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Abstract

Lotteries operate today in several countries in the whole world. This type of gambling is often run by governments and is sometimes described as a regressive tax. As lottery is an unfair bet, the purchase of lottery tickets by consumers who are generally risk-averse has been a challenge for economic theory. Thus, lotteries can be analyzed from either of two economic perspectives: as a source of public revenue or as a consumer commodity. In this paper the state of economic research on the demand for lotteries is reviewed focusing on its main empirical findings.

Keywords: Lottery, regressive tax, effective price, jackpot.
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1. Introduction

Lottery is a type of gambling which involves the drawing of lots for winning a prize. Currently, lotteries operate in several countries in the whole world. Some of the largest lotteries are those in Spain, United Kingdom, Ireland and several Australian and US states[2]. Usually they are operated by governments for profit and the high amounts extracted may be regarded as coming from an implicit (and regressive) tax (Clotfelter, 1987).

Apart from the United States, lottery dominates most gambling markets[3] for a number of reasons. It is a very simple game that does not require specific knowledge such as is needed for other gambling activities like sports betting. This makes lottery gambling much more accessible than other forms of gambling and therefore it is to be expected that participation rates are higher than for other modes.

Although the basics are the same, modern lotteries include many different formats and may be known by different names. The main ones are, among others, the Draw (passive) Lottery, where tickets are pre-numbered and prizes are already set in advance, so the role of the player is limited to buying the ticket; active or semi-active lottery games as Lotto-type games[4], where the player selects a set of numbers which are entered into the draw, or Numbers games, where he attempts to pick three or four digits to match those that will be randomly drawn; and Instant lotteries or Scratchcards where the player scratches a latex-based play surface to determine if the ticket is a winner or a loser, instantly. In addition, with the explosion of the internet, several online web-only lotteries and traditional lotteries with online payments have surfaced.

Given the popularity and growth of lotteries, the interest in the field of economic analysis in this form of gambling has been growing rapidly. There are several arguments why the economic analysis of lottery gamble seems to be very interesting. Lottery is a very important economic industry from which either local or national governments obtain resources due to some sort of fiscal imposition on lottery participation. On the other hand, although the consumption of lottery tickets violates the premises of economic theory (risk aversion, maximizing and rational conduct) lottery probably is the most popular gambling game. Risking small sums of money for the chance to win a very big prize attracts many players. So economic analysis could provide information about whether the demand for lottery games responds to expected return, as maximizing behavior predicts, or whether the remote chance of winning a life changing sum is the single feature players take into account. Lotteries can thus be analyzed from either of two economic perspectives: as a source of public revenue or as a consumer commodity.

As lottery games have grown in popularity, the demand for these products has received considerable attention. A wide international literature exists on the economics of

[2] For a survey of US lotteries see Clotfelter and Cook (1989).

[3] In the particular case of the Spanish lottery, the sales of lottery tickets overcame 9.4 thousands of million Euros in 2007; over the 94% of the whole of the expense in games managed by the government and about a 30% of the whole of Spanish gambling expense.

[4] It is also known as the Genoese format and is the largest source of revenue for the European lottery organizations.

lotteries that tries to explain its importance for tax revenue or to understand the gambler's behavior. In particular, several papers have dealt with the analysis of the demand for the main lottery games offered across the world. Demand for lottery determines who buys lottery tickets and in what quantities. The empirical literature on this field has tried to answer several questions that might be summarized as follows: who does play lottery games? why do people buy lottery tickets? and, how do game features – such as the rules or the prize structure – affect the demand for lottery tickets?

This paper is organized as follows. The next section describes the structure and operation of the main formats of lottery. Next, the empirical research on participation and tax incidence of lotteries is reviewed. An overview of the main economic determinants of the demand for lottery is considered in following sections. Later, the economics literature on the response of players' behavior to exogenous events as well as the role of some statistical fallacies in the demand for lottery and the coexistence of many competing lottery games are reviewed. Finally, some relevant conclusions are drawn.

2. Lottery games

The seminal paper of Sprowls (1970) proposed three measurable characteristics that can describe a lottery gamble: the expected value[5], the probability of winning a prize, and the inequality of the prize distribution[6]. In addition, lottery games take different formats according to the player's role and the way the lottery is run.

With a relative important weight in worldwide annual lottery sales, draw games are fairly universal - with the exception of the United States and UK - and remain an important part of the lottery industry. Draw lotteries are considered passive games because the tickets are pre-numbered and the player cannot choose the numbers but buys the ticket, or a fraction of it, and waits for the draw that would indentify the ticket as a winner. Selling periods are usually long between draws and prizes are set in advance and do not increase depending on sales.

Lotto-type games differ from draw lotteries since they are pari-mutuel games in which the expected monetary value of a ticket depends on sales. It is a very simple game where a player must guess n numbers out of a set of m numbers regardless of the order and prizes are awarded according to how many of the numbers in the winning combination they have chosen[7]. When several players win, the prize is shared among them. So, Lotto-type games are active games which allow players to choose their own

[5] The lottery is an unfair bet. The total amount paid out in prizes is less than the total revenue derived from the sale of tickets. The difference between these two is the expected loss while the expected value refers to the mathematical expectation of the prize distribution that players buy in the form of a ticket.

[6] The general prize distribution of a lottery is a structure with one top prize (jackpot), several smaller prizes and very many small prizes, often equal to the nominal price of a ticket or usually flat prizes.

[7] Most of the modern lotto-type games are variations of the pari-mutuel lotto design in which the structure of the game is basically defined by the number of digits the player chooses and the size of the matrix of available numbers. For example, in a 6/49 lotto game, a bettor chooses 6 numbers without replacement from a matrix of 49. In this particular case the odds of matching the winning combination are 1 in 13,983,816.

numbers, affecting demand by giving players the "illusion of control"[8], whereby players believe that they can choose winning numbers through skill or foresight.

The same as occurs in the numbers game wherein the bettor attempts to pick three or four digits to match those that will be randomly drawn. In this type of lottery winning numbers are set by the outcome of a random drawing of numbered balls. But numbers games are usually fixed odds rather than pari-mutuel.

Lotto games also differ in respect of the structure of the prize pool - with a top prize (jackpot) and several small prizes -. If there are no winners of the top prize, it is added to the top prize in the next draw – this event is known as a rollover - so, in lotto games it is possible for top prizes to accumulate to very large amounts[9]. Thus, as is proposed in Walker (1998), lotto is intrinsically more interesting than other lottery formats because of the variation in jackpot size that it offers. The face price of a unit bet is also different among lotto games, but it usually does not vary for any one game over long periods of time. Drawing frequency also distinguishes different lotto games.

An instant drawing frequency is given in instant lotteries. In these games there are no centrally drawn numbers and the prize structure is set in advance. The player's role is limited to scratching a latex-based surface to determine if the ticker is a winner. The variety of scratch games is endless.

Lottery tickets could be considered to be financial assets with risk where the prizes are considered as the returns to a certain investment (the price of a bet). In most lottery games, the takeout rate (the share of the revenues that is not distributed as prizes) ranges from 0.3 to 0.5, so if lottery players are rational, wealth maximising, risk averse economic agents, it is difficult to explain why lots of people play the lottery.

Thus, every time someone buys a lottery ticket, common assumptions in economics appear to be violated. However, lotteries exist and their worldwide popularity increases more and more.

3. Lottery participation and tax incidence. The 'state lotteries'

Discussion about who plays the lottery is very interesting not only from the point of view of market analysis but also from the perspective of public policy. Since most of the lotteries are managed by the government, the takeout rate can be understood as including a large implicit tax on bet price. So it would be interesting to study the impact on the relative distribution of income among the population to assess whether the implicit tax is progressive, neutral or regressive.

[8] "Illusion of control" is the tendency for human begins to believe they can control, or at least influence, outcomes that they demonstrably have no influence over.

[9] In 2007 lotto games in Spain gave out over 2 thousands of million Euros as prizes.

As several US states have introduced lotteries as a way to increase their budgetary income[10] a line of research examines the economic and social implications. Most early studies focused on the relation between state lotteries and fiscal issues[11], but also socioeconomic features of lottery expenditures have received attention in an attempt to analyze the characteristics of the people who play lotteries. However, only nonprice determinants of lottery demand, such as income, education, marital status, race and gender, were taken into account in this seminal research[12].

