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ABSTRACT

The lottery is a huge business. In 2011, $57.6 billion worth of lottery tickets were sold in 43 states and the District of Columbia. There are three major parties (governments, lottery players, and retailers) involved in the lottery industry, plus many more stakeholders. This paper examines the lottery from the viewpoints of these three primary parties. From the lottery players' viewpoint, we show how to statistically determine the expected value of a lottery ticket and discuss when to conclude it is profitable to buy lottery tickets. We explore the question of whether lottery players are rational. State governments have, for years, relied on lottery money to fund education and other expenses. We examine the economic benefits as well as the societal costs of operating the lottery business. Finally, we examine the economics of selling lottery tickets from the retailers' viewpoint.

INTRODUCTION

Lottery tickets are sold in more than 100 countries worldwide. The lottery industry took in revenue of over $260 billion worldwide in 2011, of which $57.6 billion or 22% was derived from U.S. sales (LaFleur 2012). On average, an American spends about $200 buying lottery tickets per year (Dubner 2010). Lottery tickets are legally available for sales in 43 states and the District of Columbia. The seven states that do not sell government-run lottery tickets are Alabama, Alaska, Hawaii, Mississippi, Nevada, Utah, and Wyoming.

There are currently 44 lotteries in the United States. More than 80% of the U.S. population lives in lottery states. There are two major categories of lottery games, namely draw and instant/scratch-off. In 2011, U.S. draw lottery sales accounted for about 42% of the total lottery sales, whereas U.S. instant lottery sales represented approximately 58% (LaFleur 2012). Mega Millions and Powerball are two of the largest draw games, and they are available in 42 states and DC (Mega Millions is unavailable in Florida, while Powerball is unavailable in California). The Mega Millions drawings are held twice a week, on Tuesday and Friday nights. The Powerball drawings are also held twice a week, on Wednesday and Saturday nights.

On March 30, 2012, Mega Millions announced the world's largest jackpot of $656 million had been won by three winning tickets. Each winning ticket received a third of the jackpot or about $219 million. It is important to note that the winning amount is divided into 26 annual payments and is spread over a period of 25 years. The holder of a winning ticket can choose to

receive a lump-sum payment; however, the lump sum is significantly smaller than the total annuity payment.

There are three main parties involved in the lottery industry—issuers (governments), buyers (lottery players), and intermediaries (retailers)—and many more stakeholders, such as advertisers. The issuers of lotteries certainly have vested interests in the lottery industry. Lotteries create jobs for government agencies as well as in the retail sector. In addition, state governments derive hundreds of millions of dollars in revenue annually, if not billions of dollars, from selling lottery tickets. Lottery revenue is particularly important because it is relatively stable and enjoys a hefty profit margin. It earns more than one-third of the revenue as profit.

Lottery players are clearly at the center of the lottery industry. They are the reason why the industry exists. A critical question facing lottery players is how and when to play so as to maximize the return.

The third major party is made up of intermediaries or retailers. The retailers serve as an important bridge between the issuers and lottery ticket buyers. They benefit greatly from selling lottery tickets as this business helps drive traffic to their stores, especially important for smaller retailers such as convenience stores.

In addition to these three major parties, there are other stakeholders involved. Companies that are involved in the production of ticket machines, the printing of lottery tickets, and advertising media for the lottery.

This paper examines the lottery from the viewpoints of the three main parties with a primary focus on draw lottery. State governments have, for years, relied on lottery money to fund education and other expenses. Section 2 examines the challenges and problems facing state governments associated with the lottery business. Section 3 shows how to statistically determine the expected value of a lottery ticket and discusses when to conclude it is profitable to buy lottery tickets. It also explores the question of whether lottery players are rational. Section 4 examines the economics of selling lottery tickets from the retailers' viewpoint. Finally, we conclude this paper in Section 5.

