Universidad de Oviedo

Departamento de Economía

THE DEMAND FOR GAMBLING: EMPIRICAL EVIDENCE FROM STATE-OPERATED LOTTERIES AND FOOTBALL POOLS IN SPAIN

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Doctoral Thesis

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May the luck be with you!

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Introduction

"*That the chance of gain is naturally over-valued, we may learn from the universal success of lotteries… The vain hope of gaining some of the great prizes is the sole cause of this demand... There is not, however, a more certain proposition in mathematics than that the more tickets you adventure upon, the more likely you are to be a loser*."

Adam Smith, Wealth of Nations[1]

Gambling is risking money on an event with an uncertain outcome with the primary intent of winning additional money. Typically, the outcome of the wager is evident within a short period. There are many forms of gambling including lotteries, casinos, slot machines, bingo, sports betting, as well as wagering in financial markets and over the Internet. These gambling forms differ in terms of access, growth potential, and regulations. Gambling occurs in a variety of settings including betting outlets, casinos, and racetracks. It is participated in widely among people of all age groups, social economic status and cultural background.

Gambling is as old as human history. However, after decades of prohibitions or restrictive regulation, the gambling industry has experienced a huge increase in turnover and popularity around the world. The story of increased liberalization and expanded opportunities for gambling could be explained in terms of the expansion of government-sanctioned legalized gambling due to the desire of governments to identify new source of revenues without involving new or higher taxes, greater spending power available in the leisure market, and also to changes in attitudes towards an activity taken to be the easiest way to increased wealth. The involvement of governments has led to the establishment of several public agencies in most countries offering a wide variety of gambles. As more states legalized gambling, the states have become

[1] A. Smith (1776) The Wealth of Nations. In: A. Skinner, Editor, *Pelican Classics*, Harmondsworth (1976), p 210.

very effective at innovating and creating new games. Other factors contributing to increased participation in gambling include the rise of new technologies, mega-lotteries and internet gambling.

Within this rapid growth one of the biggest events of the last decades has been the prevalence and scale of long-odds high-prize gambling products. This type of gambling is frequently state-regulated and organized as pari-mutuel gambles where all bets of a particular type are placed together in a pool and payoffs are calculated by sharing the pool among all winning bets after deducting taxes and operational expenses.[2] This pari-mutuel gambling differs from traditional fixed odds gambling products in that the final payout is not determined until the pool is closed while in fixed odd gambles the payout is known at the time the bet is made.

In the United States, following the successful experiences in New Jersey (1974) and New York (1978),[3] many US states introduced long-odds high-prize products as pari-mutuel lottery games and established state agencies as the sole provider of lottery products in order to use the profits from the state lottery operation as a source of revenue. Besides the US states, a growing demand for lotteries had emerged worldwide as an important gambling medium. Lottery mania (so termed by Kaplan, 1990) spread across North America and the rest of the world. Thus, lotto games followed in most Canadian states and provinces and national lottery games had appeared in Australia and in several European countries.

In Spain, although the demand for a long-odds high-prize gambling product was already met by the football pools, the government followed this international growth trend in a big way. In June, 1985 the National Organization for State Lotteries and Betting (ONLAE) was set up,

[2] The pari-mutuel system is used in gambling on horse racing, greyhound racing, jai alai, and sport betting. A modified pari-mutuel system is also used in some lottery games.

[3] Researchers usually point to New Jersey as the first modern successful lottery. The New Jersey lottery was more successful because of the more frequent drawings and larger purses.

the primary organization in charge of managing state lotteries, betting and gaming. That year, a lotto game (*Lotería Primitiva*) was first introduced in Spain, hitting the football pools hard. Before 1985 the Spanish football pools (*La Quiniela*) along with the *Lotería Nacional* (a weekly draw) and the Spanish National Organization for blind people (ONCE) lottery (a daily draw) were the only betting games available in Spain.

Now, management of gambling activities in Spain requires a concession from the proper authorities; the National Government, in the case of games managed by the Spanish National Lottery Agency (LAE) and the games managed by ONCE; and Regional Governments in the case of privately managed games played in their corresponding areas.

Three different gambling management groups can be identified in Spain: games privately operated (Casino games, bingo and slot machines), games managed by LAE or state-operated games (the Spanish National Lottery - *Lotería Nacional* -, lotto games – *La Primitiva*, *Bonoloto*, *El Gordo* and *Euro Millones* -, football pools – *La Quiniela* and *El Quinigol* – and some games related to horse racing - *Lototurf* and *Quintuple Plus*), and games managed by ONCE (a daily lottery – *Cupón Pro-Ciegos* - with several modalities, a weekly numbers game – *El Combo* – and some scratch cards). There are also other minor gambling activities including racetrack betting on horses, gambling on greyhound racing, bets in jai-alai games, and some regional lotteries (Catalonia lottery), but they are not considered in this analysis because of the absence of data and their small relative economic importance in the overall Spanish gambling market.

It is estimated that the gambling industry in Spain accounts for about the 2.95 per cent of GDP, which shows its relative importance within the Spanish economy. According to a recent information of the Gambling National Commission (*S.G. de Estudios y Relaciones Institucionales. S.G.T. Ministerio del Interior*, 2008), in 2007 the Spanish spent over €30.9 billion on gambling activities, about €685.61 per inhabitant or some 4.6 per cent of the average net household income. Nearly 60 per cent of this spending on gambling went to private gambling activities like casinos, 33 per cent to public gambling and over 7 per cent to lottery games managed by the ONCE. The most popular form of gambling is the national lottery on which Spaniards spend about €126 per year, 57 per cent of the total spending on LAE games in 2007 (€220.92 per person). The spending on privately managed gambling was €416.79 while total spending on games managed by ONCE was about €48. Playing lotteries represents a traditional and increasingly popular gambling activity in Spain. Spain's lottery market is one of the largest in the world.