Regarding the tax incidence of the implicit tax from public lotteries, the main conclusion reached in these studies analyzing the relationship between lottery play and (household) income is that the lottery is regressive, in the sense that as a percentage of income, tax payments decline as income increases (Clotfelter and Cook, 1990).

Thus, Spiro (1974), Suits (1977) and Clotfelter (1979), using information on the characteristics of players from a number of sources- including several household surveys- find evidence of a regressive tax in several individual state lotteries. Clotfelter (1979), relating income to sales of daily and weekly tickets in Maryland, estimates negative and less than one income elasticities. Also, Brinner and Clotfelter (1975) show at a state level that families with low incomes spend a higher percentage of their revenues on public lotteries than families with the highest incomes. Even where these studies differ in empirical approach and in the use of aggregate or survey data, this regressive pattern persists. Clotfelter and Cook (1987, 1989) use individual data to analyze the regressive character of the implicit tax on lottery games, and later, Borg and Mason (1988) find that age, race, and place of residence affect the propensity to play the lottery and confirm the regressive character of the lottery implicit tax. However, Mikesell (1989) questions the conventional wisdom about the regressive character of the lottery. This paper show that estimated income elasticities for instant games and on-line games in Illinois are not statistically different from one.

A good early survey of the literature on states lotteries is in Clotfelter and Cook (1990)[13] where the importance of state lotteries as consumer commodities or sources of public revenue is discussed. Clotfelter and Cook's papers constitute the starting point of several studies on the determinants of the decision to play lottery as well as on those which influence the amount of a player's expenditure. They conclude that lottery play is systematically related to social class, although perhaps not always as strongly as the conventional wisdom would suggest. However, Jackson (1994), in the case of the Massachusetts lottery, provides additional evidence on the relationship between the purchase of several lottery games and income and demographic variables through time. This paper shows a less than one elasticity of income for each game studied and

[10] The propensity of states to adopt lotteries as a source of additional revenue is analyzed in Davis, Filer and Moak (1992).

[11] A current analysis of this relation in the case of the state programs of lotteries in the United States can be found in Glickman and Painter (2004).

[12] A thorough summary of this literature is in Clotfelter and Cook (1989) which provides a comprehensive description of legalization, provision, marketing, and implicit taxation of state lotteries.

[13] Clotfelter and Cook (1990) also deal with other topics on the demand for lottery as the analysis of the effect of changing prices and payoffs on lottery expenditures. They derive the relationship between the expected value of a lotto bet and sales and rollover, but they focus their analysis in economies of scale.

concludes that, in later years, the lottery was a regressive source of government revenue because per capita sales for each of the games did not increase proportionately with income.

This increasing interest in lottery participation and tax incidence continued as economic analysis of state lotteries extended beyond the United States. Thus, Kitchen and Powells (1991) evaluate the statistical significance of several socio-economic and demographic variables on the level of household lottery expenditures in the six regions of Canada, while Worthington (2001) considers demographic factors in the analysis of several gambling activities in Australia. In both papers lottery expenditures are - as in the case of the states - found to be regressive. However, these findings differ from other Canadian studies (Livernois, 1987) in which the income level is not found significantly to influence lottery expenditure.

Following Mikesell (1989) and Worthington (2001) the analysis of the socioeconomic incidence of lottery taxation employs several empirical approaches to identify the relationship between lottery expenditures and income: research based on data collected from questionnaires (Scott and Garen, 1994) or a winners' survey[14] (Spiro, 1974; Borg and Mason, 1988), analysis of lottery sales by geographic area with census data used to infer the economic characteristics of players (Clotfelter, 1979; Price and Novak, 2000), papers that investigates the income incidence of lottery taxation assuming demand homogeneity across states, counties, communities or zip codes[15] (Brinner and Clotfelter, 1975; Mikesell, 1989; Clotfelter and Cook, 1987; Davis, Filer and Moak, 1992**;** Jackson, 1994), and studies that use household expenditures surveys to analyze tax incidence (Kitchen and Powells, 1991; and Worthington, 2001).

Table 1 summarizes some of the empirical studies where lottery expenditures are regressed on income and several socioeconomic and demographic variables in order to estimate the effect of the lottery on the income distribution. There is remarkable consistency in these studies of the regressive character of lottery[16].

Most of these papers use a Probit model to estimate the effect of explanatory variables on the probability that an individual plays lottery games and a truncated Tobit model to estimate the amount that an individual spends on lottery tickets as a function of these variables conditional on participating at all. However, Scott and Garen (1994) and Stranahan and Borg (1998), among others, raise important model specification issues. Thus, Scott and Garen (1994) propose that estimation of a demand function for lottery tickets requires a maximum likelihood procedure instead of a Tobit model. They use sample selection methods not previous utilized in this literature and find that income, in the presence of other socioeconomic and demographic variables, has no apparent impact on how many tickets lottery players monthly buy. Stranahan and Borg (1998) follow a similar procedure examining how demographic differences affect lottery tickets purchase, focusing on the horizontal equity of the lottery tax. Income is found to have a

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[14] As Mikesell (1989) explains, winners represent a random sample of lottery players because winners are randomly selected from all players. In this type of analysis, data for lottery play, income, and other attributes are obtained from a survey of those winners.

[15] These studies focus on "instant" (or "scratch") lotteries.

[16] The one exception is Mikesell (1989) which found lottery taxes to be proportional.

negative and significant effect on the probability of playing lottery but does not affect lottery expenditure conditional on participation.

There is an argument that regressivity should be measuring by estimating expenditure as a function of income with no controls – e.g. if education is included in the estimation positive income elasticity might be found even though richer people (typically highly educated) buy fewer lottery tickets -. This point is supported by Kearney (2005).

A complementary literature analyzes the redistributive effects of spending from the proceeds of public lotteries in the United States and Canada where this is often for specific purposes set out when the lottery was first approved. Johnson (1976) dealt with this question analysing the effects of some lotteries introduction in terms of efficiency and equity. The analysis of the impact of lottery funded spending continued with Livernois (1987) in the case of western provinces of Canada, where is usual to fund recreational and cultural activities from the lottery.

In the case of UK National Lottery, Feehan and Forrest (2007) reported that sports, cultural and heritage grants from lottery went disproportionately to high income areas. They provided evidence showing lottery spending to be regressive as well as lottery tax.

4. Temporal and spatial effects. Looking for price determinants

Overall, the papers mentioned above dealt with the estimation of demand functions for lottery using cross section data and including nonprice determinants. As explained in Gulley and Scott (1993), that is because there is usually no change in the nominal price of a lottery ticket over long periods of time: states typically do not vary the take-out rate over time nor does it vary much across states[17].

Farrell and Walker (1999) use cross section information taken in different weeks to allow for the effective price of a lottery bet to be included as explanatory variable together with income and demographic variables. This makes it possible to estimate price and income elasticities[18]. The income elasticity determines - as in previous papers - how regressive (or otherwise) a lottery is, while the price elasticity gives relevant information in terms of efficiency. They found low income elasticities and high price elasticities and concluded that the former implies that taxing lotto is regressive while the latter implies that is inefficient[19].

Before Farrell and Walker (1999), earlier papers had considered rollover-induced changes in the expected value of a lottery ticket to infer a price elasticity of demand using aggregate time series data (as in Gulley and Scott, 1993; or Farrell et al., 1999).

[17] Some empirical analyses of lottery sales have included the takeout rate as explanatory variable. Vrooman (1976), Vaasche (1985) and Mikesell (1987) all find no significant link between the takeout rate and sales. A likely problem for these studies is the endogeneity of takeout rate.

[18] The price elasticity of demand for lottery tickets shows how demand varies with the expected values of the return from a ticket. See Scott and Gulley (1995) for further discussion of the relationship between sales and expected value in lotto games.

[19] A critic to this paper has to do with small variability of effective price variable – only two observations in time – in terms of the identification and estimation of price elasticity.