GOVERNMENTS

With the current dire financial situation of state governments, it is hard to imagine that these governments would abandon their involvement in lotteries. In fact, most state governments have devoted a great deal of their effort to increasing lottery demand and thus revenue. This is understandable because the lottery business model is very simple and yet highly profitable. Revenue is made of lottery tickets sold, whereas total expenses consist of prizes paid to lottery players, commissions paid to retailers, and gaming and operating costs. Profit, which is computed as revenue minus total expenses, goes directly to government coffers. As a result,

lotteries provide a stable source of additional revenue for the governments. More importantly, state governments are essentially monopolies and do not have to face any competition; thus, they are very well suited to operate the lottery business. Nevertheless, there are several challenges and problems facing state governments regarding their lottery businesses:

1. Lottery demand
2. Gaming and operating expenses
3. Regressive tax
4. Crime

Lottery Demand

Over the past several decades, state governments have tried various ways to increase lottery sales. Previous research has identified three factors related to lottery design (i.e., the odds of winning, the prize structure, and the payout rate of the game) which can affect demand.

There has been a rise in multi-state lotto games with huge jackpots at longer odds over the past 20 years. According to Cook and Clotfelter (1993), this phenomenon is known as the *scale of economies of lotto*. They find that states frequently design their lottery games so that the probability of winning the jackpot is approximately equal to the reciprocal of the population within the state. Hence, the larger the population is, the smaller the probability of winning the jackpot will be. DeBoer (1990) concludes that the New York state lottery should offer an extremely small probability of winning the jackpot so as to attract more lottery players to its lotto game. Thiel (1991) draws a similar conclusion regarding the Washington state lottery. The rationale is that consumers pay more attention to the size of the lottery prize than they do about the odds of winning. Furthermore, longer odds would result in more rollovers, resulting in larger jackpots. Nevertheless, the ability to generate more demand by lengthening the odds of winning the jackpot is not unlimited. If the jackpot is won too rarely, this could cause players to lose interest (Forrest and Alagic 2007).

With respect to the prize structure, Scoggins (1995) finds that Florida lottery officials should increase the jackpot prize from 25% to 30% of the sales to increase demand. Quiggin (1991) develops a mathematical model which suggests that consumers may prefer lottery games with multiple prizes and prize levels, even though smaller prizes do not have much impact on the overall expected value of a ticket. Garrett and Sobel (1999) conclude that lottery players in 216 U.S. games appear to be risk averse and favor skewed returns. They recommend lottery providers achieve more skewness by offering smaller consolation prizes along with larger jackpots.

A higher payout rate of lottery games, which is defined as percentage of sales returned to lottery players as prizes, may have a positive effect on consumer demand if consumers are

responsive to the effective price. On the other hand, a higher takeout rate, which is defined as percentage of sales that is not distributed as prizes, may depress demand. Hence, it is critical to set an appropriate level of the payout rate and thus the effective price so as to maximize profit. Researchers have recommended that changes be made to payout rates when effective price elasticities of demand deviate from the revenue-maximizing figure (i.e., −1).

In addition to lottery design, there are other aspects that states have adjusted to increase lottery sales. One of the simplest ways is to increase the frequency of games; for example, both Mega Millions and Powerball games have two drawings a week. It is important to point out that continuously increasing the frequency could lead to undesirable results, such as lottery players' fatigue. Another way is to introduce a wide variety of lottery. States have added more lottery games over the years as a means to increase sales. However, states must be mindful when introducing new games so as to avoid or minimize market cannibalism.

Recently, states have employed technology to bypass the traditional lottery retailers and sell lottery tickets directly to consumers. The Illinois Lottery launched a revamped Web site aimed at boosting lottery ticket sales in November 2012. According to the Illinois Lottery, one of the biggest changes to the site is the ability to play Powerball, Mega Millions, and Lotto using cell phones and other mobile devices, including iPads, as long as they are connected to the Internet (Lazare 2012). The technology allows the site to verify that online players of the Illinois Lottery are of legal age and live within the state's borders. In addition, the new site can measure and limit play per registrant to a maximum of $150 per day.

At about the same time, the Georgia Lottery board members approved online lottery after making sure that proper technological controls on players were put in place. These controls include mandatory account registration, banking requirements that will match an applicant's name, address and social security number, and limits on how much account activity is allowed (Torres 2012). Similar to the Illinois Lottery, players must be of the legal age of 18 and live within the state's borders to purchase lottery tickets online. The addition of online sales is expected to boost revenue by about 2% of annual existing sales of those games.

