The Effect of Casino Proximity on Lottery Sales: Evidence from Maryland

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Abstract: The continued expansion of the casino industry has caused increasing concern regarding the cannibalization of other industries, and in particular, state lotteries. For example, Maryland Lottery sales flattened shortly after casinos began opening in the state. Although previous papers have found that casinos and lotteries have a negative relationship with each other, no previous research has analyzed the impact of casino proximity on lottery sales or examined the relationship between casinos and different types of lottery games. In this paper, we examine ZIP code-level monthly lottery sales data from Maryland between July 2009 and February 2014, in order to test the impact of casino proximity on lottery sales, by type of game. Our findings indicate that aggregate lottery sales decline more in closer proximity to casinos, but that casinos affect different lottery products differently. We discuss the consumer behavior and public finance implications of the findings.

Keywords: Lottery, casinos, tax revenues, inter-industry competition, industry cannibalization

JEL Codes: H27, H4, L83

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1. Introduction

Legal gambling has been an important policy issue for state governments since New Hampshire introduced a lottery in 1964. Other states followed suit, and now only a few states do not have lotteries. Beginning in 1989 legal casinos began to spread outside Nevada and Atlantic City, NJ, and well over 1,000 casinos now operate in the United States.[1] For calendar 2015, U.S. casino revenues were estimated to be $73.3 billion; U.S. lottery sales in fiscal year 2015 were $73.8 billion.[2]

Gambling taxes can be significant sources of state government revenue, and tax revenues have been a primary motivation for the legalization of gambling. The effective lottery "tax" averages around 40%, after accounting for administrative expenses (Perez and Humphreys 2013). Commercial casino gross revenues are taxed at various rates, historically ranging from about 6% in Nevada up to nearly 70% in states such as Delaware, Maryland, New York, and Rhode Island (American Gaming Association 2013).[3]

As casino expansion continues across the United States, there is increasing concern that casino revenues may come at the expense of lottery sales (i.e., revenue "cannibalization"), raising questions about the net tax impacts of casino legalization. Although there have been analyses of the inter-industry relationships between casinos and lotteries, many of these studies were published at a time when casinos were relatively isolated.[4] Such casinos could attract large numbers of visitors from out-of-state, which likely mitigated any negative impacts these casinos may have had on a state's lottery. Nevertheless, later evidence still suggests that lotteries and casinos are generally substitutes (Walker and Jackson 2008). No published study to date has addressed the degree to which proximity to casinos impacts lottery sales, nor has any examined the relationship between casinos and specific types of lottery games. These issues are fundamental to understanding the net effects of legalizing or expanding casino gambling, and in particular the likely impact of new casinos on existing lotteries.

In this study, we use ZIP code-level monthly lottery sales data from the Maryland State Lottery and Gaming Control Agency to analyze the impact of casino proximity on the sales of different types of lottery products. Our analysis focuses on Maryland, where the first casino began operating in September 2010. We examine the impact of casinos on lottery sales using

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[1] A casino listing by state is available at www.casinocity.com or in American Gaming Association (2016). For an analysis of the factors affecting lottery adoptions, see Alm, McKee, and Skidmore (1993) or Jackson, Saurman, and Shughart (1994); for a similar analysis of commercial casinos, see Calcagno, Walker, and Jackson (2010).

[2] Aggregate casino revenue data are from www.statista.com. Historical annual estimates suggest that 60% of revenues come from state-regulated commercial casinos, while around 40% come from tribal casinos. Lottery sales data are from the North American Association of State and Provincial Lotteries, at www.naspl.org/nasplmembers/.

[3] The Delaware and New York "tax" rates include allocations to horsemen's purses at those states' race track casinos (http://www.ncsl.org/research/financial-services-and-commerce/casino-tax-and-expenditures-2013.aspx; New York Office of Budget and Policy Analysis (2014)); Maryland (as of the date of this study) and Rhode Island also owned the slot machines employed at their casinos, thereby absorbing some of the costs of casino operations.

[4] For example, see Siegel and Anders (2001); Elliott and Navin (2002), and Fink and Rork (2003), all of which are discussed in the next section.

lottery sales data from July 2009 through February 2014. Our findings suggest that casinos have had a significant negative impact on Maryland's lottery sales, and that the impact varies by lottery product. Furthermore, our results indicate that the impact of casinos on lottery sales is very sensitive to casino proximity.

This study provides important evidence on how two forms of gambling affect each other, which could be of great interest to policymakers in most states and in jurisdictions around the world. Furthermore, the analysis in this study could be adapted to analyze other markets, as the impacts of casinos on lotteries are likely to be sensitive to jurisdictional idiosyncrasies.

2. Background and literature review

With the continued expansion of casinos across the United States, there has been increasing concern that casinos may compete for revenue with state lotteries. If casinos attract revenues at the expense of lottery sales (i.e., if casinos "cannibalize" lottery revenues), then the actual net impact of casino tax revenue could fall short of policymakers' expectations and casino industry promises. There have been a number of studies in the literature which examine inter-industry relationships among gambling products. We review that literature, but first provide some background information on casinos and the lottery in Maryland – the focus of our empirical analysis.

Background on Maryland

The Maryland Lottery began in 1973, and by the mid-1990s, annual sales surpassed $1 billion per year. Casinos were legalized in Maryland in 2008, and the Hollywood Casino was the first to open in September of 2010 in Perryville. Five other casinos have opened since then: Ocean Downs (January 2011), Maryland Live (June 2012), Rocky Gap (May 2013), the Horseshoe (August 2014), and the MGM National Harbor (December 2016). These casinos initially provided only slot machines; table games were legalized at Maryland casinos in spring 2013. Figure 1 is a map of Maryland that shows the locations and opening dates of all six casinos in the state, as well as nearby casinos outside Maryland.[5]

Gambling in Maryland is regulated by the Maryland Lottery and Gaming Control Agency (hereafter referred to as "Maryland Lottery"), which operates the lottery and oversees the casinos in the state. Revenues the state receives from the lottery and casinos are pooled and distributed to a variety of programs. For example, in fiscal year 2015, the lottery contributed about $1 billion to "The Maryland Education Trust Fund; public health and safety; small-, minority- and women-owned businesses; horse racing; veterans' organizations; and more." About $525 million came from the lottery, and $487 million was raised from casino taxes.[6]

Aggregate casino revenues in the state have steadily climbed, of course, as new casinos opened. Nominal lottery sales growth, on the other hand, has been modest over the past two decades. Figure 2 illustrates nominal annual lottery sales in Maryland and some nearby states. Lottery sales in Maryland appear to be flat since fiscal year 2008, with a slight decline beginning

[5] See footnote 22 for more detail on casino opening dates in states adjacent to Maryland.