Gulley and Scott (1993) show that because of the rollover feature in lotto games, the effective price of a bet can change dramatically from one drawing to the next, and estimate on a drawing-by-drawing basis a demand function including the effect of this price variation. However, time series analysis is not able to identify the income elasticity because there is such little variation in income over a relatively short run of data.

The information available at different levels (state, city or zip code level) together with the increasing interest in controlling for the effective price effect has improved the development of studies through time in order to estimate both the effective price and the income elasticities.

Regarding the spatial analysis of the demand for lottery, information on regional variation of the determinants of lottery expenditure is largely ignored in the literature. With the exception of Kitchen and Powells (1991) in the case of the Canadian regions, few previous papers had dealt with the analysis of variables affecting the level of lottery expenditure across regions. Some of them use cross-section data to estimate income elasticities at zip level getting a soft idea of demand spatial distribution, while others, as Barr and Standish (2002), just analyze the optimal location of gambling activities. Moreover, in both cases the effect of economic variables such as the effective price or the jackpot on the demand for lotto is not considered.

The availability of panel data information is necessary to estimate demand models in which both, price and geographical effects, are included. Thus way, Oster (2004) was able to use a panel data set at zip code level to analyze how the regressivity of lottery varies according to the prize level. He finds that lottery could be less regressive at higher prize levels.

In addition, several papers carry on with the analysis of the demand for lotteries, studying the dependence of sales on certain population features, analysing if lottery displace other forms of gambling, or testing whether the demand for lotteries responds to expected returns (Garret and Sobel, 2004; Garret, 2001; or Layton and Worthington, 1999).

5. Prospect theory and expected utility. Why do people play the lottery?

The purchase of lottery tickets by consumers who are generally risk-averse constitutes a problem for expected utility theory (Quiggin, 1991). Lottery tickets could be considered to be financial assets with risk, where prizes are taken to be the returns to investment, and also as providing entertainment. Thus, analysis about why people play lottery games has not been the concern of economic analysis only: psychologists and sociologists have also paid attention to this topic. Since most lotteries offer unfair bets[20] - the average payout rate is around 50% - the question about why risk-averse consumers purchase lottery ticket is meaningful.

Clotfelter and Cook (1989) use responses from surveys of players to formulate their hypotheses: some bettors play for fun while others play hoping for monetary gain.

[20] Thaler and Ziemba (1988) show that in presence of large jackpot, most likely due to accumulating rollovers, it is possible to place a bet with a positive return, but it is rare.

Having said that, all the contributions on this question might be summarized in three alternative theoretical approaches, with different normative implications, that try to explain why people play; but surely, the hope of private gain is what sells the bulk of lottery tickets (Clotfelter and Cook, 1990).

5.1. The Friedman-Savage explanation

The idea is that the individual's utility function in wealth is not strictly concave. Rather it is initially concave, then becomes convex, and finally returns to being concave. So an individual takes his decision to play in an area at a level of wealth where winning the prize would project him through a range of wealth where the utility function in which they are risk lovers, for what they are ready to accept unfair bets. This approach is based on Friedman and Savage (1948) that also focused on wealth as the key variable determining the willingness to assume risk. However, this theory cannot explain why people play several times and why play is not concentrated on the part of distribution where such non-convexities are most commonly observed (Walker, 1998).

5.2. Prospect Theory

Kahneman and Tversky (1979) explain that individuals, instead of taking decisions according to the true probabilities of getting the top prize, tend to overweight small probabilities. So their decisions are different from those expected on the basis of expected utility theory. *Prospect theory* makes consumer behavior consistent with the fact of playing lottery (Camerer, 2000).

5.3. Entertainment Utility or the Pleasure of Gambling

This approach (Conslik, 1993) argues that the decision to bet or not does not depend only on expected utility of wealth, but also on an additional term representing utility (entertainment) derived from the simple fact of playing lottery. As mentioned in Scott and Gulley (1995), in addition to the monetary return from the bet, there also exists a nonmonetary return, i.e., the value derived from watching the numbers being drawn on television, discovering whether an instant ticket is a winner, thinking of how any prize money would be spent, or discussing lotto strategy with workmates. Thus, for some people, playing the lottery is an amusing pastime (Clotfelter and Cook, 1990). In this case it is possible to prove that consumers averse to risk could decide to bet (Le Menestrel, 2001).

This last view seems relevant to lotteries where the stakes are invariably small and tickets are widely available. Explaining lottery participation by the non-pecuniary pleasure derived is also compatible with empirical evidence that participation occurs throughout the income distribution (Walker, 1998). Furthermore, the conscious selection of numbers in lotto games may increase fun in several ways[21].

[21] Conscious selection exists when bettors exhibit preferences for particular combinations of numbers such as key dates – birthdays and anniversaries – or numbers sequences – such as 1 through to 6 -. This would generate fun even if preferences were uncorrelated across bettors.

From an empirical point of view, the main question arising from these approaches is whether consumer demand for lottery games responds to true expected returns, as maximizing behavior predict, or whether consumers seem to be misinformed about the risks and returns of lottery games. Some analyses of lottery sales have included the takeout rate as an explanatory variable (Vrooman, 1976; Vasche, 1985; Mikesell, 1987, DeBoer, 1986; Clotfelter and Cook, 1989) which tests whether consumers are responding to actual expected values.

The principal studies in lottery demand focus on whether changes in the takeout rate could increase the funds raised for governments through affecting sales. DeBoer (1986) using panel data for some state lotteries from 1974 to 1983, finds a significant negative effect of the takeout rate on sales. Clotfelter and Cook (1989) also find this negative effect in an alternative approach using a cross-section of states lotteries in 1986. However, Vrooman (1976), Vasche (1985) and Mikesell (1987) did not find a significant relationship between the takeout rate and sales.

Several researchers have presented estimates of the expected value from a lottery ticket starting with Clotfelter and Cook (1989) and including DeBoer (1990), Shapira and Venezia (1992), Gulley and Scott (1990) and Matheson (2001).

Although the price of a bet itself does not usually vary, what varies considerably from drawing to drawing in lotto games are prizes - due to variation in participation or rollovers -. The most common approach in the empirical literature on the demand of lotto employs the “effective price” model (Cook and Clotfelter, 1993, Gulley and Scott, 1993; Scott and Gulley, 1995; Walker, 1998; Farrell and Walker, 1999; Farrell et al., 1999; Forrest et al., 2000b). The effective price model, based on expected utility theory, has been the most frequently used in this type of analysis. In this model the lottery tickets or coupons are considered to be financial assets with risk and the prizes are considered as the returns to a certain investment (the price of a bet). The effective price of a bet is then defined as the difference between the nominal value and the expected prize.

As the face value of a ticket is usually fixed, variation in the effective price can be identified from changes in expected value (return)[22]. Thus, Scott and Gulley (1995) find that in general lottery bettors’ decisions to play generate a level of sales linked to their forecast of expected value. Gulley and Scott (1993) and Farrell and Walker (1999) also include the expected value in their studies[23] and, in addition, Farrell et al (1999) identify price elasticity though changes in the expected value of holding a ticket. Furthermore, if the demand for lottery is estimated on a drawing-by-drawing basis, a price variable can be included on the right-hand side (Gulley and Scott, 1993). This way, a true demand function could be estimated[24].

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[22] The determination of the expected value of holding a lottery ticket was first derived in Sprowls (1970) and has subsequently been used in Scogginns (1995), Cook and Clotfelter (1993), Gulley and Scott (1993), Lim (1995), Farrell et al. (1997) and Farrell and Walker (1999).

[23] Farrell and Walker (1999) use the expected value to identify the price elasticity using cross section data pooled across regular and rollover draws in the UK.

[24] Gulley and Scott (1993) examine the demand for lottery tickets and use this procedure to assess demand elasticity for the lottery sales in four US states.