For economists, lotteries are challenging markets to understand and model. Besides the public interest on lotteries as an alternative method for the government to raise revenue, demand for lottery tickets is an interesting field to study since it contains a specific paradox: playing the lottery is economically irrational.[4] So lotteries can be analyzed from either of two economic perspectives: as a source of public revenue or as a consumer commodity.

Standard economic theory is based on the idea that individuals are risk averse and therefore decline gambles that are unfair. In a purely economic sense lottery - given its low payout rates and remote odds of winning - is an unfair bet because it has an expected value lower than its cost. Since individuals, being risk-averse according to standard economic theory, continually purchase lottery tickets, the fact that lottery are popular leads to a contradiction with the predictions of standard economic theory. Thus, economic analysis has tried to provide information about whether the demand for lottery responds to expected returns, as utility maximizing behavior predicts, or to the contrary, whether consumers seem to be misinformed about the risks and the prizes in lottery games (Kearney, 2005). So, would a risk averse expected utility maximizer play lottery?

[4] Standard economic teaching promotes rationality – people make decisions based on their expected utility and with all information to hand.

In principle, there exist alternative explanations to justify spending on lottery (as a form of gambling). It could be that lotteries give an illusion of control to some players, because they can pick their own lucky numbers in some games. Another attraction of the lottery is that people enjoy the non-monetary aspects of it, including talking about playing, engaging in the ritual weekly purchase, socializing with friends and co-workers to pool to buy tickets, and dreaming about winning, perhaps the favourite activity among lottery players.

Economists have studied this question at length, and have found it to be much more complex than it may appear at first glance. Several published papers have dealt with the modelling of lottery demand. Within this analysis the concept of pricing in relation to gambling products is a very interesting aspect. The most common approach is to identify the price with the expected loss to the player. The underlying model is one of consumers deriving utility from the process of gambling itself, in the sense of Conlinsk (1993), rather from the uncertain payoffs alone. Thus, the expected loss equates to the amount players are willing to pay to gain the 'fun and excitement' of the gambling process and under some assumptions a demand for lottery ticket could be derived, sensitive to this expected loss (or price of participation).[5]

Although the takeout rate – the proportion of sales that is not returned in the prize pool - is the main characteristic determining expected loss and the face price of a bet itself does not change frequently enough to infer demand elasticities, what varies considerably in pari-mutuel gambles are prizes. As the takeout rate is fixed as a percentage of the handle, if there are no winning tickets, then the undistributed prize pool must be paid out in a different way. Usually, 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 – affecting the expected loss from buying a ticket. Rollovers introduce exogenous price variation allowing estimation of a demand function sensitive to the expected

[5] This approach is less useful in the context of long-odds high-prize gambling products such as lotto games and football pools where a player would need to play for extended periods to gain average winnings on his bets. In these cases the price of playing is usually seen as the ticket price rather than the expected loss.

loss. The rolling over of the prize is crucial to a modern lottery's success, because it creates a large jackpot which has a significant effect in stimulating sales.

Trying to explain the behavioural trend of lottery product purchase throughout the world has employed an expected loss explanation utilizing the effective price, computed as the face value of a ticket minus the expected value of the bet's payoffs, as their primary explanatory variable (Cook and Clotfelter, 1993; Gulley and Scott, 1993; Scott and Gulley, 1995; Walker, 1998; Farrell et al., 1999; and Forrest et al., 2000b). Since the effective price cannot be observed ex ante, previous studies argued that bettors form their rational expectation of the effective price, using all available information such as previous sales, sales trends, and the amount of money carried over from the previous draws. However, this approach omits important variables.

The main limitation of the effective price model is that demand does not depend on the structure of prizes (Forrest et al., 2002). If we consider a lottery with several prizes, and not only a top prize, any change in the structure of prizes which does not have an effect on the actual effective price will have no effect on demand.

As mentioned by Sauer (1998), it is not easy to find a theoretical framework consistent with the effective price model. Bettors would be indifferent to the prize structure if they are risk neutral, but in this case they will make clearly unfair bets.

Forrest et al. (2002) demonstrated the relevance of prize structure by including size of the top prize alongside effective price in a demand model estimated on data from the United Kingdom. The jackpot model 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 this hope or dream has to do with the size of the top prize. However, they identify collinearity as a practical obstacle to obtaining reliable estimates on how sales respond separately to the two changes associated with a rollover, the fall in effective price and the greater weighting of the top tier prize in the expected value of a ticket.

Walker and Young (2001) proposed an alternative tack, modelling demand as depending on the probability distribution of prize amounts that might be won from a single ticket. The distribution was to be summarised by the mean (expected value), variance and skewness. They employed data from the principal game in the United Kingdom National Lottery and found that sales patterns responded positively to mean (i.e. expected value), negatively to variance and positively to skewness.

Apart from several analyses of the determinants of household expenditure on lotteries as well as the regressive character of the implicit state tax included in the lottery price, research in this field continues to be centered on applications of the three economic models proposed in the empirical literature on the demand for lottery: the effective price model, the jackpot model and the mean-variance-skewness model. Thus, demand for lotteries has been estimated under several assumptions and many variables to represent bettors' changing behaviour over time and their response to exogenous events have been considered.

In the following chapter, the state of the economic research on the demand for lotteries is reviewed, focusing on its main empirical findings. From the point of view of empirical economic analysis, topics on the demand for lottery, as a particular type of gambling, might be summarized as answers to the following questions: who plays 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?

For the Spanish case, the empirical evidence is limited. Apart from the pioneering works of Garvía (2000) trying to explain why and when Spain became a great consumer of lotteries or focusing on syndicate lottery play (Garvía, 2007), there are very few attempts to analyze the determining factors in the consumption of lotteries or how the Spanish gambling market works, including Mazón (2007).