Back in November 2012, Minnesota became the first state to sell lottery tickets at gas pumps and ATMs. With a debit card, driver's license, and cell phone number, buyers can try their luck at a touch screen (Matos 2012). The system allows people to purchase quick-pick Powerball and Mega Millions tickets without going inside a store. According to the Minnesota lottery's executive director, Ed Van Petten, "People are always in a hurry nowadays. The thought is it takes 10 to 15 seconds to go through the process, and I think people would say, 'Why not? I'll give it a shot.'"

Virginia has recently installed self-service machines (called the Lottery Express) to sell lottery tickets at Richmond Airport, again bypassing the traditional retailers. According to

Virginia Lottery director Paula Otto, the Lottery Express is expected to generate $10.7 million in revenue annually for the Virginia Lottery, of which more than $4 million goes to the Virginia public schools (Macenka and Llovio 2013). The Lottery Express enables the Virginia Lottery to reach a lot more potential customers. In February 2013, a couple bought a lottery ticket from a Lottery Express machine and won the Virginia Lottery's $217 million Powerball jackpot.

We believe that a pricing strategy could also help stimulate consumer demand—that is, offering discounts for lottery drawings with low expected jackpots. For example, giving a 5% discount on draw tickets when the expected jackpot is below a certain benchmark point, such as the median, and a 10% discount when it is below the 25th percentile. The pricing strategy may be applied to both lottery tickets sold in stores or online.

Gaming and Operating Expenses

Keeping gaming and operating expenses low is critical for states to maximize profit. Since the lottery does not actually involve the production of goods (i.e., tangible output), information technology can play a very important role in reducing costs and, at the same time, protecting the environment.

Selling lottery tickets online and thus bypassing the traditional retailers is an effective way to keep expenses low. In addition, paying lottery winners electronically is another way that technology can help bring costs down.

Regressive Tax

One of the most compelling criticisms against lotteries is that they are very regressive; that is, lotteries place a heavier tax burden on the poor than on the wealthy. In fact, there is general agreement among economists on this point; see Kearney (2005), Campbell and Finney (2005), Wisman (2006), and Combs et al. (2008). Moreover, Combs et al. (2008) find statistically significant differences in regressivity between some lottery products and conclude that Minnesota's newly introduced G3 instant/scratch product is the most regressive lottery game. Freund and Morris (2005, 2006) studied the impact of gambling on income inequality from 1976 to 1995. They find clear evidence that state-run lotteries foster inequality, but no evidence of a similar effect is found for other types of gambling.

Another stream of research focuses on where the lottery spending goes rather than who pays for the lottery tickets when assessing income equity. The studies from Stranahan and Borg (2004) and Feehan and Forrest (2007) indicate regressivity in the spending of lottery taxation, thus exacerbating the regressivity of the income side of lotteries. Gripaios et al. (2010) suggest that inequalities in the distribution of lottery proceeds go beyond income level; race/ethnicity and geography also play an important role.

Crime

Crime rate is certainly influenced by a large number of factors. A crucial issue states must deal with is whether the introduction of lottery games increases crime rate. Mikesell and Pirog-Good (1990) conducted a comprehensive study to examine the impact of having a state lottery on the crime rate. Analyzing data for the 50 states and the District of Columbia from 1970 through 1984, they find that there is a significant positive correlation between crime rate and the presence of a lottery.

The adoption of lotteries may also impact the well-being of lottery players. Kearney (2005) finds that household lottery gambling reduces roughly $38 per month of other household

consumption, or 2%, with larger proportional reductions among low-income households. This finding is consistent with a general concern of Borg et al. (1991).

LOTTERY PLAYERS

The lottery players are the consumers. In this section, we will discuss the expected value of a lottery ticket and explore the following question: is playing lottery rational?