Consider the simple case where there is only one prize and where we assume a unit price for each bet to simplify the presentation. Following Cook and Clotfelter (1993) the expected value (EV) of a bet is the amount of the prize adjusted by the probability of having a winning ticket and divided by the expected number of winners. Farrell et al. (1999) reinterpret this expected prize as the value of the total amount of prizes (the maximum prize or the jackpot (J) in this case) multiplied by the probability of having at least one winning ticket (1-P) and divided by the total number of tickets sold (A), i.e.,

$$EV = (1 - P)\, J/A \qquad [1]$$

with the jackpot defined as

$$J = B + (1 - \tau)\, A \qquad [2]$$

where B is the rollover from a previous fixture without winners, τ is the *take-out rate* (the share of the revenues that is not distributed as prizes) and P is the probability of not having a winner ticket.

The expected value of a lotto ticket depends on several factors such as the structure of the game – the probability of winning -, the value of previous jackpots rolled over into the current jackpot, and the number of tickets bought. The expected value will vary from drawing to drawing due to sales and rollover variation[25] because the odds structure of the game does not usually change from drawing to drawing[26]. A problem of this approach is that rollovers are expected to occur with relative infrequency. Surprisingly this usually has not been the case for most lotteries. Farrell et al. (2000) show that one reason for this is that players appear to select their numbers in a non-uniform way. This leads to a lower coverage of the possible combinations of numbers increasing the probability of a rollover occurring[27].

Since the "effective price" is the mathematically expected price buyers could calculate if they are able to predict sales and all of them choose numbers randomly (Forrest et al. 2002), it cannot be observed *ex ante* (the expected value of the bet's payoffs depends on the behavior of other bettors and is determined by current sales, which are only known *ex-post*), researchers using this model argue that bettors form their rational expectations[28] of the "effective price" using all the available information – such as sales

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[25] Rollovers generate systematic variation in the level of sales across draws because a rollover induces an exogenous change in price that causes a movement along the demand curve. This allows the occurrence and size of rollovers to be used as instruments to determine effective price in most empirical approaches to modeling lotto sales.

[26] Scott and Gulley (1995) try in practice to answer which is more important in determining expected value, sales or rollover?; and Cook and Clotfelter (1993) find that rollover-induced variation in the expected value of a ticket is an important determinant of sales.

[27] Most empirical papers on demand for lotto consider the case where players are assumed to select their numbers uniformly. Cook and Clotfelter (1993), speculate that the theoretical structure of the game is unchanged if individuals pick their numbers non-randomly – "conscious selection" -, and Farrell et. al (2000) show that "conscious selection" has minimal impact on the estimated elasticity.

[28] The concept of rational expectations assumes that economic agents make the best possible probability assessments of key economic variables based on the information available to them.

in previous draws, trends in sales, and the amount rolled over from previous drawings - and they must then project expected value based on what they think other bettors will do (Scott and Gulley, 1995). The concept of rational expectations has typically been assumed in the analysis of consumer demand in betting markets. This argument is supported by Forrest et al (2000a) using information for the UK National Lottery.

The probability of not having a winning ticket (P) is:

$$P = (1 - \pi)^{A} \qquad [3]$$

Notice that P decreases with both the number of tickets sold (A) and the difficulty of the game (π) - the probability of having a winning ticket -. Also, according to the definition of the jackpot in expression (2) the expected prize increases with the amount of the rollover and decreases with the take-out rate. The difficulty of the game has a negative effect on the expected prize.

On the other hand, the expected value of a lottery ticket depends not only on the rollover and the share of the revenue allocated to the prize pool[29], but also on the total amount bet by other players. So there are two externalities from adding a bet: a positive one, raising the jackpot available, and a negative one, increasing the probability of sharing the prize if winning. Cook and Clotfelter (1993) refer to the "Peculiar Scale Economies of Lotto" and conclude that adding another player to the pool increases the expected value of a bet, the first effect dominates the second. This paper analyzed the lotto sales of 17 US states using a cross-sectional procedure and found that sales increase with the scale of operation, presumably because sales are mainly sensitive to the size of the jackpot.

Forrest et al. (2002)[30] question the validity of the "effective price" model. As the effective price model is based on total expected prize payouts it does not take account of possible consumer preferences with regard to the structures of prizes. Furthermore, the explanatory variables in these models do not explain why bettors accept an unfair gamble[31]. Therefore, they propose an alternative model to explain the demand for lotto.

The "jackpot" model follows a more direct approach to why people buy lottery tickets, assuming that fun or pleasure is derived from gambling activities. It is based on a previous idea by Clotfelter and Cook (1989) who consider that bettors are buying a hope (or a dream) each time they buy a ticket and that hope has to do with the amount of the jackpot. The "jackpot" model proposes not to use the effective price but the amount of the top prize as the main economic variable affecting the number of bets

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[29] Scoggins (1995) find that expected net revenues will be increased by allocating a greater percentage of sales to the grand prize.

[30] Forrest et al. (2002) test whether the effective price or the jackpot better explains the demand for lottery.

[31] Quiggins (1991) argues that with regards to lottery tickets, there is no acceptable explanation with risk aversion and conclude that the only reason for betting is the chance of winning a large amount of money.

played[32]. Because the chances of winning a large prize are usually known to be very remote bettors do not really expect to win but enjoy the dream of spending the prize that could be won. This explains how variation in sales is not affected primarily by the effective price but rather by the jackpot.

Most of the studies on demand for lotteries reported in Table 2 use a two-stage least squares procedure for modelling time-series lotto demand. Since rollovers cause most of the variation in effective price, their frequency and size are the most used instruments in these studies. The empirical findings show, as one might expect, a standard negative relationship between effective price and sales and a statistically significant and positive effect of the jackpot on sales. In addition, most price elasticities are estimated to be around minus one in the long-run.

Apart from price, rollover, and jackpot, other influences on lotto demand such as time trend, structural changes or special events or draws are included in most of these studies. The goodness of fit is always high.

Alternatively, the jackpot model could be interpreted as players buying consumption benefits from the lottery as well as a monetary return, where the benefits of "buying a dream" are related to their perception of the third moment of the lotto's payoff. The theoretical basis of this argument is justified in the sense that the expected utility does not only depend on the expected effective price and its variance, but also on the third moment, which implies that risk averse individuals could still accept unfair bets (Golec and Tamarkin, 1998). Furthermore, if consumers are misinformed, their demand for lottery might respond to the top prize, but would not systematically respond to the expected value of the bet. Including the first three moments of the prize distribution in the analysis[33] is equivalent to allowing variations in the top prize to affect the decision to buy independent of its contribution to the effective price. Note that including higher moments of the prize distribution is justified even without consumption benefits. The individual who buys an investment will consider more than the first moment if his utility of wealth function is non-linear.

These models ("higher moments" models or "jackpot" models) propose a new framework in which changes in the prize structure relating to lower prizes, even if they do not change the effective price, nevertheless affect the number of bets[34].

Regarding this, it is important to estimate how demand for lottery responds to changes in the statistical moments as well as to differences in game characteristics. As the effective price model and the jackpot model have different implications in terms of the demand for the lottery, each model could be catching a different view of bettors behaviour, and the variables included respond in a different way to changes in the

[32] A number of papers also deal with the relationship between jackpot size and lotto sales including DeBoer (1990), Shapira and Venezia (1992), Gulley and Scott (1990), Scott and Gulley (1995), and Matheson (2001).

[33] See Garret and Sobel (1999), Walker and Young (2001) and Wang et al (2006´) to find examples in which the third moments of the effective price are included in the specification of the demand function.

[34] However, if more (or less) of the pay out is for the jackpot, effective price will fall (or rise) because more money is used for a prize which might not be won

structure of prizes, García and Rodriguez (2007) suggest an alternative model in which both variables, the effective price and the jackpot, are included.[35]

6. Spread findings, statistical fallacies and competing lottery games.

From the beginning of the analysis of state lotteries in the 70s and 80s, including the seminal empirical papers on the determinants of the demand for lottery in the 90s, most of the studies have been applied to the particular case of lottery-type games in the United States (or Canada) and the United Kingdom. Nevertheless, the current trend of the empirical research is based fundamentally on the application of demand for lottery models, the "effective price" model, the "jackpot" model or the "higher moments" model, to many lotteries around the world in order to capture the effects on the demand for lotto of ticket pricing, jackpot announcements or prize structure. Other relevant influences on demand for lotto such as exogenous events affecting players' strategy are taken into account in many of these recent papers. Table 3 shows some of the empirical papers in this respect.