This thesis tries to shed more light on the questions identified above, focusing on the particular case of state-operated lotteries and football pools in Spain. Specifically, we are interested in examining what aspects drive gamblers' participation in Spanish lottery markets and spending on lotteries, focusing on patterns in consumer spending on closely related gambling goods like tickets for different lottery games. Although the general consensus is that the introduction of new games attracts new customers, and potentially induces additional expenditure from existing lottery players, no previous analysis of lottery ticket purchase has explored the issue using micro data. Thus, in the second chapter of this thesis we deal with the relationship between consumer spending on a number of lottery games available in Spain (the *Lotería Nacional*, the *Euro Millones* game, *La Primitiva*, *El Gordo de la Primitiva*, and *Bonoloto*) using individual level data from two nationally representative Spanish surveys in 2005 and 2006. In order to do that both Tobit and double hurdle models of participation in lottery markets and spending on lottery tickets are estimated. Unlike previous papers we examine spending on alternative lottery games in the context of consumption network externalities.

Next, we study the demand for lottery tickets, paying attention to the factors that explain why individuals bet, especially, those that refer to the design of the game and the structure of prizes. This particular analysis is expected to show a first valuation of how the number of tickets played responds to changes in the design of the game (affecting the difficulty of success) or changes in the structure of prizes. Thus, we use weekly data for all lottery draws from 1997 to 2008 to evaluate the effect of LAE policy on the demand for a particular Spanish lotto game (*El Gordo de la Primitiva*) in terms of whether a change in the game design – prizes and odds structure – *does* or does not affect tickets sales. The change in rules introduced by LAE in 2005 provides a unique opportunity to study the effect on sales of features of lotto games other than the entry fee and pay-back rate. The changes in design appear in this case to have allowed the operator to achieve higher and more stable sales. Reasons for this are explored through estimation of demand models. Results indicate that gains to the operator had been achieved by better satisfying players' preference for skewness in the distribution of returns.

In chapter four, the analysis of the main economic determinants of demand for lottery is extended to football pools[6] as a particular form of sports gambling. Although football pools share some characteristics with lotto games in that both are pari-mutuel games in which prizes are a percentage of the total revenue - being also a long-odds high-prize game - football pools are not a lottery in the sense that the winning combination is not the outcome of a draw but is instead related to the final results of several football matches. Thus, unlike lotto games, where players just chose the numbers they play, in football pools bettors use historical information on the performance of both teams and players to make their forecasts. In this type of gambling it is crucial to consider the importance of the active role of the player which uses his knowledge on a particular sport to try to correctly guess the outcome of the sport event. In this case, gambling could be expected to be a complementary good with many sports.

Apart from lottery games, the football pools have long occupied an important place in the Spanish gambling market. The exceptional importance of this gambling industry in Spain lies in the scope of its economic and social benefits; generally speaking, the funds generated have the objective of promoting sports activities. Unfortunately, there has also been little empirical research on the demand for football pools. However, previous research has found pools sales are influenced - besides the conventional economic determinants - by game characteristics, such as the overall expected value, the prize structure and the composition of the list of games in the coupon (García and Rodriguez, 2007).

[6] A pari-mutuel betting medium based on the results of professional soccer games.

Using annual data, a demand equation for football pools in Spain is estimated using a panel data set at provincial level for the years 1985-2005, merging the traditional economic models in the lotto demand literature: the effective price model and the jackpot model. The model is estimated by instrumental variables.

In this empirical exercise we are interested, as in previous research, in identifying the main economic determinants of demand for football pools in Spain controlling for geographical effects given the nature of the data we use. In addition, we try to measure the effect on sales of football pools in a particular geographical area in Spain (a province) of having a professional football team in order to shed light on the nature of the complementarity between sport consumption and sport gambling.

To summarize, this dissertation undertakes an empirical analysis of contemporary Spanish lottery and football pool markets dealing with the demand for gambling, based on different sources of representative data. The three main chapters focus on participation in lottery markets and spending on lottery tickets in the context of consumption network externalities, the effect of a change in lotto game design on ticket sales, and finally, the demand for football pools and the relation between sport consumption and sport gambling. In addition to these empirical findings, the study contributes to the economics of gambling by briefly reviewing the theoretical work and empirical highlights from the previous analysis of the demand for lottery and football pools. A bibliography to aid in research on demand for lottery is also featured. Finally, the thesis concludes with a brief discussion of the main findings.

It should be noted that the chapters which follow are adaptations of articles which have either been submitted to economic journals or are being prepared for this purpose. The first chapter is expected to lead to a publication in a specialist journal in economic surveys. A version of the second chapter, prepared jointly with professor Brad R. Humphreys (Chair in the economics of gaming, University of Alberta), is in the process of submission. Chapter three is an adapted version of an article which is work in progress with David Forrest (Centre for the Study of Gambling, University of Salford) and Rose Baker (Centre for Operational Research & Applied Statistics, University of Salford). Finally, a version of the fourth chapter has already been published in the *International Journal of Sport Finance*.

Chapter I

The 'Who and Why' of the demand for lottery: Empirical highlights from the economic literature

1.1 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. 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 and Cook, 1987).

Apart from the United States, lottery dominates most gambling markets[7] 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.[8] 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,[9] where the player selects a set of numbers which are entered into the draw, or Numbers games,

[7] 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.

[8] For example, in football pools players use information about the previous performance of teams included in each fixture in order to decide which forecast to choose.

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

where he attempts to pick three or four digits to match those that will be randomly drawn; and Instant lotteries or Scratch cards 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 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?

Studies of demand for lottery can also be a rich source of knowledge on the main empirical findings that have emerged in the literature but, as far as I know, no previous studies have tried to collect all these topics showing an overview of the state of empirical research on the demand for lottery.

This chapter is a pioneering attempt to briefly review the theoretical work, tracing the contribution of seminal researchers, and explain relevant empirical issues in modelling and estimating lottery demand functions in the hope of stimulating new lines of inquiry in the field. Notably, it summarizes the salient features of a number of relevant studies and it features a bibliography to aid in research on demand for lottery.