[6] http://mlgca.com/where-the-money-goes/

Figure 1. Map of casino locations in Maryland and surrounding states

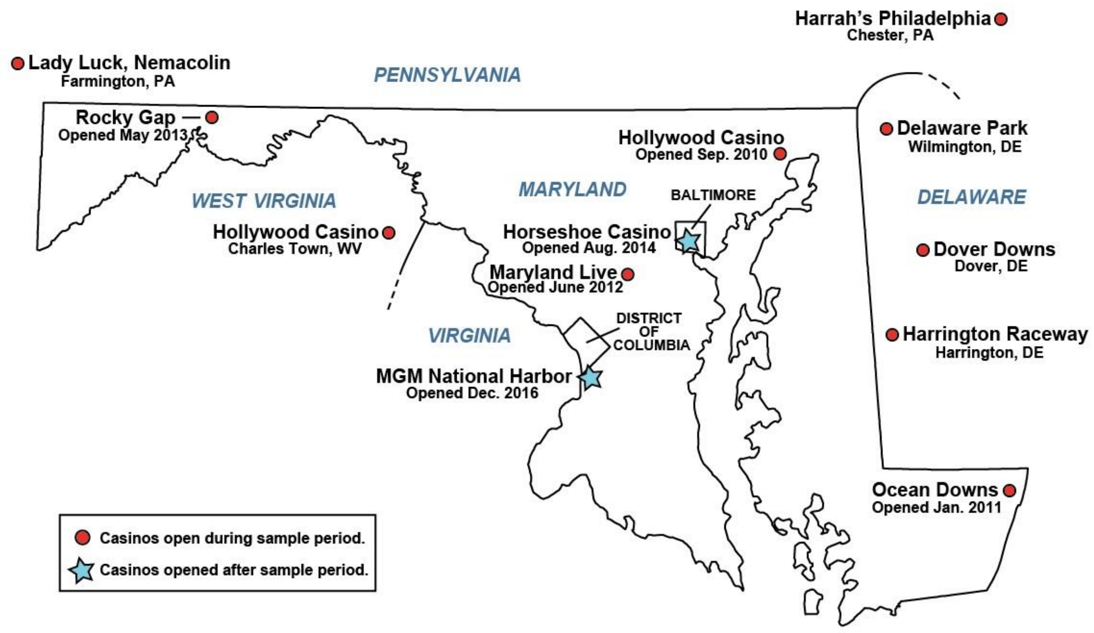
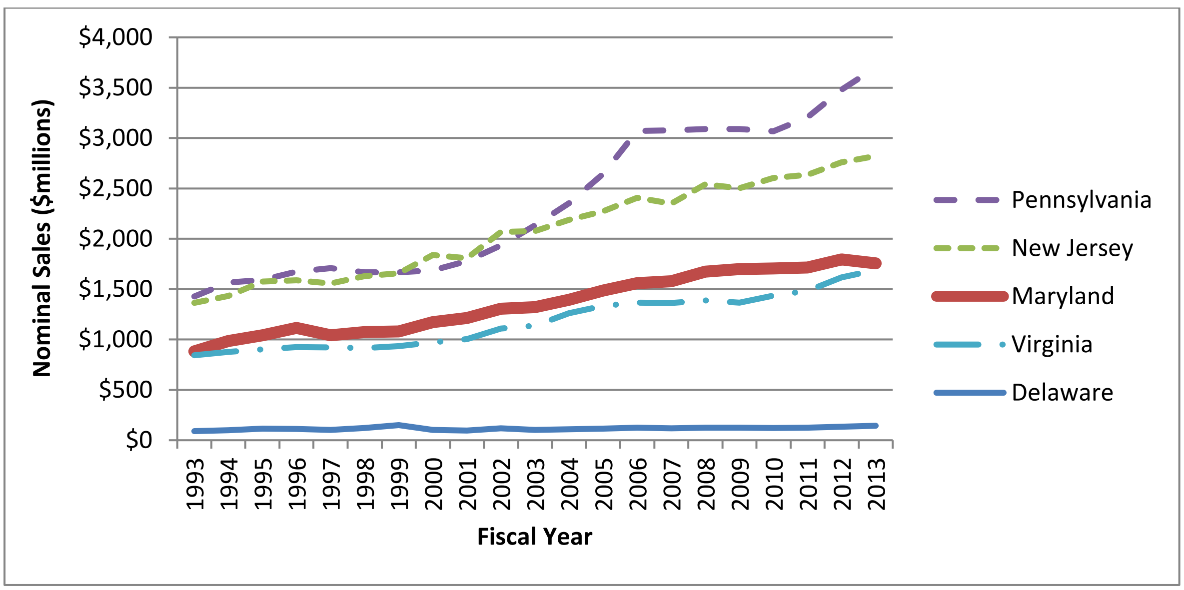


Figure 2. Annual lottery sales (excluding VLTs) in Maryland and states nearby, FY 1993-2013



Data source: LaFleur's 2009 World Lottery Almanac, LaFleur's Magazine, and state lottery annual reports.

in FY 2013.[7] While one might expect the 2007-09 recession to have had a negative impact on state lotteries, a comparison with other nearby states raises doubt that the recession alone explains Maryland's recent lottery performance.

Given that the casino expansion in Maryland coincides closely with the leveling-off of lottery sales, Maryland provides a suitable case study of the relationship between casinos and lotteries. [8] An explanation of the decline in lottery sales would presumably be of great interest to policymakers in Maryland and in other states with expanding casino industries and stagnant or shrinking lotteries.

Literature review

Lotteries received much attention in the literature during the 1980s and early '90s, particularly focused on explanations for their adoption, their regressivity, and cross-border purchases.[9] More recently, researchers have begun to analyze the inter-industry relationships among different forms of gambling. Several studies have looked at the relationships among different types of lottery products, focusing either on revenues from particular lottery games or aggregate government lottery revenues.[10] For example, using telephone survey data from Spain, Humphreys and Perez (2012) found that different type of lottery products appear to be complementary with respect to total sales. In particular, they found that participation in one type of lottery is linked to increased expenditure on other lottery products. The researchers argue that this is evidence of a positive consumption network externality across lottery games.

Looking at lotto games in Colorado, New Jersey, and Ohio, Grote and Matheson (2006) analyzed the effect on smaller state lotto games of introducing larger multi-state games such as Mega Millions and Powerball.[11] Their key focus was on the state's revenues from the different lottery products. Their general finding was that, although the introduction of the multi-state games results in lower revenues from the smaller "pick" games, aggregate revenue from the two types of games increases. Therefore, the addition of multi-state lottery products generally will increase a particular state's net lottery revenues.

Using data from the U.K. National Lottery, Forrest, Gulley, and Simmons (2004) found similar evidence that different types of lottery products are complementary with respect to total sales. In addition, these authors found that the introduction of a temporary lottery product

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[7] Although not shown in Figure 2, the negative lottery sales trend in Maryland continued into FY 2014, but rebounded slightly in FY 2015 (Maryland Lottery and Gaming Control Agency 2015).

[8] It is interesting to note that Pennsylvania's first casino opened in November, 2006. Lottery sales were flat there from 2006 to 2010, perhaps due in part to the recession. Since 2010, the Pennsylvania Lottery's sales have been increasing (https://www.palottery.state.pa.us/About-PA-Lottery/Annual-Economic-Reports.aspx).

[9] For a comprehensive, but somewhat dated discussion of lotteries, see Clotfelter and Cook (1991). For a discussion of the factors affecting the decision to adopt lotteries, see Alm, McKee, and Skidmore (1993) and Jackson, Saurman, and Shughart (1994).

[10] The terms "complements" and "substitutes" are commonly used in this literature to refer to whether sales of one type of gambling supplement or come at the expense of another. Throughout this paper we use these terms in that context, and not in their more technical senses relating to the relationship between the price of one good and the demand for another. That definition, however, does apply here, even though we are not modelling demand *per se*.

[11] In the next section, we describe the different types of lottery products, specifically for Maryland. Many lottery states have a "pick" game similar to Powerball or Mega Millions but on a much smaller scale, in which 3 or 4 numbers are drawn daily. The winning ticket must match these randomly-drawn numbers.

contributes to net sales. In contrast to the above studies on lotteries, Trousdale and Dunn (2014) focused on the price elasticity of demand for “online”[12] lottery products in Texas. They found mostly substitute relationships among the different types of online lottery products studied.