Beenstock and Haitovsky (2001) test Shapira and Venezia's (1992)[36] findings using time series data to estimate a demand function for lotto in Israel. They find a direct and positive effect on sales from increases in the announced jackpot and an inverse relationship between sales and the price of a ticket. Concerning the prize structure a preference for multiplicity is observed[37]. As will be discussed later, they also investigate the presence of psychological phenomena affecting this demand.

The effect of changes in the probability of winning on the size of the prize in a certain category is analyzed by Lim (1995) in the particular case of lotto in Australia. He also pays attention to the hardly discussed dependence of the expected value of a lotto ticket on the rollover.

Papachristou and Karamanis (1998) analyze the Greek market for the 6/49 lotto under the assumption of random number selection. In a later paper, Geronikolau and Papachristou (2007) deal with optimal pricing rules in Greece. Both models proposed m in the empirical literature, the effective price model and the jackpot model, are estimated and the corresponding point elasticities are calculated on the basis of the time-series of a 5/45 + 1/20 lotto game (*Joker*). This paper finds that lottery demand in Greece is twice as elastic as in any other game, so the game appears to be overpriced as compared to international standards.

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[35] They estimate a demand equation for football pools in Spain merging the traditional economic models in the lotto demand literature: the effective price model and the jackpot model.

[36] Shapira and Venezia (1992) use an experimental procedure to investigate the effects of ticket prices, the probability of winning, and the prize structure on the demand for lotto in Israel. They find that larger jackpot are preferred to larger secondary prizes, and more frequent secondary prizes are preferred to lower ticket prices. Clotfelter and Cook (1990) focused on the analysis of the effect of changing price and payoffs on lottery ticket sales, and later, Quiggin (1991) deals with the optimal prize structure in lottery design and asks whether it is better to have a single prize or a multiplicity of prizes.

[37] When a sixth prize is introduced an increase in sales is observed, while the decision to lower the share of the second prize induced a decrease in sales.

In addition, several lotto games in continental Europe are also analyzed in the literature, including the Austrian Lotto 6/45 (Hauser-Rethaller and Köning, 2002), the German Lotto 6/49 (Henze, 1997) and the Swiss Lotto (Henze and Riedwyl, 1998). Lin and Lai (2006) extend the analysis to lotto in Taiwan.

Hauser-Rethaller and Köning (2002) deal with the empirical study of demand for lotto in Austria and try to calculate implicit price given the evidence of "conscious selection", i.e. players choosing numbers non-randomly. They conclude that accounting for "conscious selection" leads to higher elasticity estimates. The existence of preferred numbers is also analyzed in Henze (1997) for the German 6/49 lotto and in Roger and Broihanne (2007) in the case of the French lottery market.

The effective price elasticity of a lotto type game (Big Lotto) in Taiwan is examined in Lin and Lai (2006). They use the same method as Gulley and Scott (1993) and Scoggins (1995) to calculate the effective price and find the expected negative relationship between effective price and number of tickets sold in Taiwan lotto. The estimated effective price elasticity is -0.145, so they recommended increasing the effective price in order to increase revenues from lotto.

The empirical literature in economics has also dealt with other topics in the demand for lottery including several empirical phenomena that are apparently inconsistent with expected utility theory. People facing choices under conditions of uncertainty are quite often subject to several statistical fallacies. Accordingly many variables to represent bettors´ changing behaviour over time and their response to exogenous events have been considered in research on demand for lotto. Thus we can find studies on "lotto fever" (it occurs when an increase in ticket sales reduces the expected value of a lottery ticket despite a higher jackpot) as in Matheson and Grote (2004)[38], "lottomania" (the effect on the demand for lottery induced by the rollover over and above that through its effect on the effective price) or "prize fatigue" (when demand decreases though the announced jackpot does not change), both analyzed in Beenstock and Haitovsky (2001), or the importance of non random selection –"conscious selection" – in numbers betting that implies that certain numbers or combinations (memorable dates, birthdays, superstition, etc.) have more probability of being bet. Many researchers have shown that gamblers prefer numbers they choose themselves because this choice allows them to feel more in control of the (random) outcome (Goodman and Irving, 2006).

In gambling activities, people may believe that the history of a purely random event, such as numbers drawn in a lottery game, contains information about its future realization. In fact, some players believe that they can improve their chance of winning by adjusting their bets according to which numbers have won in recent drawings (Clotfelter and Cook, 1991). Several papers, including Tversky and Kahneman (1974), Thaler (1992), Clotfelter and Cook (1991, 1993) or Terrell (1994), have dealt with this

[38] Matheson and Grote (2004) find that "lotto fever" phenomenon is exceedingly rare, occurring in less than 0.1% of all drawing examined. Ticket sales increase due to jackpot size almost never reaches the level of hysteria resulting in a reduction of expected value despite the larger jackpot.

'gambler's fallacy'[39]. Thus, Tversky and Kahneman (1974) found that subjects are guided by a "negative dependence" existing between independent events. Later, Clotfelter and Cook (1991, 1993) supported the existence of the 'gambler's fallacy' in analysis of data from the Maryland lottery numbers game. They found a significant reduction in betting on the same numbers on the day after they win. Terrell (1994) examines the significance of the 'gambler's fallacy' in pari-mutuel games. Recently, Papachristou (2004) investigates the existence of the 'gambler's fallacy' among lotto players in the UK concluding that history marginally affects the number of winning tickets, this could be interpreted as evidence of some lotto players believing in some form of statistical fallacy.

The decision on the numbers to be bet is not irrelevant in lottery games. According to the structure of the lottery the decision of other players will influence own payoff because the probability of the grand prize not being won is sensitive to the way that players choose their numbers. 'Conscious selection' phenomena are analyzed in several papers including Cook and Clotfelter (1993)[40], Walker (1998), Farrell et al (2000), Farrell and Walker (1999) and Hauser-Rethaller and Köning (2002).

Using data from the UK Lottery Walker (1998) finds that non-random selection is shown to exist because different numbers have different levels of popularity. Ziemba et al. (1986) also analyze popular and unpopular numbers and combinations in the Canadian Lotto.

As already mentioned, both the effective price and the jackpot, the main economic determinants of demand for lotto, depend on sales of current drawings. And sales are not known ex-ante by players. Thus, the behaviour of players regarding the purchase of lotto tickets depends crucially on their expectations on sales. Some studies, including Forrest et al. (2000a), test whether players "act rationally" and show evidence that lotto players act rationally using the best information available.

In general, players are in the habit of increasing ticket purchase when the expected return of a bet rises due to a large jackpot while reducing this ticket purchase when the expected return falls. Nevertheless, Farrell et al (2000) and Matheson and Grote (2005) find an unusually high level in lotto sales after a large jackpot has been won. This 'Halo Effect' is also discussed in Grote and Matheson (2007) who offer several explanations for this phenomenon besides the gambler addiction argument.

Farrell et al (2000) investigate addiction among lotto players suggesting that there is quite considerable addiction which is essentially induced by rollovers. Following Becker and Murphy (1988) they estimate a myopic addiction model by including a lag

[39] The 'gambler's fallacy' is the belief that the probability of an event is decreased when the event has occurred recently, even though the probability of the event is objectively known to be independent across trials.

[40] In this paper on Massachusetts Lotto they acknowledge that non-random selection of numbers by lotto players will bias their results but do not attempt to account for these phenomena.

of consumption in the regression of current sales and find that the coefficient on lagged consumption is positive and significant (0.33)[41].

Most state lottery agencies offer a variety of games to suit the tastes of players in order to maximize government revenues (Forrest et al., 2004). Accordingly, a recent strand of empirical research on lottery demand is related to the coexistence of many lotto games with different formats, frequency and prize structures, referring to the potential substitutability or complementarity among these competing lotto games. Gulley and Scott (1993) focus on this question and estimate a demand equation for lotto games in Massachusetts including the expected value of competing lotto games and controlling for the existence of rollovers in other competing games. They find that increasing sales in one game generally does not reduce sales in other games. Forrest et al. (2004) use weekly data from three UKNL – United Kingdom National Lottery – games offered over the considered sample period finding partial substitution between two of the three games analysed. They also found a substantial intertemporal substitution between Wednesday and Saturday drawings of the lotto game. Grote and Matheson (2006) found evidence of complementarities between a single state lotto and a larger jackpot multi-state lotto. Lin and Lai (2006) found no significant substitutive or complementary relationship between Big Lotto and Lotto in Taiwan. An early example of substitution – cross price effects – between different gambling activities is Forrest et al. (2008) in the case of betting and lotto.