The chapter 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 the following section. 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.

1.2 Lottery games

The seminal paper of Sprowls (1970) proposed three measurable characteristics that can describe a lottery gamble: the expected value,[10] the probability of winning a prize, and the

[10] 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.

inequality of the prize distribution.[11] 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. Lotto had emerged worldwide as an important gambling medium following its successful introduction in New Jersey (1974) and New York (1978). 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.[12] When several players win, the prize is shared among them. So, Lotto-type games are active games which allow players to choose their own numbers, affecting demand by giving players the "illusion of control",[13] 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

[11] 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.

[12] 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.

[13] "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.

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.[14] 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.

Apart from lottery games, football pools – a pari-mutuel betting medium based on the results of professional soccer games - demand special attention in this study.

Certainly one can characterise the pools as being sufficiently similar to a lottery and also name them as sports lotteries. Although this type of gambling is not a lottery in the sense that the winning combination is not the outcome of a draw but is instead related to the final result of several soccer matches, it shares some characteristics with lotto games in that both are pari-mutuel games – so the size of the jackpot depends on sales -. It is also a long-odds high-prize game.

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

The football pools have long occupied a uniquely prominent place in the European gambling market offering a potential single large jackpot when no other form of gambling did (Forrest, 1999). Notwithstanding this past importance, the introduction of lotto games in Europe hit the pools hard.[15] So, one could expect football pools sales to be highly (negative) correlated with lottery sales.

Lottery tickets (and also football pools bets) 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.

1.3 Lottery participation and tax incidence

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. Introducing lottery games gave governments in most jurisdictions access to a new and substantial source of tax revenue. Thus, the takeout rate can be understood as including a large implicit tax on bet price.[16]

Within a decade, lotto games had been introduced in a majority of American and Canadian states and provinces and national lottery games had appeared in countries as diverse

[15] Since it happened in Spain when a 6/49 lotto game was introduced in 1985, or in UK in when the UKNL – United Kingdom National Lottery – began in 1994.

[16] The takeout rate is not itself a tax because it covers operating costs.

as Australia and Brazil (Forrest, 1999). Europe of course, was not immune from this lottery expansion.

Although football pools held an effective monopoly on high-prize betting in both Spain[17] and the United Kingdom, it became evident to European governments from American experience that it would be likely to generate much greater tax revenue by allowing a lottery to replace the pools because, even if the takeout rate in both products were almost the same, the lottery could be marketed year-round (rather than just for the soccer season) with simpler rules and lower costs (Forrest, 1999). The impact of the introduction of a competing state lottery on the pools was severe. For instance, the large fall in Spanish football pools sales, close to 80%, between the year 1985 and 1990 can largely be explained by the appearance of a 6/49 lotto game on the Spanish gambling market This also happened in the case of British football pools (Forrest, 1999).

Since most of the lotteries are managed by the government, 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.

As several US states have introduced lotteries as a way to increase their budgetary income a line of research examines the economic and social implications. Following Davis, Filer and Moak (1992) who analyze the propensity of states to adopt lotteries as a source of additional revenue, most early studies focused on the relation between state lotteries and fiscal issues as in Glickman and Painter (2004), but also socioeconomic features of lottery expenditures have received attention in an attempt to analyze the characteristics of the people

[17] For several years *La Quiniela* – the Spanish football pools -, together with the *Loteria Nacional* – the state draw lottery - and the Spanish National Organization for the Blind (ONCE) lottery (a daily draw) were the only legal betting games available in Spain.

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.

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) where the importance of state lotteries as consumer commodities or sources of public revenue is discussed. Furthermore, they 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. 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 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[18] (Spiro, 1974; Borg and Mason, 1988), analysis of lottery sales by geographic area with census data used to infer the economic characteristics of

[18] 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.

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[19] (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 1.1 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. Apart from Mikesell (1989), which found lottery taxes to be proportional, there is remarkable consistency in these studies of the regressive character of lottery. But despite the volume of work on this topic we still know very little about the nature of this regressivity. However, 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.

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

[19] These studies focus on “instant” (or “scratch”) lotteries.

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

TABLE 1.1 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	Connecticut, Massachusetts and Pennsylvania (US)		- 0.41 to -0.46
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- and 4-digit numbers	1984	Maryland (US)		- 0.42 to -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	Atlantic 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] Commission 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.

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).

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

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.

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 expected value of the prize distribution or the top prize on the demand for lotto is not considered.[20]

1.4 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. Although in presence of large jackpot, most likely due to accumulating rollovers, it is possible to place a bet with a positive return as it is shown in Thaler and Ziemba (1988), most lotteries offer unfair bets - the average payout rate is around 50% -. So 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. 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).

1.4.1 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

[20] The availability of panel data information is necessary to estimate demand models in which both, price and geographical effects, are included.

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).

1.4.2 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).

1.4.3 Entertainment Utility or the Pleasure of Gambling

This approach (Conlisk, 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]

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. A likely problem for these studies is the endogeneity of takeout rate.

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 -.

[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.

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) - 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. (1999) and Farrell and Walker (1999) -. 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 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.

Consider the simple case where there is only one prize and where we assume a unit price for each bet to simplify the presentation. Cook and Clotfelter (1993) defined the expected value (*ev*) of a bet as the amount of the prize adjusted by the probability of having a winning ticket and divided by the expected number of winners. Thus, following Farrell and Walker (1999), the *ev* of holding a lotto ticket assuming a single jackpot and uniform number selection is calculated as follows:

$$ev = \left[\frac{b}{q} + (1-\tau)\right](1-\pi) \qquad (1.1)$$

where b is the rollover from a previous draw without winners, q is the total number of tickets sold, τ is the *take-out rate* (the share of the revenues that is not distributed as prizes), and π is the probability of not having a winner ticket (so, the probability of a rollover exists).

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[22] because the odds structure of the game does not usually change from drawing to drawing. 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. 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.

It should be noted that 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.

