES	YES
Observations	22231	22231	22231
R-squared	0.884	0.886	0.886

*Notes: Sample excludes DC. Robust standard errors in brackets, clustered by state (40 clusters). *** p<0.01, ** p<0.05, * p<0.1. Competing ratio is the size of the population near borders with competing states divided by the number of residents. Neither ratio is the size of the foreign population near borders with non-lottery states divided by the number of residents.*

Table 9: Robustness check using sales per capita

VARIABLES	salespc *(dist=25km)*	salespc *(dist=50km)*	salespc *(dist=100km)*
affiliated price	-0.802***	-0.976***	-0.840***
	[0.254]	[0.237]	[0.184]
rival price	-0.109***	-0.091***	-0.086***
	[0.031]	[0.025]	[0.022]
inflow ratio	2.206***	0.920***	0.695***
	[0.556]	[0.259]	[0.131]
outflow ratio	-0.171**	-0.067**	-0.055***
	[0.074]	[0.027]	[0.020]
affiliated price*inflow ratio	-2.392***	-1.007***	-0.773***
	[0.581]	[0.302]	[0.152]
rival price*outflow ratio	0.005	-0.008	-0.013
	[0.022]	[0.008]	[0.010]
month by year fixed effects	YES	YES	YES
Observations	22231	22231	22231
R-squared	0.658	0.667	0.696

*Notes: Sample excludes DC. Robust standard errors in brackets, clustered by state (40 clusters). *** p<0.01, ** p<0.05, * p<0.1. Inflow ratio is the size of the population near borders with competing states plus the size of the foreign population near borders with non-lottery states divided by the number of residents. Outflow ratio is the size of the population near borders with competing states divided by the number of residents.*

Table 10: Predicted percent change in sales from Powerball/Mega Millions cross-selling			
state	Δsalespc	state	Δsalespc
AZ	18.71%	NC	18.82%
CA	18.39%	ND	19.85%
CO	19.23%	NE	19.35%
CT	13.45%	NH	13.33%
DE	9.57%	NJ	15.32%
GA	16.51%	NM	17.47%
IA	18.32%	NY	17.44%
ID	17.44%	OH	16.79%
IL	18.17%	OK	17.73%
IN	15.26%	OR	16.53%
KS	19.46%	PA	13.44%
KY	16.95%	RI	10.92%
LA	17.91%	SC	15.80%
MA	14.94%	SD	17.81%
MD	17.65%	TX	18.15%
ME	19.46%	VA	15.96%
MI	21.01%	VT	14.77%
MN	17.35%	WA	16.61%
MO	16.42%	WI	18.19%
MT	19.65%	WV	14.54%

Note: Sample excludes DC, calculations for 25km distance.