Of course, there have been other studies of the relationships among lottery products. As above, however, most of the evidence from the literature suggests that the different types of lottery products tend to be substitutes for one another, but that adding new types of games to the lottery menu results in an increase in total lottery sales.[13]

More closely related to the subject of this paper are studies that have examined the relationship between lotteries and other forms of gambling, casinos in particular. Most of the available evidence suggests there is some degree of cannibalization between casinos and lotteries. For example, Elliott and Navin (2002) developed a panel-data model estimating state-level gross lottery revenues for all lottery states from 1989 to 1995. Their findings indicated that casinos and pari-mutuel betting both caused reductions in state lottery revenues. They found that “each additional dollar of revenue from riverboat gambling reduces gross state lottery revenue by $1.38.” They estimate that a $1.00 gain in casino taxes causes a loss of 83¢ in lottery taxes, so that the introduction of casinos only modestly increases net tax revenues from gambling.

Fink and Rork (2003) extended the work by Elliott and Navin by taking into account the fact that when states legalize casinos they are making a choice: states may introduce casinos *because* of declining lottery revenues. There is then a potential self-selection bias which might help explain the negative relationship between casinos and lotteries. Fink and Rork’s analysis, however, also indicated that casino tax revenues cannibalize lottery revenues. In particular, they found that a $1 increase in casino tax revenues results in a 56¢ decrease in lottery tax revenues. Thus, a consumer who spends $5 on casino games (resulting in about $1 in tax revenues for the state) would typically spend $1.60 less on the lottery. This effect of casinos on lottery sales is slightly larger than that estimated by Elliott and Navin (2002).

Siegel and Anders (2001) tested the impact of Arizona tribal casinos on the state’s lottery sales, using monthly data from 1993 to 1998. Their findings indicated that the number of slot machines had a significantly negative effect on lottery sales, but horse and dog racing had no effect on the lottery. Specifically, their results indicated that “a 10% increase in slot machines is associated with a 3.8% decline in [overall] lottery revenues and a 4.2% decrease in Lotto revenues” (p. 144). However, after making seasonal adjustments, these decreases dampened to 2.8% and 3.7%, respectively.

The most recent and comprehensive analysis of the general relationships among gambling industries is by Walker and Jackson (2008). They examined state-level gambling industry data from 1985 to 2000 for commercial casinos, lotteries, greyhound racing, and horse racing in all states. Their sample period included much of the early casino expansion in the United States. Their key result relevant to our study is that casinos have a negative impact on the lottery in states that have both forms of gambling. Unfortunately, the Walker and Jackson analysis does not provide information on the degree to which increases in the number or scale of casinos tend to reduce lottery sales.

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[12] Games formerly called “online” are now usually called “draw” games to avoid confusion with retail sales via the internet.

[13] In a recent analysis of the lottery literature, Garrett (2016) raises a number of concerns about the aggregate data and implicit assumptions typically used in studies that estimate lottery demand.

In addition to the academic papers discussed above, there have been several consulting and government reports that have addressed the relationships between casinos and lotteries. These studies can provide interesting anecdotal evidence. For example, Spectrum Gaming Group (2008) analyzed the expected impact of casinos in Massachusetts on the state's lottery. As a part of their analysis, they calculated growth rates in population and lottery revenues prior to and after the introduction of casinos in all casino states. They found that lotteries' annual sales growth rates were 5.8% on average prior to casinos and only 1.2% after their introduction.

By Pennsylvania law, the state's Legislative Budget and Finance Committee is required to release annual reports that examine the impact of slot machines (and casino gambling generally) on the Pennsylvania State Lottery. This report typically includes recent data on lottery ticket sales and casino revenues, showing the trends in each. Their 2013 report indicates that the growth rate of lottery sales in counties hosting casinos is lower than in non-casino counties. In fact, the growth rate of lottery sales in casino counties is typically less than half that in the non-casino counties (Pennsylvania Legislative Budget and Finance Committee 2013). These data suggest that casinos negatively impact traditional lottery ticket sales, at least in areas close to casinos.

Recent evidence of a negative impact of casinos on lotteries has surfaced in other states as well. For example, casinos began operating in Ohio in 2012. A report by Bell (2013) indicated that the Ohio Lottery's scratch-ticket sales declined by 4% in the first year of casino operations, and other games also declined. However, government data show that Ohio lottery sales began increasing again in fiscal year 2014,[14] which suggests that casinos may have just had a one-time negative impact on the lottery.

In considering the relationship between casinos and lotteries, the primary concern of policymakers seems to be net tax revenues. Therefore, a key concern is the degree to which introducing casinos might negatively impact lottery revenues. However, aside from increased tax revenues, the legalization of casinos may also increase consumer surplus and reduce the deadweight losses associated with gambling taxes (Mason, Steagall, and Fabritius 1997). At the same time, however, the expansion of casino gambling may exacerbate the social costs associated with problem gambling.[15] Policymakers typically give much less attention to these issues than to tax revenues.

Anecdotal and empirical evidence suggests that casinos harm lotteries, at least at the state level. There is, however, no rigorous empirical evidence in the literature on how individual lottery game sales react to casinos, nor is there any previous evidence regarding the effect of casino proximity on lottery sales. This information could be valuable for policymakers concerned with the net revenue effects of introducing or expanding casinos in lottery jurisdictions.

[14] https://www.ohiolottery.com/SupportingEducation/Funding-Education/Revenues/

[15] Several authors have emphasized the importance of consumer benefits from the legalization of casino gambling (Collins 2003; Crane 2006; Eadington 1996; Walker 2013). There is also a substantial literature on the social costs of gambling; for examples see Thompson, Gazel, and Rickman (1997) and Walker and Barnett (1999). Psychology research suggests that the prevalence of problem gambling has not been very sensitive to casino expansion in the United States (St-Pierre et al. 2014).

3. Data and methods

The Maryland Lottery, through its vendor Scientific Games, provided us detailed monthly lottery sales data from July 2009 through February 2014. There were 14 different types of traditional lottery products available throughout our sample period. We classify these data into four different types of games, which account for over 97% of all lottery sales. Descriptions of these four game categories are detailed in Table 1.[16]

Table 1. Maryland Lottery game categories and monthly sales statistics

Game Category	Description	Examples of games	Average monthly sales, ZIP code[◊] (standard deviation)	Max* Monthly sales, ZIP code[^]
"Instant"	Instant scratch-off tickets[†]	(various; scratch-off tickets)	$106,822 (141,223)	$1,112,400
"Monitor"	Games played on video monitors; many times per day, with associated bonuses	Keno, Keno Bonus, Keno Super Bonus, Racetrax, Racetrax Bonus	$109,958 (163,097)	$1,433,065
"Pick"	"Daily numbers" games	Pick 3 Eve, Pick 4 Eve, Pick 3 Mid, Pick 4 Mid	$114,298 (215,735)	$1,907,317
"Multi-State"	Large multi-state lottery games with associated bonus games	Mega Millions, Megaplier, Powerball, PowerPlay	$40,276 (53,868)	$712,196

Notes: [†] The Lottery's data regarding instant ticket pack "activations" are used as our measure of the sales of such games. Ticket activations slightly precede actual sales by retail agents to the consumer, but are the best available measure of sales for our analyses.
[◊] Averages are for the estimation sample, which encompasses the July 2009 – February 2014 time period.
* The minimum monthly sales is zero for each game, as there is at least one ZIP code-month in the sample that did not have a particular game at some point.
[^] Some very small ZIP codes do not always have a lottery vendor available for all periods, so in these rare cases monthly lottery sales data is zero for these ZIP codes. Other ZIP codes (such as the U.S. Naval Academy) never have a lottery vendor, so do not enter the estimation sample.