[22] 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 modelling lotto sales.

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[23] of the "effective price" using all the available information – such as sales 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.

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 as it suggested in Scoggins (1995), 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.

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

[23] 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.

elasticities - 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 -. 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.[24]

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). 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. Furthermore, the use of the effective price model has also been extended to other forms of pari-mutuel gambling, as it is the case of the sports lotteries or football pools.

Since football pools moved to incorporate rollovers into the rules variations in expected return are induced allowing to estimate a demand function for football pools from the correlation between variations in coupon sales and changes in the effective price. In fact,

[24] 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.

rollovers make the pools more like lotto. However, given the information players have about the *ex ante* probabilities of the final result of any match, the number of players getting all forecasts right is much higher than that we would expect if the final results were completely random. This implies, given the pari-mutuel structure of both games, that prizes are larger in lottery games than in football pools, so the expected effective price of a coupon is lower in the former game, implying a higher demand.

Forrest et al. (2002) question the validity of the "effective price" model testing whether the effective price or the jackpot better explains the demand for lottery. 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. Thus, 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. 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 played. 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). 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.

Since 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 structure of prizes, García and Rodriguez (2007), among others, suggest a model in which both variables, the effective price and the jackpot, are included.

They estimate a demand equation for football pools in Spain by instrumental variables. Following Kelejian (1971), the set of instruments used makes the matrix of instruments of a sufficient rank to obtain consistent estimates,[25] making it possible to simultaneously include both variables (the effective price and the jackpot) in the model and estimates their effect consistently. However, Forrest et al. (2002) note that collinearity is a practical obstacle to obtaining reliable estimates on how sales respond separately to the two changes associated with a rollover, the fall in effective price and the greater weighting of the top tier prize in the expected value of a ticket.

Since expected value depends on sales, so the effective price is endogenous to the demand function, the model could not be estimated by ordinary least squares. Most of the studies on demand for lotteries reported in Table 1.2 use a two-stage least squares procedure for modelling time-series lotto demand. As 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.

[25] The nonlinearity in variables (but linearity in parameters) of their model allows them to use polynomials of the original instruments and the predetermined variables to form the final set of instruments.

TABLE 1.2 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	Payout rate positive and significant for Lotto, elasticity not reported
Gulley and Scott (1993)	Lotto (6/42)	1990-91	Kentucky (US)	- 1.15		
	Lotto (6/46)	1987-90	Massachusetts (US)	- 1.92		
	Lotto (6/44)	1989-90	Ohio (US)	- 1.2		
Walker (1998)	National Lottery (6/49)	1994-96	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
Farrell et al. (1999)	National Lottery (6/49)	1994-97	United Kingdom	- 1.05 to - 1.55		Addiction [b]
Forrest et al. (2000a and 2000b)	National Lottery (6/49)	1994-97	United Kingdom	- 0.66 (- 1.03)		
Forrest et al. (2002)	National Lottery (6/49)	1997-99	United Kingdom	(- 0.88) [c] (- 1.04) [d]		
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.

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.

On the other hand, 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 statistical 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 statistical moments of the prize distribution in the analysis is equivalent to allowing variations in the top prize to affect the decision to buy independent of its contribution to the effective price. Garrett and Sobel (1999), Walker and Young (2001) and Wang et al. (2006) offer examples in which the third moments of the effective price are included in the specification of the demand function. 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.

Thus, Walker and Young (2001) proposed an alternative tack, modelling demand as depending on the probability distribution of prize amounts that might be won from a single ticket. The distribution was to be summarised by the mean (expected value), variance and skewness. They employed data from the principal game in the United Kingdom National Lottery and found that sales patterns responded positively to mean (i.e. expected value), negatively to variance and positively to skewness.[26] However, the precision of their coefficient estimates was low. This is likely to have been due to collinearity. Once again, the problem is that all variation in the data is induced by rollovers and, in this case, rollovers always move mean, variance and skewness together and always with a similar relationship to each other. This

[26] Walker and Young (2001) recognised that mean, variance and skewness were endogenous to the extent that they were influenced by, as well as influencing, sales. Despite this, they were compelled to estimate by ordinary least squares because of there being too few potential instruments relative to the number of endogenous regressors. Nevertheless, they argued that the estimates will be little affected because variation in sales will not have influenced mean, variance and skewness very much within the range of sales figures experienced in the data period.

problem could potentially be resolved where a design changes produces exogenous impacts on mean, variance and skewness.

The mean-variance-skewness model proposes 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.[27]

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. For this reason, research needs to move on from the first generation of lotto demand studies to a focus on characteristics of the prize structure as well as on the effective price of a ticket.

In addition, several papers has carried 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 (Garrett and Sobel, 2004; Garrett, 2001; or Layton and Worthington, 1999).

1.5 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

[27] 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

affecting players' strategy and the coexistence of competing lottery games are taken into account in many of these recent papers.

TABLE 1.3 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	1978-03	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"

1.5.1 Empirical findings around the world

Table 1.3 shows some of the empirical papers dealing with the analysis of the demand for lottery throughout the world. These papers examines the pattern of lottery buying in different countries in order to analyze the socio-economic features that help to explain lottery consumption around the world

The main empirical findings from these papers relating to the effect of prize structure, game characteristics and gambler's behaviour on the demand for lottery are listed below.

Regarding the effect of prizes features on lottery sales, Beenstock and Haitovsky (2001) test Shapira and Venezia's (1992) findings - 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 - 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. Before, 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. Concerning the prize structure a preference for multiplicity is observed.[28] 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.

In addition, several lotto games in continental Europe are also analyzed in the literature, including the Greek lotto 6/49 (Papachristou and Karamanis, 1998) 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). Most of these papers focus on the decision on the numbers to play.

Thus, Papachristou and Karamanis (1998) analyze the Greek market for the 6/49 lotto under the assumption of random number selection. In a later paper, Hauser-Rethaller and Köning (2002) deal with the empirical study of demand for lotto in Austria and try to calculate

[28] 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.