Expected Return

From the angle of lottery players, the focus is primarily on how to maximize their return. In order to do so, lottery players should understand how to calculate the odds of winning and the expected value of a ticket. The probabilities of any number of matched winning numbers are determined by a ratio of three combinations in the hypergeometric distribution. A combination counts the number of ways items can be arranged when their order of occurrence is unimportant and the numbers cannot be duplicated (i.e., the same number cannot be drawn twice among the winning numbers selected). The following terms are used to specify the hypergeometric distribution using Mega Millions as a specific example:

N: population size (56)
n: sample size (5 numbers on each ticket)
W: number of winning numbers (5)
w: number of winning numbers on any ticket (0 to 5)
$N - W$: number of losing numbers
$n - w$: number of losing numbers on any ticket

The mathematical formula for the hypergeometric distribution is as follows:

$$\frac{\dfrac{W!}{w! \cdot (W - w)!} \times \dfrac{(N - W)!}{(n - w)! \cdot (N + w - W - n)!}}{\dfrac{N!}{n! \cdot (N - n)!}},$$

where $!$ represents a factorial.

The denominator computes how many combinations there are when using a sample of size n = 5 from a population of size N = 56. This gives $56!/(5! \cdot (56 - 5)!)$ or 3,819,816 possible tickets for the lottery. Applying the numerator of the formula as follows: $5!/(5! \cdot (5 - 5)!) \times 51!/(0! \cdot (51 - 0)!) = 1$. Only one of the possible tickets can have all the winning numbers (5) in any drawing. Therefore, the probability of any ticket having all five winning numbers is $1/(3,819,816)$ or 0.0000002561.

In addition to matching the five winning numbers, the Mega Millions jackpot ticket also has to match the winning Powerball number. Here, the lottery player selects only one of 46 numbers (1 to 46). Clearly, the probability of matching the winning Powerball number alone is 1/46.

Let X be the event of matching the five winning numbers, and let Y be the event of matching the winning Powerball number. Since these two events are statistically independent, $P(X \cap Y) = P(X) \cdot P(Y)$. Therefore, the probability of winning the Mega Millions jackpot is as follows: $1/(3,819,816) \times 1/(46) = 1/(175,711,536) = 0.00000000569$, whereas the odds of winning are 1:175,711,536. Table 1 summarizes the probability calculations of eight other prizes available from the Mega Millions lottery.

Table 1. The Probability of Winning the Mega Millions Lottery

Prize	Matching White Balls	Matching Mega Ball	$P(X)$	$P(Y)$	$P(X \cap Y)$	Odds
Jackpot	5	Yes	0.000000262	0.021739130	0.00000000569	1:175,711,536
$250,000	5	No	0.000000262	0.978260870	0.00000025610	1:3,904,701
$10,000	4	Yes	0.000066757	0.021739130	0.00000145124	1:689,065
$150	4	No	0.000066757	0.978260870	0.00006530590	1:15,313
$150	3	Yes	0.003337857	0.021739130	0.00007256211	1:13,781
$10	2	Yes	0.054518333	0.021739130	0.00118518115	1:844
$7	3	No	0.003337857	0.978260 870	0.00326529500	1:306
$3	1	Yes	0.327109997	0.021739130	0.00711108689	1:141
$2	0	Yes	0.614966794	0.021739130	0.01336884335	1:75
Any	NA	NA	NA	NA	0.02050699874	1:38.9888

The probability of winning any prize is certainly of great interest to lottery players. It is simply equal to the sum of the individual winning probability of the prizes since a ticket can at most win one prize (i.e., mutually exclusive). Therefore, P(*Jackpot* or $250,000 or ... or $2) = ($P$(*Jackpot*) + P($250,000) + … + P($2) = (0.00000000569 + 0.00000025610 + … + 0.01336884335) = 0.02050699874. The overall odds of winning are computed as follows: 1:1/ (0.02050699874) = 1:39.888333.

The expected value cannot be determined prior to buying a lottery ticket since the jackpot amount is pari-mutuel. The expected present value assuming the jackpot is $100 million (annuity value) and with only one winning ticket is as follows: ($100,000,000) · P(*Jackpot*) · *Discount Factor* + ($250,000) · P($250,000) + ... + ($2) · P($2) = $0.593. We use a discount factor of 0.7226, which is based on the largest Mega Millions jackpot data from March 2012. Suppose that there are two jackpot-winning tickets, then the expected present value is reduced to $0.388. When the expected present value of a lottery ticket is less than the price of the ticket or when net expected present value, defined as expected present value minus ticket price, is negative, it is unprofitable to play the lottery in the long run.