We have monthly lottery sales data by game type for each retailer in the state during our sample period. Thus, in the raw data we have 238,208 retailer-level months of information for 14 types of games, for a total of about 3.3 million data points.

Figure 3 illustrates Maryland's total monthly lottery sales, which range from $120-183 million during our sample period, with an average of around $145 million. In Figure 4 we show

[16] We have omitted three Maryland Lottery games from our study as too minor and erratic for reliable analysis. The omitted games account for less than 3% of lottery sales.

lottery sales by the game categories as listed in Table 1. "Instant," "monitor," and "pick" games average around $40 million each in monthly sales; "multi-state" (large lotto) games average around $15 million per month.

Figure 3. Maryland Lottery total sales per month

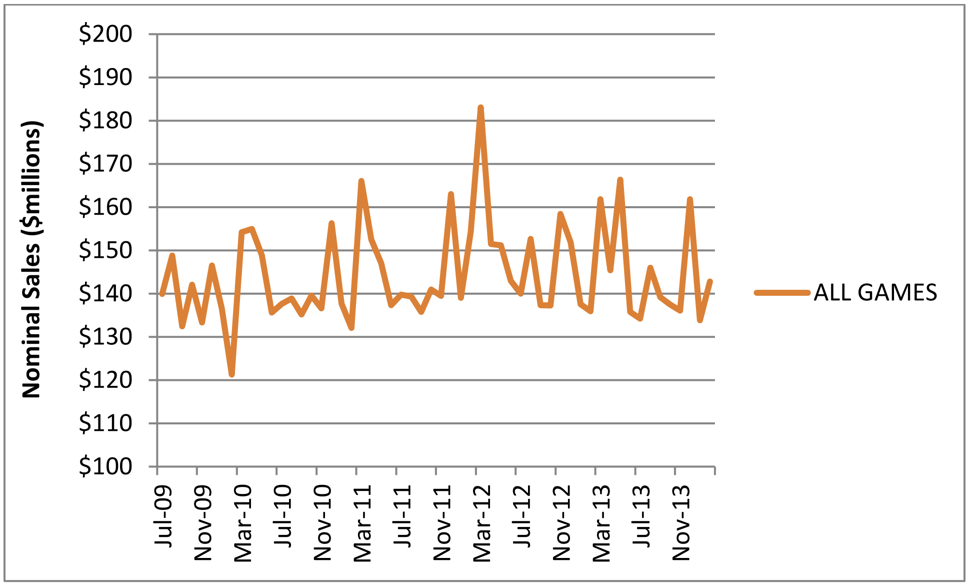
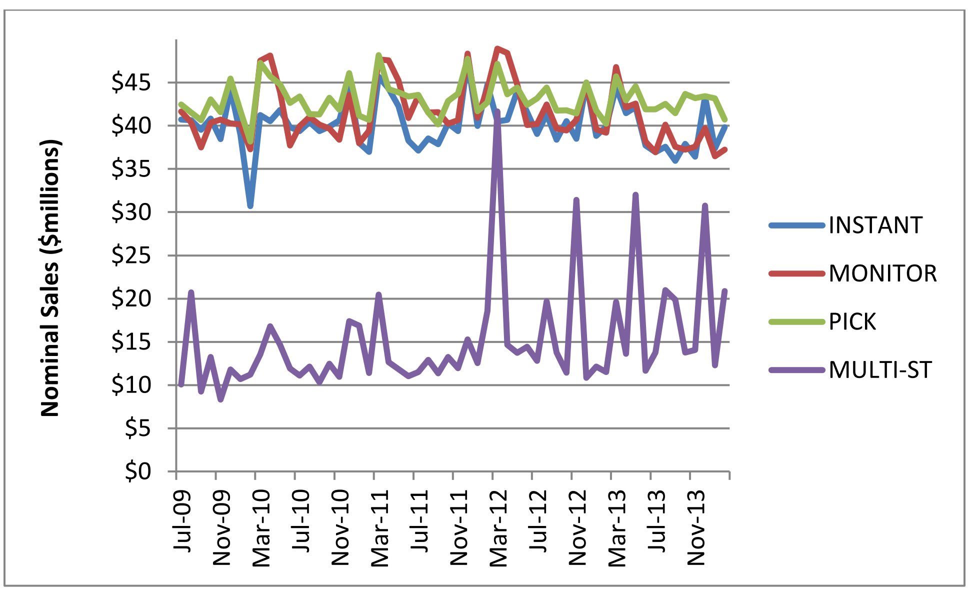


Figure 4. Monthly lottery sales, by game category



Examining Figures 3 and 4, it appears that a downward monthly trend may have begun in early 2012 (Figure 3), caused primarily by declines in instant and monitor games (Figure 4).[17]

Data aggregation

There is good reason to believe that the different types of lottery games might have different relationships with casinos. For example, the Maryland Lottery offers a Keno game which is almost identical to the same game that is offered at most casinos, including those in Maryland. On the other hand, no casino game offers the enormous jackpot size that one can win in Powerball and Mega Millions (multi-state) games. We might therefore expect lottery games like Keno to be impacted to a greater extent than the multi-state games, simply because casinos offer a closer substitute to Keno than to the multi-state games.

In order to identify the relationships between casinos and the different types of lottery products offered in Maryland, we analyze the lottery sales data aggregated to the four game types listed in Table 1. As noted above, the lottery products included in each category are similar. For example, Powerball and Mega Millions, the two key games that comprise the “multi-state” games category, are quite similar.

While lottery products are sold at more than 4,000 locations in Maryland, the data are very noisy at the retailer level. An additional complication is that a majority of lottery products are purchased at retail outlets that offer a wide variety of other products, such as gasoline, cigarettes, and groceries. It is likely that a significant proportion of lottery purchases are either impromptu, or are secondary to a different product that the customer purchased at the retail outlet. Therefore, a retail location-level analysis is likely to confound the relationship between casinos and lotteries with those between casinos and the variety of other products sold at lottery retailers.[18]

Given these issues, and the fact that we are particularly interested in the general impact of casino openings on lottery revenues, we perform the analysis at the retailer ZIP code level. We selected ZIP codes because they are much more geographically compact than counties or MSAs in Maryland, but are not so small as to make unnecessary distinctions between retailers on opposite sides of the same street. Thus, our lottery sales data are aggregated by type of game and ZIP code. We use ZIP code census tract areas (ZIPCTAs, which represent “populated” ZIP codes) provided by Easy Analytic Software, Inc. There are 461 such ZIP codes in Maryland, but only 394 of these have lottery retailers, and therefore sales data.[19] Summary statistics of the four game categories utilized in the analysis are detailed in Table 1.

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[17] A review of individual graphs by lottery type bears this out. For the sake of brevity, we present all sales data in Figure 4, rather than showing a separate graph for each type. This presentation is admittedly crowded, but it adequately illustrates the declining revenues beginning around early 2012.

[18] Our dataset does not include information on categories of retailers that sell lottery products.

[19] Some very small ZIP codes don’t always have a lottery vendor available for all periods, so in these rare cases monthly lottery sales are zero for these ZIP codes. Other ZIP codes (such as the U.S. Naval Academy) never have a lottery vendor, so do not enter the estimation sample.