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.

Optimal pricing rules of different lotteries are also analyzed around the world. Geronikolau and Papachristou (2007) deal with this issue in Greece. Both models proposed 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.

Lin and Lai (2006) extend the analysis to a lotto type game (Big Lotto) in Taiwan examining effective price elasticity. 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.

1.5.2 Anomalies in the demand for lottery

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),[29] "lotto mania" (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 "gambler's fallacy".[30] 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.

[29] They found 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.

[30] 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.

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),[31] 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.

Although the problem of conscious selection seems not to be crucial in the case of lotto, as pointed out by Farrell et al. (2000) it is probably more important in the case of other pari-mutuel betting mediums such as football pools or horse track betting.

As mentioned by Walls and Busche (2003) which share different win probability for each bet and a case of conscious selection in analysing horse track betting, if each horse's win probability equals the proportion of the total betting pool on each horse, then expected returns across all horses would be the same. However, in the case of football pools both issues together can introduce differences to the standard framework for the effective price model because the fact that some fixtures have no winner of the jackpot (so a rollover occurs) means that previous result is not applicable (García and Rodriguez, 2007).

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

[31] 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.

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. (1999) 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 of consumption in the regression of current sales and find that the coefficient on lagged consumption is positive and significant (0.33). Similarly, García and Rodríguez (2005) specify a model for the Spanish football pools where only lags of the endogenous variable appear as explanatory variables. The estimated effect of addiction, obtained as the sum of the coefficients of the lag endogenous variables varies from 0.17 to 0.49. [32]

1.5.3 Complementarities and displacements among competing lottery games

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

[32] However these arguments are 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.

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. (2005) 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.[33] Price and Novak (2000) include variables describing

[33] 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.

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 Euro Millions – a European multi-country lotto game – jackpot.

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.

1.6 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 different models in the economics literature. The effective price model, based on expected utility theory, the jackpot model, and the mean-variance-skewness 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.

Furthermore, the use of these economic models has been also widespread to other pari-mutuel betting mediums, such as sports lotteries (football pools) or horse track betting

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. The mean-variance-skewness model includes 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. The literature can make real progress by building creative models that make sense of this.

Besides the US and Canada, work in this field continues to be centered on applications of both economic models proposed in the empirical literature on the demand for lottery: the effective price model and the jackpot model. Thus, 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.

It is hoped that the examples presented here provide evidence that much remains to be learned though creative application of the empirical analysis of the demand for lottery.

Chapter II

Network externalities in consumer spending on lottery games: Evidence from Spain

2.1 Introduction

The relationship between consumer spending on different types of gambling goods, for example between lotteries and casino gambling, has received a considerable amount of attention in the literature on the empirical analysis of gambling. This interest has been driven in part by the proliferation of legal gambling products offered to consumers over the past twenty years, and in part because the tax revenues generated by different gambling goods has become an important source of government revenue. However, little research has focused on patterns in consumer spending on closely related gambling goods like tickets for different lottery games. In this chapter we examine the relationship between consumer spending on a number of lottery games available in Spain (the *Lotería Nacional*, the *Euro Millones* game, *La Primitiva*, *El Gordo de la Primitiva*, and *Bonoloto*) using detailed micro-data on consumer spending.

The empirical analysis of consumer purchase of lottery tickets contains evidence developed from two distinct data sources. One strand of the literature uses aggregate data from repeated drawings of one or more lottery games to examine the effects of phenomena like rollovers, the introduction of new lottery games, and the decline in sales of specific games over time ("fatigue"). Studies using aggregated data include Clotfelter and Cook (1989), Farrell, et al. (1999), Forrest, et al. (2000a), Walker and Young (2001), Forrest, et al. (2002), Garrett and Sobel (2004), Forrest, et al. (2004), Farrell and Forrest (2008) and Guryan and Kearney (2008). The second strand of literature uses cross-sectional data from surveys of consumers to analyze the determinants of household expenditure on gaming goods like lotteries. Studies of consumer spending on gambling goods using micro data from household surveys generally focus on a single lottery product and include Scott and Garen (1994), Worthington (2004), Farrell and Walker (1999), and Kearney (2005).

Most of the empirical evidence on consumer spending on competing gambling goods comes from aggregate time series data. In general, this literature finds that gaming goods are complements. As far back as Clotfelter and Cook (1989), research on consumer participation in gambling activities has found considerable overlap between the purchase of lottery tickets and participation in other types of gambling like pari-mutuel horseracing and casino gambling, as well as evidence that adding additional lottery products in markets that already had one or more lottery games did not reduce the sales of existing products. Forrest, et al. (2004) found some evidence of substitution between lotto and instant "scratch-off" lottery tickets, and between Wednesday and Saturday drawings of the UK National Lottery, but no evidence of substitution between different lotto games in the UK. Grote and Matheson (2006) found evidence of both complementarities and substitution between a single state lotto and a larger jackpot multi-state lotto. Farrell and Forrest (2008) found evidence of complementarities between lottery and casino gaming, and evidence of substitution 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. Although the general consensus is that the introduction of new games attracts new customers, and potentially induces additional expenditure from existing lottery players, no previous analysis of lottery ticket purchase has explored the issue using micro data.

In this chapter, we examine consumer spending on different lottery games. Grote and Matheson (2006) point out that determining whether two gambling goods are complements requires data on the price of each good, which in this case depends on the expected value of the good. We cannot calculate an effective price for lottery tickets for our data, so we are unable to determine if any of the lottery goods are complements; we observe consumer participation and spending on different lottery goods, and analyze the relationship between participation and spending in one lottery market and participation and spending in other lottery markets. Unlike the papers discussed above, we examine spending on alternative lottery games in the context of consumption network externalities. Economides (1996) observed that positive direct consumption network externalities arise when additional customers enhance all other customers who purchase a good or service. This clearly applies to lottery games, where additional customers in a given lottery draw increases the size of the jackpot, thus increasing the expected value to all purchasers. Also, positive indirect consumption network externalities arise when different varieties of a network good exist, and additional customers for one variety of good yields indirect externalities to buyers of other varieties. In this case, different lottery games represent varieties, and the purchase of additional tickets for one game can generate benefits to all purchasers of other games through direct and indirect consumption network externalities. The surveys we use contain detailed information about consumers purchase, intensity of purchase, and length of play for different lottery games that allow us to look for evidence of consumption network externalities.