Whether a traditional lottery product is substituted by a new product is also tested in the literature. Clotfelter and Cook (1989) deal with displacement and cannibalisation issues and conclude that sales of existing games in the United States have not been hurt by the introduction of lotto games during the 1980s. Stover (1987) finds that contiguous state lotteries are substitutes.

Purfield and Waldron (1999) examine variations in Lotto sales and fixed-odds betting to determine the complementary character of their relationship in the particular case of the Republic of Ireland betting market. Unlike previous studies based on annual data they use semi-weekly, draw-by-draw, turnover data to find that Irish players appear to complement their lotto purchase with fixed-odds bets[42]. Price and Novak (2000) include variables describing expenditures on other games in analyzing the purchases of alternative products. They find that games are complementary and apparently, those who gamble on one game tend to gamble on others. Farrell and Forrest (2008) also found evidence of complementarities between lottery and casino gaming, and evidence of displacements between lottery and electronic gaming machines in Australia.

Guryan and Kearney (2008) found no evidence of substitution in overall sales of different lottery games in Texas, even during periods of increased demand during jackpot rollovers in a large, multi-state lotto game. Forrest and McHale (2007) find that UK lotto sales respond positively to increases in the EuroMillions – a European multi-country lotto game – jackpot.

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[41] However their argument is not solid. A lagged dependent variable is often significant in accounting for consumption of all shorts of goods. It does not require the good to be addictive. So addictiveness must be distinguished from serial correlation.

[42] It is very important to mention that they look not at fixed-odds bets in general but at fixed odds bets on which numbers will win in the lotto game.

Relating to the consumer consequence of a lottery as a mean of public finance and regarding displacements effects among games, Kearney (2005) investigates whether state lotteries crowd out other gambling activities, or they crowd out non-gambling consumption.

7. Summary and concluding remarks

Understanding gambling, in our context on the lottery, has been a challenge for economic theory. The consumption of lottery tickets can appear inconsistent with risk aversion, maximizing and rational conduct. However, playing lotteries has come into an increasingly popular gambling activity in the whole world.

There is a large literature in economics on who plays and why people play lotteries. The fore-runners of today's empirical research used cross-sectional data from surveys of consumers – or other different data sources - to analyze the determinants of household expenditure on lotteries as well as the regressive character of the implicit state tax included in the lottery price. Most of these seminal papers in the US and Canada estimated that the lottery tax is weakly is regressive.

A later strand uses aggregate data at a draw level to investigate the effects of expected returns, prize structure and other statistical phenomena. Studies using aggregated data consider price determinants as explanatory variables. This allows them to estimate price and income elasticities.

Trying to explain why people play lottery has yielded two different models in the economics literature. The effective price model, based on expected utility theory, and the jackpot model. Under the assumptions of the effective price model, lottery tickets are considered to be financial assets with risk and the prizes are considered as the returns to an investment (the price of a bet). The effective price of a bet is then defined as the difference between the nominal value and the expected prize. However, as mentioned by Forrest et al (2002), the main limitation of the effective price model is that, in the case of having several prizes, a change in the structure of prizes could not generate a change in the effective price and therefore could not cause a change in demand. So the alternative jackpot model rather than the effective price proposes using the amount of the top prize as the main economic variable affecting sales. This model is based on a previous idea by Clotfelter and Cook (1989) who considered that bettors are buying a hope (or a dream) each time they buy a ticket and that hope has to do with the amount of the jackpot.

Given that even big jackpot lotteries are only very, very rarely positive in expected value, most theories of why people play lotteries rely either on a "fun" component of gambling which increases lottery utility, or on players having a poor understanding of the odds of the game. In addition, if consumers are misinformed, their demand for lottery might respond to the top prize, but would not respond to the expected value. 'Higher moments' models include the first three moments of the prize distribution in order to allow variations in the top prize to have a direct influence on sales rather than only an indirect one through effective price.

So a new framework is proposed in the literature in which changes in the prize structure, though they may not cause changes in the effective price, nevertheless affect lottery sales.

Besides the US and Canada, demand for lotteries has been estimated in several countries and many variables to represent bettors´ changing behaviour over time and their response to exogenous events have been considered in this research.

The relationship between consumers’ spending on different types of gambling or between different lottery games has also been considered in the empirical literature on gambling. Most of the empirical evidence has been derived from aggregated data while just a few papers use cross-sectional data from surveys of consumers. The general consensus is that the introduction of new games attracts new customers, and potentially induces additional expenditure from existing lottery players.

References

Barr, G. and B. Standish (2002), “Modelling the economics of gaming in South Africa”, *Journal of Gambling Studies* 18, pp.371-397.

Becker, G. and K. M. Murphy (1988), “A theory of rational addiction”, *Journal of Political Economy* 96, pp. 675-700.

Beenstock, M. and Y. Haitovsky (2001), “Lottomania and other anomalies in the market for lotto”, *Journal of Economic Psychology* 22, pp. 721-744.

Borg, M.O. and P. M. Mason (1988), “The budgetary incidence of a lottery to support education”, *National Tax Journal* 41, pp. 75-85.

Brinner, R.E. and C. Clotfelter (1975), “An economic appraisal of state lotteries”, *National Tax Journal* 28, pp. 395-404.

Camerer, C. (2000), “Prospect theory in the wild: Evidence from the field”, in D. Kahneman and A. Tversky (eds.), *Choices, Values and Frames*, Cambridge University Press, Cambridge, UK.

Clotfelter, C. (1979), “On the regressivity of state-operated Numbers Games”, *National Tax Journal* 32, pp. 543-548.

Clotfelter, C. and P. Cook (1987), “Implicit taxation in lottery finance”, *National Tax Journal* 40, pp. 533-46.

Clotfelter, C. and P. Cook (1989), *Selling Hope: State Lotteries in America*, Harvard University Press, Cambridge, MA.

Clotfelter, C. and P. Cook (1990), “On the economics of state lotteries”, *Journal of Economic Perspectives* 4, pp. 105-119.

Clotfelter, C. and P. Cook (1991), “Lotteries in the real world”, *Journal of Risk and Uncertainty* 3, pp. 227-232.

Cook, P. and C. Clotfelter (1993), “The peculiar scale economies of lotto”, *American Economic Review* 83, pp. 634-643.

Conlisk, J. (1993), “The utility of gambling”, *Journal of Risk and Uncertainty* 6, pp. 255-275.

Davis, J.R., J. E. Filer, and D. L. Moak (1992), “The lottery as an alternative source of State revenue”, *Atlantic Economic Journal* 20, pp. 1-10.

DeBoer, L. (1986), “When will state lottery sales growth slow?”, *Growth and Change* 17, pp. 28-36.

DeBoer, L. (1990), “Lotto sales stagnation: Product maturity or small jackpots?”, Growth *and Change* 21, pp. 73-77.

Farrell, L., E. Morgenroth, and I. Walker (1999), “A time series analysis of U.K. lottery sales: Long and short run price elasticities”, *Oxford Bulletin of Economics and Statistics* 61, pp. 513-26.

Farrell, L. and I. Walker (1999), “The welfare effects of lotto: Evidence from the UK”, *Journal of Public Economics* 72, pp. 99-120.

Farrell, L., R. Hartley, G. Lanot, and I. Walker (2000), “The demand for lotto: The role of conscious selection”, *Journal of Business and Economics Statistics*, 18, pp. 228-241.

Farrell, L. and D. Forrest (2008), “Measuring displacement effects across gaming products: a study of Australian gambling markets”, *Applied Economics* 40, pp. 53-62.

Feehan, P. and David Forrest (2007), “Distribution of UK National Lottery grants across local authority areas”, *Applied Economics Letters* 14, pp. 361-365.