Distance in travel time

We calculated the travel time from each ZIP code to each casino in Maryland, as well as to casinos in surrounding states. Given that the focus of our analysis is how casino proximity affects lottery sales, travel time is a better measure of distance than simple mileage (either road miles or "as the crow flies"). This is because the typical consumer appears more likely to focus on travel time than on miles in deciding whether to visit any casino at all, and if so, which casino to visit.[20] We assume that the geographic centroid of each ZIP code represents the location of the typical resident of that ZIP code for measuring the distance to casinos. Typical travel time was calculated in minutes using Microsoft MapPoint software, with manual checks via MapQuest and Google Maps.[21]

Our travel time variable takes a new value if a new casino opens closer to a ZIP code than existing casinos.[22] Therefore, in our model the distance variable can either remain constant or decrease as time passes. As an example, ZIP code 21012 is located at and around Arnold, in Anne Arundel County. From July 2009 through August 2010 (periods 1-14), the closest casino was outside Maryland, about 70 minutes away, at Harrington Raceway in Harrington, DE. Thus, the travel time variable takes a value of 70 minutes for periods 1-14. When the Hollywood Casino opened in Perryville in late September 2010 (period 15), it became the closest casino to ZIP code 21012, with a typical travel time of 64.5 minutes.[23] When the Ocean Downs casino opened in Berlin in January 2011, it was not as close to ZIP 21012 as the Hollywood Casino was, so the variable remains unchanged at the value of 64.5. Table 2 details the changes from different casino openings on the number of ZIP codes impacted and different measures of average travel time. Overall, there is a meaningful amount of identifying variation, as over the course of the sample period studied the average travel time to the nearest casino across all ZIP codes fell from 72.4 minutes to 40.7 minutes, and impacted 387 ZIP codes in our sample (typically several times each).

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[20] A parallel is provided by the fact that virtually all GPS map applications (e.g., Google Maps, MapQuest, Waze) provide directions based on shortest travel time, although shortest distance in miles is typically an option that can be chosen. An additional issue arises in Maryland, as in many other states. Although the largest of the casinos is located in an urban area, the others are all in rural areas. For example, the Rocky Gap casino is in the Rocky Gap State Park, and Ocean Downs is in a rural area near a beach resort. Travel to and from these two casinos is much easier than travel near Maryland Live or the Horseshoe Casino in Baltimore.

[21] These services typically define the "centroid" of a geographic area in geographic term. This will differ from the centroid of the distribution of population, but for compact ZIP codes such as Maryland's, such differences are not material. The MapPoint software calculates travel time by exploring alternative routes, estimating travel time along each based on typical (non-rush-hour) road speeds for each type of road, and then selecting the minimum such travel time.

[22] Some casinos opened in nearby states during the period we analyzed. These include the Greenbrier in White Sulphur Springs, WV, the Valley Forge Casino in King of Prussia, PA, and the Nemacolin Resort in Farmington, PA. The first two were never the closest casino to any ZIP code in Maryland. The Nemacolin is several minutes' travel time closer to some ZIP codes, but opened less than two months after Rocky Gap. The most relevant out-of-state casinos for most of the residents of Maryland are in Charles Town, WV, and the three in Delaware, and these were all opened long before, and remained open throughout, our sample period.

[23] In calculating the travel time to the closest casino for Hollywood's first (partial) month, we used a weighted average of the old time and new time. For ZIP 21012 in period 15, this value is 69.3, which reflects that the Hollywood was open few days in that month. For period 16 (October 2010), the casino was open the full month, so the travel time takes a value of 64.5 in that period and after, unless and until another casino opens closer.

Table 2: Casino opening dates, ZIP codes impacted, and measures of average travel time			
Panel A			
Casino, City	Date of Opening	# of ZIP codes Impacted	Average Change in Travel Time: *(Impacted ZIP codes only)*
Hollywood Casino, Perryville	September 2010	208	-16.5 min.
Ocean Downs, Berlin	January 2011	26	-23.6 min.
Maryland Live, Hanover	June 2012	221	-30.0 min.
Rocky Gap, Cumberland	May 2013	19	-50.5 min.
Horseshoe, Baltimore*	August 2014	--	--
MGM National Harbor, Oxon Hill*	December 2016	--	--
Panel B			
Distance Statistics: All ZIP codes	Average	Standard Deviation	
Travel Time	57.4 min.	28.7	
Travel Time (start of sample)	72.4 min.	28.0	
Travel Time (end of sample)	40.6 min.	19.5	

Note: * These casinos opened after our sample period (July 2009 – February 2014).

Methods

Maryland is surrounded by states that also sell lottery tickets and host casinos, with the exception of Virginia, which does not have casinos. As it is likely that most of Maryland's lottery ticket sales are attributable to its own residents, a model that considers mainly factors within Maryland seems appropriate for explaining changes in lottery sales as casinos opened. To the extent that casinos and lotteries have a substitute relationship with each other, we would expect that this effect would be stronger in closer proximity to casinos. We therefore utilize the following fixed effects regression model as our baseline empirical approach to estimate the impact of casino proximity on sales of each major type of lottery product:

$$SALES\$_{it} = f\,(\gamma_{iy} + \mu_m + \beta_I TT_{it} + e_{it}) \qquad (1)$$

In equation (1), *SALES$* is the total sales for each type of lottery game investigated (e.g. instant, multi-state, etc.); subscript *i* denotes the ZIP code, and *t* denotes year-month.

Our variable of interest is the effect of travel time to the nearest casino on lottery sales. Intuitively, the cost of travel should increase with travel time. The *impacts* of such costs, however, should scale in proportion to *relative* changes in travel time. (That is, a ten-minute difference will be more meaningful to the typical consumer when it is, for example, the difference between 10 and 20 minutes versus 60 and 70 minutes.) For this reason, an estimation strategy that captures this nonlinear relationship will likely provide a more accurate depiction of the true effects of changes in the relative distance to casinos on lottery sales. Moreover, there is no distance where the size of the effect should begin to decline, hence the log of travel time is the preferred approach because it has the advantage that it never reaches a maximum (or minimum) *y* value. So, variable *TT* is the natural log of the approximate travel time from the nearest casino to the centroid of each ZIP code. Results are robust to alternative non-linear estimation approaches, as will be demonstrated.

Month-specific fixed effects, denoted by μ_m, absorb seasonal differences in lottery sales across ZIP codes, while γ_{iy} are ZIP code-by-year fixed effects which absorb time-invariant differences in lottery sales across ZIP codes by year (including annual trends). This latter fixed effect control is particularly important because it helps address concerns that unobserved factors that vary across ZIP codes over time, which also impact lottery sales and are correlated with variation in casino distance, may confound our distance estimates and, hence, the interpretation of our results.

All inference of equation (1) estimates is based on standard errors that have been corrected to allow for non-independence of observations from the same ZIP code through clustering (Arellano 1987; Bertrand, Duflo, and Mullainathan 2004).