2.2 Lottery markets in Spain

According to a recent Gambling National Commission report (*S.G. de Estudios y Relaciones Institucionales. S.G.T. Ministerio del Interior*, 2007), in 2006 Spanish people spent over €28.8 billion on gambling, about €646 per inhabitant. Nearly 60 per cent of this spending on gambling went to private gambling activities like casinos, 33 per cent to public lotteries and over 7 per cent to lottery games managed by the Spanish National Organization for the Blind (ONCE). Although the most popular game for Spanish gamblers is slot machines, on which Spaniards spend about €244 per year, playing lotteries represents a traditional and increasingly popular gambling activity in Spain. Spain's lottery market is one of the largest in the world.

There are many lotteries in Spain. A state-run Spanish lottery dates back nearly 250 years. The fore-runner to today's national lottery, the *Lotería Nacional*, was introduced as a way of increasing state income in the eighteenth century. Other state-run lotteries include several pari-mutuel lotto games managed by *Loterías y Apuestas del Estado* (LAE) – the Spanish National Lottery Agency – and *Euro Millones*, a European multi-country lotto game. ONCE also runs lottery games through a state concession in order to generate operating funds and provide employment for thousands of disabled people in Spain.

We focus this analysis on consumers' purchase of tickets in state-run lottery games. These lottery games are widely available throughout Spain. Tickets can be purchased at any LAE outlet. LAE offers five different lottery games that run throughout the week: the *Lotería Nacional* a (passive) draw lottery game played every Thursday and Saturday, *Euro Millones*, a multi-country lotto with a 5/50 plus 2/9 format that has a weekly drawing on Fridays, *La Primitiva*, a 6/49 lotto game with drawings on Thursday and Saturday each week, *El Gordo de la Primitiva*, a 5/54 plus 1/10 lotto with drawings on Sunday each week, and *Bonoloto*, a lotto game with a 6/49 format that has drawings on Monday, Tuesday, Wednesday and Friday each week. The price of tickets varies depending on the game played. The *Bonoloto* costs 50 cents per bet, *La Primitiva* costs €1, *El Gordo de la Primitiva* costs €1.50, and Euro Millones costs €2. Lotto tickets can be completed by choosing numbers or by buying a randomly generated set of numbers. The takeout rate is .45 for all games except *Euro Millones*, which has a takeout rate of .50. Prizes are awarded when there are a minimum of two or three winning numbers out of a maximum of 5 or 6, according to each lotto game.

The passive *Lotería Nacional* has a fixed number of digits on each ticket. Players have no ability to select specific numbers in this game. Prizes are awarded based on the number of digits matching the winning numbers. In addition, some more numbers are drawn in order to set low prize categories. In each draw there are numbers between 0 and 99,999 (except in the Christmas Special Draw where numbers goes from 0 to 84,999). Each of these numbers is divided into "series", depending on the kind of draw (6 series are generated in the Thursday draw and 10 series are generated in the Saturday draw). Each of this "series" is divided into "décimos", or a tenth part of an entire lottery number. The ticket ("décimo") price ranges from €3 to €12 depending on the draw (there are three special draws during a year - two Christmas draws and a Summer draw – in which the ticket price is increased to €20 and prizes are also increased). The *Lotería Nacional* distributes 70% of the handle as prizes – among the highest percentages in the world. As all of these games are state-run lotteries, prizes are paid immediately and there are no taxes on winnings.

TABLE 2.1 Spanish state-run lottery games features

Game	Average Jackpot (Euros 2006)	Price (Euros)	Takeout rate
Lotería Nacional (Thursday)	1,200,000	3	.30
Lotería Nacional (Saturday)	3,000,000-5,000,000	6-12	.30
Euro Millones	50,940,123	2	.50
La Primitiva	4,183,750	1	.45
El Gordo de la Primitiva	10,191,510	1.5	.45
Bonoloto	1,214,553	0.5	.45

Because these games share drawing days over the course of the week, have large jackpots and frequent rollovers, are widely available in Spain, and are designed with a small probability of winning a large prize, these games can potentially generate consumption network externalities. Detailed survey data about individuals' participation in each of these games provides us with a unique setting in which to investigate the inter-related spending on different lottery games at the household level. Previous research on spending on alternate lottery games has been carried out using aggregated data that obscures any inter-related purchases.

2.3 The empirical analysis of consumer spending on lotteries

We motivate our analysis of consumer spending on lottery games with a standard latent variable model of consumer choice extended to the case where the consumer must pass two hurdles before observing positive consumption of lottery tickets. We assume that the decision to purchase lottery tickets and the decision about how many lottery tickets to purchase are separate decisions. Suppose that g is household expenditure on a gaming good like lottery tickets, c is all other household expenditure, and e is household income. The utility function $U(g; c)$ relates satisfaction to the consumption bundle (g,c) and the budget constraint is $g + c = e$. Note that no assumptions are made about the household's risk aversion in this model. Lottery tickets are simply treated as a good that households purchase. Based on this constrained utility maximization problem, it is straightforward to derive an equation relating purchase of lottery tickets to explanatory variables through a demand function

$$g^*_i = \beta' X_i + \varepsilon_i \tag{2.1}$$

where g^*_i is a latent variable that captures the utility that individual i gets from purchasing lottery tickets, X_i is a vector of variables like economic and demographic characteristics of individual i that affect the quantity of lottery tickets purchased and ε_i is an unobservable random variable that captures all other factors that affect individual i's decision about what quantity of lottery tickets to purchase. The first hurdle captures the decision to gamble or not to gamble. This decision can be modeled as

$$I^*_i = \alpha' Z_i + \nu_i \tag{2.2}$$

where I^*_i is an unobservable indicator variable that determines whether or not individual i is a gambler or not, Z_i is a vector of economic and demographic factors that affect individual decision to gamble, and ν_i is an unobservable random variable capturing all other factors affecting individual decision to gamble. β and α are vectors of unobservable parameters to be estimated.