Forrest, D., O. D. Gulley and R. Simmons (2000a), “Testing for rational expectations in the UK National Lottery”, *Applied Economics* 32, pp. 315-326.

Forrest, D., O. D. Gulley and R. Simmons (2000b), “Elasticity of demand for U.K. National Lottery tickets”, *National Tax Journal* 53, pp. 853-63.

Forrest, D., R. Simmons and N. Chesters (2002), “Buying a dream: Alternative models of demand for lotto”, *Economic Inquiry* 40, pp. 485-496.

Forrest, D., O. D. Gulley and R. Simmons (2004), “Substitution between games in the UK National Lottery”, Applied *Economics* 36, pp. 645-651.

Forrest, D. and I. McHale (2007), “The relationship between a national and a multistate lotto game”, *The Journal of Gambling Business and Economics* 1, pp. 207-216.

Forrest, D., O. D. Gulley and R. Simmons (2008), “The relationship between betting and lottery play”, *Economic Inquiry*, forthcoming.

Friedman, M. and L.J. Savage (1948), “The utility analysis of choices involving risk”, *Journal of Political Economy* 56, pp. 279-304.

García, J. and P. Rodríguez (2007), “The demand for Football Pools in Spain: The role of price, prizes, and the composition of the coupon”, *Journal of Sports Economics* 10, pp. 1-20.

Garrett, T. A. (2001), “An international comparison and analysis of lotteries and the distribution of lottery expenditures”, *Public Finance Review* 32, pp. 313-330.

Garrett, T. A. and R. S. Sobel (1999), “Gamblers favor skewness not risk: Further evidence from United States’ Lottery Games”, *Economic Letters* 63, pp. 85-90.

Garrett, T. A. and R. S. Sobel (2004), “State lottery revenue: The importance of game characteristics”, *International Review of Applied Economics* 15, pp. 213-227.

Geronikolaou, G. and G. Papachristou (2007), "On the demand for lotteries in Greece", *International Journal of Business and Economics* 6, pp. 255-59.

Glickman, M. M. and G. D. Painter (2004), "Do tax expenditure limits lead to State lotteries? Evidence from the United States: 1970-1992", *Public Finance Review* 32, pp. 36-64.

Golec, J., and M. Tamarkin (1998), "Bettors favor skewness not risk at the horse track", *Journal of Political Economy* 106, pp. 205-25.

Goodman, J.K. and J. R. Irwin (2006), "Special random numbers: Beyond the illusion of control", *Organizational Behaviour and Human Decision Processes* 99, pp. 161-174.

Grote, K. R. and V. A. Matheson (2006), "Duelling jackpots: Are competing lotto games complements or substitutes?", *Atlantic Economic Journal* 34, pp. 85-100.

Grote, K. R. and V. A. Matheson (2007), "Examining the "Halo Effect", in lotto games" *Applied Economics Letters* 14, pp. 307-310.

Gulley, O. D. and F. Scott (1990), "Lottery effects on pari-mutuel tax revenues", *National Tax Journal* 42, pp. 89-93.

Gulley, O. D. and F. Scott (1993), "The demand for wagering on state-operated lotto games", *National Tax Journal* 46, pp. 13-22.

Guryan, J. and M. S. Kearney (2008), "Gambling at lucky stores: Empirical evidence from State lottery sales", *American Economic Review* 98, pp. 458-473.

Hauser-Rethaller, U. and U. Köning (2002), "Parimutuel lotteries: Gamblers' behaviour and the demand for tickets", *German Economic Review* 3, pp. 223-245.

Henze, N. (1997), "A statistical and probabilistic analysis of popular lottery tickets", *Statistica Neerlandica* 51, pp. 155-163.

Henze, N. and H. Riedwyl (1998), *How to Win More - Strategies for Increasing a Lottery Win*, A.K. Peters, Natick, MA

Jackson, R. (1994), "Demand for lottery products in Massachusetts", *The Journal of Consumer Affairs* 28, pp. 313-325.

Johnson, J. A. (1976), "An economic analysis of lotteries", *Canadian Tax Journal* 24, pp. 339-351.

Kahneman, D. and A. Tversky (1979), "Prospect theory: An analysis of decision under risk", *Econometrica* 47, pp. 263-291.

Kearney, M. S. (2005), "State lotteries and consumer behaviour", *Journal of Public Economics* 89, pp. 2269-2299.

Kitchen, H. and S. Powells (1991), “Lottery expenditures in Canada: a regional analysis of determinants and incidence”, *Applied Economics* 23, pp. 1845-1852.

Layton, A. and A. Worthington (1999), “The impact of socio-economic factors on gambling expenditure”, *International Journal of Social Economics* 26, pp. 430-440.

Lin, C. and C. Lai (2006), “Substitute effects between Lotto and Big Lotto in Taiwan”, *Applied Economics Letters* 13, pp. 655-658.

Lim, F.W. (1995), “On the distribution of lotto”, Australian National University WP 282.

Livernois, J. R. (1987), “The redistributive effects of lotteries: Evidence from Canada”, *Public Finance Quarterly* 15, pp. 339-351.

Le Menestrel, M. (2001), “A process approach to the utility for gambling”, *Theory and Decision* 50, pp. 249-262.

Matheson, V. (2001), “When are state lotteries a good bet? (Revisted)”, *Eastern Economic Journal* 27, pp. 13-22.

Matheson, V. and K. Grote (2004), “Lotto fever: do lottery players act rationally around large jackpots?”, *Economics Letters* 83, pp. 233-237.

Matheson, V. and K. Grote (2005), “Rationality and Efficiency in Lotto Games”, in Williams, V. (ed.), *Information Efficiency in Financial and Betting Markets*, Cambridge and New York; Cambrige University Press, pp. 313-29.

Mikesell, J. L. (1987), “The effect of maturity and competition on State lottery markets”, *Journal of Policy Analysis and Management* 6, pp. 251-253.

Mikesell, J. L. (1989), “A note on the changing incidence of State lottery finance”, *Social Science Quarterly* 70, pp. 513-521.

Oster, E. (2004), “Are all lotteries regressive? Evidence from the Powerball”, *National Tax Journal*, 57, pp. 179-187.

Papachristou, G. (2004), “The British gamblers’ fallacy”, *Applied Economics* 36, pp. 2073–2077.

Papachristou, G. and D. Karamanis (1998), “Investigating efficiency in betting markets: Evidence from the Greek 6/49 lotto”, *Journal of Banking & Finance* 22, pp. 1597-1615.

Price, D. I., and E. S. Novak (2000), “The income redistribution effects of Texas state lottery games”, *Public Finance Review* 28, pp. 82-92.

Purfield, C. and P. Waldron (1999), “Gambling on lotto numbers: Testing for substitutability or complementarity using semi-weekly turnover data”, *Oxford Bulletin of Economics and Statistics* 61, pp. 527-544.

Quiggin, J. (1991), “On the optimal design of lotteries”, *Economica* 58, pp. 1-16.

Roger, P. and M. Broihanne (2007), “Efficiency of betting markets and rationality of players: Evidence from the French 6/49 lotto”, *Journal of Applied Statistics,* 34, pp. 645-662.

Scott, F. and J. Garen (1994), “Probability of purchase, amount of purchase, and the demographic incidence of the lottery tax”, *Journal of Public Economics* 54, pp. 121-143.

Shapira, Z. and I. Venezia (1992), “Size and frequency of prices as determinants of the demand for lotteries”, *Organizational Behaviour and Human Decision Processes* 52, pp. 307-318.

Scoggins, J. (1995) “The lotto and expected net revenue”, *National Tax Journal* 48, pp. 61-70.

Scott, F. and O. D. Gulley (1995), “Testing for efficiency in lotto markets”, *Economic Inquiry* 33, pp. 175-188.

Spiro, M.H. (1974), “On the tax incidence of the Pennsylvania lottery”, *National Tax Journal* 27, pp. 57-61.

Sprowls, C.R. (1970), “On the terms of the New York state lottery”, *National Tax Journal* 23, pp. 74-82.