4. Results

Primary outcomes

In Table 3 we present the primary outcomes from the fixed effects regression model. Results demonstrate a positive and highly statistically significant impact of distance to a casino on lottery sales across all four categories of lottery games. However, because the effect is non-linear in nature, relative proximity to the casino is very important to the size of the effect. As an example, coefficient estimates on pick and monitor-style games indicate that a new casino opening which reduces the proximity to the nearest casino from 90 to 60 minutes (a 33% decline) for a certain ZIP code is estimated to reduce pick and monitor game sales in that ZIP code by approximately $1,200 and $5,900 per month, respectively.[24] However, the effect on an alternative ZIP code which was initially 40 minutes away from the nearest casino, this same 30 minute reduction (a 75% decline) would be estimated to reduce pick and monitor game sales in that ZIP code by approximately $2,100 and $10,000 per month, respectively.[25] For perspective, the average monthly monitor game sales in the representative ZIP code is approximately $110,000, so a decrease in sales of $5,900 represents a permanent monthly decline in monitor game sales of roughly 5.4%, while a reduction of $10,000 per month represents a 9.2% decline.

Table 3. Estimates of the impact of casino proximity on lottery sales

Fixed effects regression model

	INSTANT	**MONITOR**	**PICK**	**MULTI-ST**
Log Travel time (in minutes)	4,008.7***	14,603.3***	2,971.5***	8,148.6***
	(1,312.2)	(2,742.6)	(844.3)	(1,140.5)
R-Squared:	*0.986*	*0.976*	*0.996*	*0.816*

Notes: Robust standard errors clustered by ZIP Code are in parentheses. All regressions include ZIP Code-year fixed effects and month fixed effects. Sample Size = 21,088 in all regressions.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

[24] These results are found by calculating Δy = [(β1*ln([100 + p%]/100)] from the coefficient estimates in Table 3, where p% is the percent change in X. For example, Δy = [(14,603.3*ln([100 – 33.3]/100)] = -$5,914.

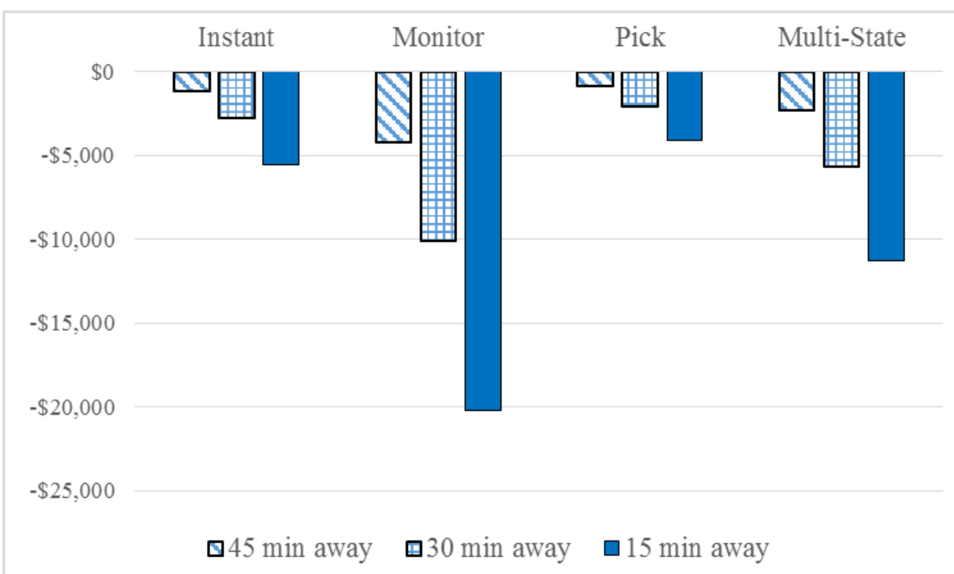
[25] See footnote 24 for reference.

The same type of calculation was made for all the game categories assuming the hypothetical new casino opens 45, 30, and 15 minutes away from a representative ZIP code. In Figure 5 we illustrate the results, which are shown relative to the benchmark in which the nearest casino is 60 minutes away. Results are shown in dollar and percentage terms from a baseline of average monthly sales. Since the estimated percentage impacts affect each month that follows the opening of the hypothetical new casino, the percent changes shown Panel B of Figure 5 also represent the long-term impact of a new casino opening at various distances from the average ZIP code. Overall, these results indicate that lottery sales will decline by meaningful amounts in the ZIP codes immediately surrounding new casinos, as those casinos present an important alternative for gambling dollars. Moreover, as casinos proliferate across the country, the impacts on lottery revenues nationally could be quite significant.

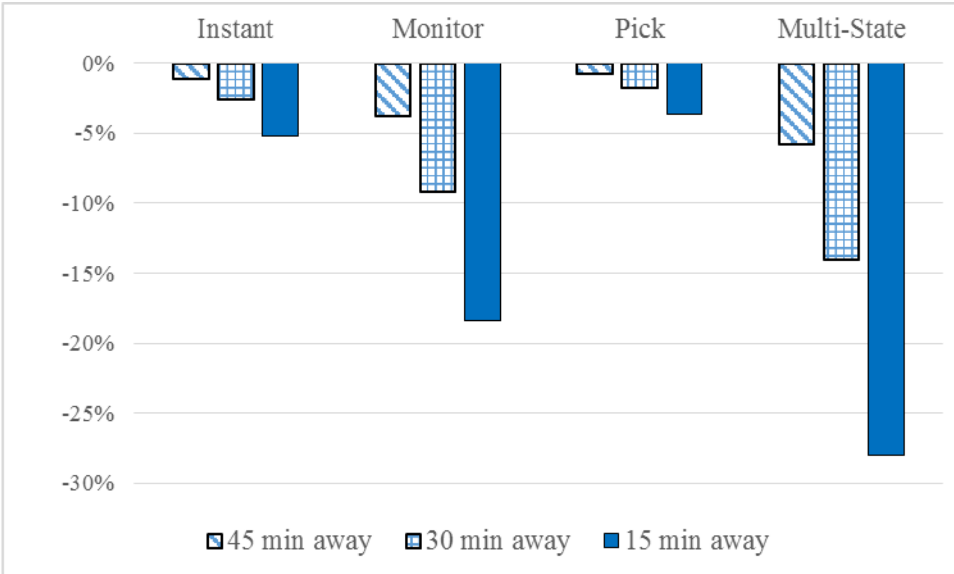
While all lottery game types demonstrate the same general negative relationship to casino proximity, as demonstrated in the above example, the magnitude of the effect clearly varies across the different games. The impact of casino proximity on monitor-style game sales, for example, is nearly five times as large as those of "pick" games. The differences in the estimated effects suggest that the strength of the relationship that exists between game types varies in important ways. Specifically, the large declines predicted for monitor sales as casino proximity increases is an intuitive finding, as monitor-style lottery games (e.g., games played on video

Figure 5. Estimated impact of a new casino opening on monthly sales in the representative ZIP code, relative to the closest casino being 60 minutes away

Panel A: $ impacts



Panel B: % impacts



monitors) are very similar in experience to modern slot machines found in casinos. These heterogeneous differences indicate that lottery revenues from games that are most similar to the types of gambling commonly found at casinos will be least robust to casino introductions. Nevertheless, the findings presented in Table 3 and Figure 5 indicate that casinos and *all* types of lottery products demonstrate a strong substitute relationship, and that relative proximity impacts consumer behavior, which subsequently impacts state tax revenues.[26]

Robustness - Multi-state jackpots

Unlike other lottery games, multi-state games, namely Powerball and Mega Millions, occasionally have enormous jackpots in the range of hundreds of millions of dollars, which generate a great deal of national attention and media coverage and appear to lead to “spikes” in the sales of such games. Several of these spikes are illustrated in Figure 4. Moreover, the relationship between jackpot size and lottery sales is not likely linear, but rather tends to demonstrate a threshold effect. Specifically, jackpots get to a certain size, then sales increase dramatically, as attention to and excitement regarding the uncommonly large prize grows. In looking at the data regarding jackpots and sales (shown in Figure 4), a jackpot threshold of $300

[26] Casinos that opened during the time frame under investigation vary in size and scope, and, as such, the magnitude of the effects may vary from the average estimated effect (presented in Table 3) because of these differences. While the objective of this study is to identify the nature of the relationship between lottery sales and distance to a casino on average, and to identify what public finance tradeoffs are faced in these cases, we did undertake a casino-specific investigation to identify whether larger effects are seen with larger casinos, *ceteris paribus*. Overall, the main distance estimate was very robust, but the results did show that the Maryland Live, which is the largest casino in Maryland, did have a statistically larger impact on lottery sales across all game types than the average measured effect of other casinos. This result is intuitive, as bigger and more centrally located casinos should create larger “substitution” effects if the results presented in Table 3 are otherwise reasonable.

million captures the sales spike pattern quite well; each of the large sales spikes in Figure 4 is associated with a jackpot of $300 million or more.