Table 2 shows the expected present value for 15 selected values of the jackpot (ranging from $50 million to $750 million at $50 million increments) for one, two and three winning tickets. As shown in the Table, it becomes profitable (i.e., expected present value is greater than $1) when the jackpot is $200 million or higher with only one jackpot-winning ticket, at least $400 million assuming there are two winning tickets, or at least $600 million with three winning tickets. People generally pay more attention to the size of the jackpot than they do about the possibility of multiple jackpot winners or the odds of winning (Thiel, 1991). Therefore, they often overreact to large jackpots. After all, the final payoff of winning the jackpot depends on the number of jackpot-winning tickets. The more the lottery tickets sold, the larger the expected number of jackpot-winning tickets.

According to the Mega Millions jackpot history, it is uncommon for the jackpot to hit $200 million or more. Hence, it is unlikely that the net expected present value is positive, implying that it is unprofitable to play Mega Millions over the long run. Of course, the jackpot does occasionally reach $200 million, even $400 million; however, even a jackpot of $500 million is no guarantee that the net expected present value is positive. Therefore, lottery players only have perhaps several opportunities a year to play the lottery based on the likelihood of net expected present value being positive. In short, it is both impractical and infeasible to play a lottery game for the purpose of making a relatively small but steady gain over the long run.

However, the lottery game does offer the lottery player a real chance, albeit small, to become a millionaire. This kind of opportunity is generally unavailable via other avenues. In addition to buying a millionaire dream, there are other reasons that people buy lottery tickets. Charity is certainly one that comes to most people's minds. The vast majority of the profits from the lottery goes to education in most states. People are generally more inclined to accept their losses for the sake of education.

Table 2. Jackpot and Expected Present Value

Jackpot (in Millions)	One Winning Ticket	Two Winning Tickets	Three Winning Tickets
$50	$0.388	$0.285	$0.251
$100	$0.593	$0.388	$0.319
$150	$0.799	$0.490	$0.388
$200	$1.004	$0.593	$0.456
$250	$1.210	$0.696	$0.525
$300	$1.416	$0.799	$0.593
$350	$1.621	$0.902	$0.662
$400	$1.827	$1.004	$0.730
$450	$2.032	$1.107	$0.799
$500	$2.238	$1.210	$0.867
$550	$2.444	$1.313	$0.936
$600	$2.649	$1.416	$1.004

$650	$2.855	$1.518	$1.073
$700	$3.061	$1.621	$1.142
$750	$3.266	$1.724	$1.210

Is Playing the Lottery Rational?

Certainly not from the economic viewpoint of earning a positive return over the long term. Why do people continue to play the lottery if it does not make pure economic sense? We contend that playing the lottery could be rational if using the utility theory to determine the net expected present utility value. People are generally risk averse when risking a large sum of their money. Let's assume that Mr. A has a monthly salary of $2,500, and he faces a betting offer as follows: wager $2,500 for a 25% of getting $10,000 and a 75% chance of getting $0. Most people would balk at this offer even though the expected value is non-negative because the high probability (75%) of losing $2,500 is very real and uncomfortable. Consequently, most people see the utility of $2,500, $U(\$2,500)$, is far higher than a quarter of $U(\$10,000)$. That is, $U(\$2,500) > 0.25 \cdot U(\$10,000)$.

Suppose that Mr. A is offered to buy a $1 lottery ticket which carries a jackpot of $5 million. Even though the probability of winning the jackpot is miniscule and the calculated net expected present value of the lottery is negative, he is quite likely willing to take the lottery offer. Hence, he is a risk taker in this case. This can be explained by the fact that most people view $1 or $U(\$1)$ as extremely small since it won't cause a material impact on their life. At the same time, they view $5 million and $U(\$5 \text{ million})$ as extremely high as they most likely have no other feasible avenue to make that much. Even though the probability of winning is miniscule, people find that a miniscule probability of receiving $U(\$5 \text{ million})$ is better than $U(\$1)$, i.e., $m \cdot U(\$5 \text{ million}) > U(\$1)$, where m is extremely small. As a result, people buy the lottery ticket. Clearly, betting $1 is very different from betting a month's salary.