Stranahan, H.A., and M. Borg (1998), “Horizontal equity implications of the lottery tax”, *National Tax Journal*, 51, pp. 71-82.

Stover, M. E. (1987), “The revenue potential of State lotteries”, *Public Finance Quarterly* 15, pp. 428-440.

Suits, D.B. (1977), “Gambling taxes: Regressivity and revenue potential”, *National Tax Journal* 30, pp. 19-35.

Terrell, D. (1994), “A test of the gambler’s fallacy: Evidence from pari-mutuel games”, *Journal of Risk and Uncertainty* 8, pp. 309-317.

Thaler, R.H., and W.T. Ziemba (1988), “Anomalies in parimutuel betting markets: Racetracks and lotteries”, *Journal of Economic Perspectives* 2, pp. 161-174.

Thaler, R.H. (1992), *The Winner´s Curse: Paradoxes and Anomalies of Economic Life*, Princeton University Press, Princeton, NJ.

Tversky, A. and D. Kahneman (1974), “Judgement under uncertainty: Heuristics and biases”, *Science* 185, pp. 1124-1131.

Vasche, J. D. (1985), “Are taxes on lotteries too high?”, *Journal of Policy Analysis and Management* 4, pp. 269-271.

Vrooman, D.H. (1976), “An economic analysis of the New York state lottery”, *National Tax Journal* 29, pp. 482-489.

Walker, I. (1998), “The economic analysis of lotteries”, *Economic Policy* 13, pp. 359-392.

Walker, I. and J. Young (2001), “An economists guide to lottery design”, *The Economic Journal* 111, pp. 700-722.

Wang, J., L. Y. Tzeng and J. Tien (2006), “Willingness to pay and the demand for lotto”, *Applied Economics* 38, pp. 1207-1216.

Worthington, A. C. (2001), “Implicit finance in gambling expenditures: Australian evidence on socioeconomic and demographic tax incidence”, *Public Finance Review* 29, pp. 326-342.

Ziemba W.T., S. Brumelle, A. Gautier and S. Schwartz (1986), *DrZ´s 6/49 Lotto Guidebook*, Dr. Z Investments, Inc. Vancouver.

TABLE 1. Lottery Incidence Papers

Paper	Game	Date	Area	Income elasticity	Index of tax incidence [a]
Spiro (1974)	Draw Lottery	1971	Pennsylvania (US)		- 0.20
Brinner and Clotfelter (1975)	Draw Lottery	1973	Connecticum (US)		- 0.41
	Draw Lottery	1973	Massachusetts (US)		- 0.46
	Draw Lottery	1973	Pennsylvania (US)		- 0.45
Suits (1977)	Several games[b]	1975	US Lottery States		- 0.31[d]
Clotfelter (1979)	Numbers	1978	Maryland (US)	0.062 to – 1.112	- 0.41[f]
Livernois (1987)	Draw Lottery and Lotto	1983	Edmonton, Alberta (Canada)	0.72	- 0.10
Clotfelter and Cook (1987)	Instant	1986	California (US)		- 0.32
	3-digit numbers	1984	Maryland (US)		- 0.42
	4-digit numbers	1984	Maryland (US)		- 0.48
	Lotto	1984	Maryland (US)		- 0.36
Borg and Mason (1988)	Lottery	1984-86	Illinois (US)	0.11 to 0.25	
Mikesell (1989)	Instant and on-line lottery	1985-87	Illinois (US)	0.94 to 1.49	
Kitchen and Powells (1991)	Lottery	1986	Atalantic Canada	0.80	- 0.21
	Lottery	1986	Quebec (Canada)	0.70	- 0.13
	Lottery	1986	Ontario (Canada)	0.78	- 0.19
	Lottery	1986	Manitoba/Saskatchewan (Canada)	0.73	- 0.19
	Lottery	1986	Alberta (Canada)	0.92	- 0.16
	Lottery	1986	British Columbia (Canada)	0.71	- 0.18
	Lottery	1986	Canada		- 0.18
Davis, Filler and Moak (1992)	Lottery	n.a.	US Lottery States	0.04	
Price and Novak (2000)	Lotto	1994	Texas (US)	0.24	- 0.058
	Instant lottery	1994	Texas (US)	- 0.21	- 0.129
	3-digit numbers	1994	Texas (US)	0.07	- 0.035
Worthington (2001)	Several games [f]	Fiscal year 1993-94	New South Wales (Australia)	0.082 to 0.112 [g]	
Oster (2004)	Lotto	1999-2001	Connecticut (US)	0.00214 to 0.00261 [h]	

NOTES: [a] Suits (1977) index of regressivity. The value for this index can range from -1 to +1 with the former value reflecting extreme regressivity and the latter value extreme progressivity. A value of 0 indicates a proportional tax. Calculation of this index is analogous to calculating the Gini coefficient. It is defined as $S=1-(L/K)$ where L is the area under a Lorenz type curve and K is the area under the diagonal. [b] Horse at the track, state lotteries, casino games, "illegal" numbers, sport cards, off-track betting parlors and sport books. [c] Commision for the Review of the National Policy Toward Gambling. [d] In the case of state lotteries. [e] In the case of daily numbers. [f] Lottery, Lotto-type games and instant lotto, on-course betting, poker machines and ticket machines, blackjack, roulette and casino-type games, other gambling. [g] In the case of lotto-type games and instant lotto (0.082), and lottery tickets (0.112). [h] Income elasticity of sales with respect to prize size.

TABLE 2. Models of demand for lotteries

Paper	Game	Date	Area	Price elasticity [a]	Jackpot elasticity	Other findings
Clotfelter and Cook (1990)	Lotto	mid-1980s	Massachusetts (US)			For each $1,000 increase in the predicted jackpot due to "rollover", sales increase by $333
Cook and Clotfelter (1993)	Lotto	1984-86	Massachusetts		0.347 to 0.541	
Gulley and Scott (1993)	Lotto (6/42)	1990-91	Kentucky (US)	- 1.15		
	Lotto (6/46)	1987-90	Massachusetts (US)	- 1.92		
	Lotto (6/36)	1984-90	Massachusetts (US)	- 0.19		
	Lotto (6/44)	1989-90	Ohio (US)	- 1.2		
Walker (1998)	National Lottery (6/49)		United Kingdom	- 1.07		
Farrell and Walker (1999)	National Lottery (6/49)	1994-95	United Kingdom	- 1.785 to - 2.633		Income elasticity from 0.267 to 0.449
Farrel et al (1999)	National Lottery (6/49)	1994-97	United Kingdom	- 1.05 (- 1.55)		Addiction [b]
Forrest et al (2000a and 2000b)	National Lottery (6/49)		United Kingdom	- 0.66 (- 1.03)		
Forrest et al (2004)	National Lottery (6/49)	1997-00	United Kingdom	(- 0.90) [c] (- 3.2) [d]		

NOTES: [a] Values in brackets are long-run elasticities. [b] The coefficient on lagged consumption is positive and significant (0.33) suggesting that lottery play is addictive since consumption in the previous period has a positive and significant effect on consumption in this period. Myopic addiction or habit? [c] For the Saturday draw. [d] For the Wednesday draw

TABLE 3. Spread findings

Paper	Game	Date	Area	Price elasticity	Jackpot elasticity	Demand for lotto topics
Purfield and Waldron (1999)	Lotto and fixed-odds betting	1990´s	Ireland			Complementary relationship between lotto and fixed-odds betting on lotto
Beenstock and Haitovsky (2001)	Lotto 6/49	1985-96	Israel	- 0.65	0.4	“lottomania” and “prize fatigue”
Hauser-Rethaller and Köning (2002)	Lotto 6/45	1986-87	Austria	- 1.3 to – 1.7		“conscious selection”
Lin and Lai (2006)	Lotto 6/49	2004	Taiwan	- 0.145		No significant or complementary relationship exist between single draws of Big Lotto and Lotto
Roger and Broihanne (2007)	Lotto 6/49		France			“preferred numbers”
Geronikolau and Papachristou (2007)	Lotto 5/45+1/20	1999-03	Greece	- 2.1	0.33	Papachristou (2004) deals with “gambler’s fallacy”