These sales spikes are also notable because they seem to begin after the 2010 expansion in Mega Millions/Powerball in which states began selling both products. As the timing of the multi-state lottery expansion potentially affects sales volume in Maryland and corresponds generally with the expansion of casinos in the state, it could confound estimated effects on multi-state game sales presented in Table 3. Hence, in order to investigate the sensitivity of our findings to the presence of large jackpots, we re-estimated the models on multi-state game sales accounting for jackpot size with the inclusion of a $300 million jackpot dummy. The estimates are very robust, indicating that the impact of large jackpots on sales is not confounding identification.[27]

Robustness – Alternative non-linear specifications

In recognizing that the impact of a new casino opening on local lottery sales will depend on how far a particular ZIP code is from the new casino, we have modeled the non-linear relationship between distance and lottery sales by taking the natural log of travel time. However, other non-linear approaches could have been selected. In order to confirm that our estimates are robust to other sensible choices, we re-estimated our models by defining the treatment variable in two alternative ways.

Table 4. Robustness models

Fixed effects regression model				
Panel A: Quadratic	**INSTANT**	**MONITOR**	**PICK**	**MULTI-ST**
Travel time (in minutes)	297.4***	678.2***	205.2**	451.8***
	(74.50)	(144.4)	(45.11)	(59.14)
Travel time squared	-2.18***	-3.29***	-1.32***	-2.63***
	(0.515)	(0.950)	(0.302)	(0.385)
Δ Sales Evaluated at the Mean of Travel Time^:	*47.0**	*300.6****	*53.4****	*150.5****
	(24.6)	*(51.5)*	*(17.64)*	*(20.9)*
Function Turning Point (minutes):	*68.2*	*103.1*	*77.7*	*85.9*
R-Squared:	*0.986*	*0.977*	*0.996*	*0.816*
Panel B: Inverse Distance	**INSTANT**	**MONITOR**	**PICK**	**MULTI-ST**
Inverse travel time (in minutes)	-208,405.5***	-368,998.7***	-86,067.1***	-210,687.0***
	(51,620.1)	(105,247.8)	(28,888.8)	(36,858.3)
R-Squared:	*0.986*	*0.976*	*0.996*	*0.815*

Notes: Robust standard errors clustered by ZIP code are in parentheses. All regressions include ZIP code-year fixed effects and month fixed effects. Sample size = 21,088 in all regressions.
*** p<0.01, ** p<0.05, * p<0.1
^ Mean of travel time is 57.4 for this sample.

[27] Distance (*TT*): Coefficient = 9,715, SE = 1,151; Jackpot Dummy: Coefficient = 30,000; SE = 1,779.

In Panel A of Table 4, we begin by re-estimating the initial models, but include both *TT* and *TT-squared*, instead of the natural log of *TT*. As indicated, results are very similar to our initial results for all four lottery game categories, indicating a strong positive relationship between casino distance and lottery sales. The results again demonstrate that the impact of a change in distance is non-linear, as the impacts are larger for more proximate casinos. In particular, estimates from Table 4 suggest that the impact on a new casino opening 30 minutes closer would reduce sales of monitor-style games by approximately $11,500 (or 10%) per month in a ZIP code that had been 60 minutes away from the closest casino, but over $15,400 (14%) per month in a ZIP code that was initially only 40 minutes away.[28] While the quadratic results suggest stronger effects for very proximate ZIP codes than observed in Table 3, they also suggest that travel time costs decline after some point, which is nonsensical. Nevertheless, this investigation demonstrates the robustness of the results in Table 3.

In Panel B of Table 4, we re-estimate the initial models utilizing a third non-linear function of travel time, the inverse of *TT*. Again the results are very similar, indicating that lottery sales are positively related to distance to a casino. Moreover, as shown in Table 3 and Panel A of Table 4, the magnitude of the relationship varies similarly across games types.

Monetary impacts

In an effort to provide a more specific picture of the aggregate impact of a new casino on lottery sales, we estimate the total annual monetary impact on the lottery from opening one particular casino – the Maryland Live, in Hanover. Maryland Live is the largest casino in Maryland, it is centrally located, and its opening impacted more ZIP codes than any other casino. Specifically, across all the ZIP codes in our sample that have lottery retailers, the average reduction in travel times to the nearest casino (weighted by ZIP code revenue for each game type) fell by between 21 and 25 minutes when Maryland Live opened in June 2012. (The initial average distance ranged from 56 to 61 minutes away, varying slightly by type of lottery game.)

We estimate the total annual impact of the Maryland Live casino opening on Maryland Lottery sales using the estimated baseline impacts from Table 3. As shown in Table 5, the estimated impact of the Maryland Live casino was a decrease in lottery sales of $71 million annually, with particularly large effects in both monitor and multi-state games sales.[29] A similar calculation was done for each of the other casinos in Maryland operating during our sample period. (These estimates are presented in the appendix, Table A1.) The estimated total negative impact of all Maryland casinos on lottery sales is $103 million, or 5.9% of annual lottery sales.[30]

Extrapolated over time and across all casinos, these results suggest that meaningful changes occur in gaming behavior among lottery players and therefore in total lottery revenues in jurisdictions that open casinos. These effects are typically unaccounted for in state governments'

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[28] These results are found by calculating $\Delta y = [(\beta 1 + (2^* \beta 2^*(TT_1+TT_0)/2))^*(\Delta TT)]$ from the coefficient estimates in Table 4, Panel A. For example, [(678.2 + (2*-3.29*45))*(30)] = -$11,463.

[29] To calculate the estimated effect, we multiply the log of one hundred plus the average percent change in travel time for each game, by the coefficient estimate for *travel time* from Table 3, then multiply by 394 ZIP codes, and multiply by 12 months. Specifically, [(β1*ln([100 + pbar%]/100)*(394)*(12)], where pbar% is the average percent change in travel time across all ZIP codes (including those where *TT* is unaffected).

[30] This estimate is based on fiscal year 2013 lottery sales of about $1.75 billion. This effect does not include the impact of the two casinos that opened after our sample period, i.e., the Horseshoe (Baltimore) and the MGM National Harbor (Oxon Hill).

preliminary analyses of casino impacts, which often overestimate the revenue streams from gambling of all types.