In summary, it is irrational to play the lottery according to the expected present value approach; however, lottery players might very well believe that their bets are rational using the utility theory as illustrated by the above example. Since there are hardly any good alternatives to becoming a millionaire overnight for most lottery players. It should be noted that on a relative basis low-income households are less rational because they spend a larger portion of their income on lottery tickets, which effectively reduces other household consumption by a larger proportion.

RETAILERS

Lottery retailers are critical to the success of the lottery business. As a result, state governments actively recruit retailers to sell lottery tickets. They are committed to making the process of becoming a lottery retailer as smooth as possible. For instance, the Georgia Lottery

Corporation, an agency of the Georgia government, provides retailers with state-of-the-art electronic equipment, attractive point-of-sale lottery materials, and marketing assistance.

The up-front cost prospective retailers are required to put up is minimal. In Ohio, a new lottery retailer submits a $25 onetime licensing fee to the government and is responsible for any internal wiring needs in regard to electrical outlets, if necessary. Also, there is a $12 weekly communication charge for selling lottery products. Furthermore, a new retailer is required to obtain a surety bond, which typically costs $15 per thousand dollars of coverage. Most retailers are required to carry a $15,000 bond, depending on past lottery sales amounts. Ohio lottery retailers earn a 5.5% commission on tickets sales, plus up to 1.5% on cashing winning tickets. According to the Ohio Lottery, the average lottery retailer sells $250,000 in lottery tickets and makes about $15,000 a year in commissions.

Selling lottery tickets is straightforward, and most state governments provide free training to lottery retailers. There are several especially favorable reasons for selling lottery tickets. First of all, it has a high rate of return per square inch of counter space in comparison to other products. A retailer requires relatively little shelf space needed for the lottery to achieve a high dollar sales volume. According to the Florida Lottery, Florida Lottery retailers average a **$1,547** gross margin per square foot. Therefore, selling lottery tickets is highly rewarding.

Second, unlike most items sold in convenience stores, such as food and newspapers, lottery retailers don't have to deal with inventory expiration for draw lottery games. As for the instant lottery games, the task for restocking is relatively simple, and the need for restocking is infrequent. This saves lottery retailers a great deal of restocking time. Another benefit of managing instant lottery inventory is that expired instant lottery tickets can be returned for a full refund, which minimizes the risk of holding inventory.

Third, lottery retailers don't have to have their capital tied up with draw lottery tickets, which means that there is almost no inventory holding cost for selling draw lottery tickets.

Fourth, there is no risk of supply shortage for draw lottery games and a minimal risk for instant lottery games.

Selling lottery tickets helps boost customer traffic and increase demand for other items. The Georgia Lottery did a study and concluded that approximately 80% of lottery players buy an additional item when making their lottery purchase. In Florida, the average customer who comes to buy a lottery ticket spends $10.35 in the store compared to $6.29 for non-lottery customers.

States have recently employed technology to sell lottery tickets directly to customers, thus bypassing the traditional retailers, as discussed in Section 2.1. This represents the most serious

threat to the lottery retailers. Moreover, the competition among the lottery retailers has become very intense. For example, New Jersey has over 6,000 lottery retailers statewide.

CONCLUSIONS

This paper provides an in-depth look at three major parties of the lottery industry, namely governments, lottery players, and retailers. State governments have, for years, relied on lottery money to fund education and other expenses. We examine the economic benefits as well as the societal costs of operating the lottery business. We also discuss ways that states have employed to increase lottery demand and propose pricing as a means to stimulate demand during drawings with low jackpots. From the lottery players' viewpoint, we show how to statistically determine the expected value of a lottery ticket and discuss when to conclude it is profitable to buy lottery tickets. Moreover, we explore the question of whether lottery players are rational. Finally, we examine the opportunities and threats of selling lottery tickets from the retailers' viewpoint.

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