Table 5. Estimated annual impact of Maryland Live! casino opening on lottery sales, by game type

	INSTANT	MONITOR	PICK	MULTI-ST	SUM ALL GAMES
Estimated casino impact (in millions $ per year)	-$8.95	-$36.04	-$7.73	-$18.17	-$70.89
Average travel time to nearest casino before Maryland Live! opened (weighted by game sales):	*56.5 min.*	*61.3 min.*	*58.9 min.*	*57.6 min.*	--
Average change in log travel time after Maryland Live! opening (weighted by game sales):	*-21.3*	*-24.9*	*-24.9*	*-21.7*	--
Average percent change in travel time after Maryland Live! opening:	*-38%*	*-41%*	*-42%*	*-38%*	--

5. Discussion and conclusion

In this paper we have addressed both public finance aspects of the relationship between casinos and lotteries, as well as consumer behavior issues related to the substitutability and complementarity of spending on different types of gambling. State governments legalize gambling in order to raise tax revenues, and indeed, the gambling industry is typically taxed at relatively high rates. One obvious concern for policymakers is the net impact on state tax revenues from the introduction or expansion of casinos, with "cannibalization" of lottery revenues being a key concern.[31]

Our results support earlier, more general studies that have found a negative (substitutive) relationship between spending at casinos and on lotteries. We find strong evidence of a negative impact of casinos on lottery sales, and that impact increases with casino proximity. For example, if a new casino opens 15 minutes away from a particular ZIP code, when previously the closest casino was 60 minutes away, we estimate that multi-state game sales in that ZIP code would decline by 28% (see Figure 5). Summing across all the nearby affected ZIP codes, the new casino could have a large negative impact on lottery sales in the area, especially for casinos located in more heavily populated areas.

If we consider the impacts of casinos on lottery sales aggregated to the state level, however, we find only a modest impact. For example, we estimate that the largest casino in Maryland (Maryland Live) negatively impacted total lottery sales in the state by approximately

[31] This issue arose recently, for example, in several of the hearings held in Georgia during 2015 in consideration of casino legalization there. See http://www.house.ga.gov/Committees/en-US/Preservation_of_Hope.aspx.

$71 million per annum. Given that annual lottery sales in Maryland are about $1.75 billion, the negative impact of casinos on lottery sales in Maryland is important, but not overwhelming. On net, the gaming tax revenue effect of opening Maryland Live is certainly positive. During 2015 the casino attracted $625 million in total gaming revenue, and it paid roughly $270 million in taxes to the state (Maryland Lottery and Gaming Control Agency 2015).[32] The casino has clearly led to a net increase in the state's overall gambling tax revenue, despite its modest negative impact on tax receipts from lottery sales.

In addition to the public finance issues addressed, our paper also provides some interesting insight regarding consumer behavior vis-à-vis gambling. Overall, the results indicate that casinos and lotteries have a substitutive relationship, and that relative proximity impacts consumer behavior in intuitive ways. Notably, Maryland is somewhat unique in its offering of monitor-style lottery games, such as Racetrax and Keno. Racetrax is a unique game, with nothing similar offered at Maryland's casinos. Keno, in contrast, is offered at most casinos, and customers can play the lottery's Keno game at home on their computer. Both monitor products are relatively fast-action games, with high event frequency, similar to a typical casino game.[33] Intuition might therefore suggest a stronger negative relationship exists between casinos and the lottery's monitor games. Indeed, we find these games are impacted a great deal by changes in casino proximity.

We believe this is the first paper to estimate the impact of casino proximity on lottery sales by lottery game type. Although we find a negative relationship between casino games and the various types of lottery products in Maryland, the results could be different in other jurisdictions, depending on the regional economy, consumers' cultures and preferences, the nature of the local casino industry, and other factors. For example, in a jurisdiction with modest lottery sales, the negative impact of large or ubiquitous casinos on lottery sales could be devastating. Conversely, a "destination resort" in a remote area of a large state might have a much smaller impact on the state's lottery sales. Nevertheless, our results generally indicate that the introduction of casinos may increase net gambling tax receipts to a lesser extent than the gross casino tax receipts themselves. Future research in other jurisdictions could provide valuable evidence on the extent to which these findings are generalizable beyond Maryland.

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[32] During 2015 the tax rate on slot machine revenues was 67%, and on table games it was 20%. Slot machines produced about 63% of the casino's gross revenues.

[33] In the gambling literature, "event frequency" refers to the number of bets that can be completed during a particular amount of time. For more details, see Parke and Griffiths (2006). A high event frequency implies a very short wait between placing the bet and learning the outcome. Among casino games, slot machines typically have the greatest event frequency. "Instant" games hold a similar position among lottery products.

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APPENDIX

Table A1. Estimated annual impact of all Maryland casino openings on lottery sales, by game type

Panel A: Hollywood	**INSTANT**	**MONITOR**	**PICK**	**MULTI-ST**	**ALL GAMES**
Estimated casino impact (in millions $ per year)	-$4.30	-$12.46	-$3.28	-$7.77	-$27.81
Average travel time to nearest casino before Hollywood opened (weighted by game sales):	*70.9 min.*	*75.1 min.*	*75.0 min.*	*70.6 min.*	--
Average change in log travel time after Hollywood opening:	*-14.4*	*-12.4*	*-15.6*	*-12.9*	--
Average percent change in travel time after Hollywood opening:	*-20%*	*-17%*	*-21%*	*-18%*	--
Panel B: Ocean Downs	**INSTANT**	**MONITOR**	**PICK**	**MULTI-ST**	**ALL GAMES**
Estimated casino impact (in millions $ per year)	-$0.23	-$1.33	-$0.12	-$0.53	-$2.22
Average travel time to nearest casino before Ocean Downs opened (weighted by game sales):	*56.9 min.*	*63.0 min.*	*59.5 min.*	*58.1 min.*	--
Average change in log travel time after Ocean Downs opening:	*-0.7*	*-1.2*	*-0.5*	*-0.8*	--
Average percent change in travel time after Ocean Downs opening:	*-1%*	*-2%*	*-1%*	*-1%*	--
Panel C: Maryland Live	**INSTANT**	**MONITOR**	**PICK**	**MULTI-ST**	**ALL GAMES**
Estimated casino impact (in millions $ per year)	-$8.95	-$36.04	-$7.73	-$18.17	-$70.89
Average travel time to nearest casino before Maryland Live! opened (weighted by game sales):	*56.5 min.*	*61.3 min.*	*58.9 min.*	*57.6 min.*	--
Average change in log travel time after Maryland Live! opening:	*-21.3*	*-24.9*	*-24.9*	*-21.7*	--
Average percent change in travel time after Maryland Live! opening:	*-38%*	*-41%*	*-42%*	*-38%*	--
Panel D: Rocky Gap	**INSTANT**	**MONITOR**	**PICK**	**MULTI-ST**	**ALL GAMES**
Estimated casino impact (in millions $ per year)	-$0.44	-$0.78	-$0.08	-$0.99	-$2.28
Average travel time to nearest casino before Rocky Gap opened (weighted by game sales):	*35.2 min.*	*35.8 min.*	*34.1 min.*	*35.6 min.*	--
Average change in log travel time after Rocky Gap opening:	*-0.8*	*-0.4*	*-0.2*	*-0.9*	--
Average percent change in travel time after Rocky Gap opening:	*-2%*	*-1%*	*-1%*	*-3%*	--
Panel E: All Casinos	**INSTANT**	**MONITOR**	**PICK**	**MULTI-ST**	**ALL GAMES ALL CASINOS**
Estimated casino impact (in millions $ per year)	-$13.92	-$50.61	-$11.21	-$27.46	-$103.20