Modelling the decision to gamble as a two part process allows for the possibility that the factors that affect the decision to gamble or not to gamble differ from the factors that affect the decision about how many lottery tickets to purchase, although there could be factors common to both decisions. This two part decision also allows for both abstentions from gambling and corner solutions to the utility maximization problem to generate observed zeros in the data.

The estimator used to generate estimates of β and α depends on the joint distribution of ε_i and ν_i and the dominance concept developed by Jones (2000). We assume that ε_i and ν_i are distributed as a bivariate normal random variable with zero means, constant variances and a coefficient of correlation of ρ. This assumption means that the unobservable factors affecting the decision to gamble and the decision about how much to gamble are correlated. Although it is possible that these two unobservable random variables are uncorrelated, we believe that the assumption of some correlation is appropriate for the case of gambling. García and Labeaga (1996) show that the likelihood function for this model is

$$L_{DH} = \Pi_1 P(\nu_i > -\alpha' Z_i) P(\varepsilon_i > -\beta' X_i \,|\, \nu_i > -\alpha' Z_i) f(g_i | \varepsilon_i > -\beta' X_i, \nu_i > -\alpha' Z_i) \cdot \Pi_0 (1 - P(\nu_i > -\alpha' Z_i) P(\varepsilon_i > -\beta' X_i \,|\, \nu_i > -\alpha' Z_i)) \qquad (2.3)$$

where Π_0 is the product operator applied to observations where g=0, Π_1 is the product operator applied to observations where g=1, and $f(\cdot)$ is the pdf for a bivariate normal random variable. In terms of the dominance concept developed by Jones (2000), we assume that the censoring mechanism in this case is

$$g_i = 1(I^*_i = 1) \max(g^*_i, 0)$$

where 1(A) indicates the occurrence of event A. In other words, in order to observe an individual purchase a positive quantity of lottery tickets there must be no abstention from gambling ($I^*_i = 1$) and no corner solution ($g^*_i > 0$).[34]

[34] Jones (2000) also discusses the case of first hurdle dominance, when the participation decision dominates the consumption decision. This condition rules out corner solutions and indicates that the Heckman sample selectivity model should be used. We assume that abstentions and corner solutions exist in the gambling data, ruling out first hurdle dominance in this case.

Alternatively, gambling could be characterized by first hurdle irrelevance. In this case, the participation decision has no effect on consumption and the zeros observed in the data arise because the individual does not purchase lottery tickets for no identifiable reason. The censoring mechanism for the case of first hurdle irrelevance is simply

$$g_i = \max(g^*_i, 0)$$

and in all instances where positive purchases of lottery tickets are not observed $g_i = 0$. In this case, the factors that determine whether on not an individual gambles and the factors that determine how many lottery tickets are purchased are identical. García and Labeaga (1996) show that in this case of corner solutions, the Tobit model

$$L_T = \Pi_1 P(\varepsilon_i > -\beta' X_i) f(g_i | \varepsilon_i > -\beta' X_i) \cdot \Pi_0 (1 - P(\varepsilon_i > -\beta' X_i)) \qquad (2.4)$$

applies. Again, Π_0 is the product operator applied to observations where g=0, Π_1 is the product operator applied to observations where g=1, and $f(\cdot)$ is the pdf for a normal random variable

A comparison of equations (2.3) and (2.4) shows that the Tobit model nests in the double hurdle model. When $P(\nu_i > -\alpha' Z_i) = 1$, Z_i and X_i contain the same variables and $\alpha' = \beta'$ the first hurdle is eliminated and the double hurdle model collapses to the Tobit model. This allows for a form test of the double hurdle model against the Tobit model using a standard likelihood ratio test.

Note that Scott and Garen (1994) and Farrell and Walker (1999) estimated the parameters of the latent variable model given by equations (2.1) and (2.2) using the Heckman selectivity model and survey data from the U.S. state of Kentucky and the United Kingdom, respectively. Jones (2000) points out that the Heckman selectivity model applies to first hurdle dominance, and not to the case where the observed zeros in the data are the result of either a utility maximizing decision by consumers not to purchase the good or service in question or abstention from gambling. Instead, Jones (2000) shows that either the Cragg model, which can be easily derived from equation (2.3) when ε_i and ν_i are independent, or the full double hurdle model, equation (2.3), are appropriate in this setting. In the latent variable model that motivates consumers' purchase of lottery tickets, observed zeros are either utility maximizing choices or abstentions. So either the Cragg model or the double hurdle model should be used. Both of these estimation approaches are maximum likelihood estimators of equations (2.1) and (2.2). In the existing literature on the empirical analysis of consumer purchase of lottery tickets, only Abdel-Ghany and Sharpe (2001) have estimated double hurdle models of consumers' participation in lottery markets and expenditure on lottery tickets.

2.4 Data description

Our data come from two computer assisted random digit dial telephone interview surveys administered by *Loterías y Apuestas del Estado* (LAE), the Spanish state lottery agency, in 2005 and 2006. Both surveys included a random sample of all residents of Spain. The first survey took place in the spring of 2005, the second in the summer of 2006. 1,412 households were participated in the first survey and 1,205 households participated in the second survey. Although a large number of identical questions appeared on both, there were a few differences between the two surveys. The exact age of the head of the household was available in the first survey but only age intervals were available in the second. We recoded each age interval variable at the midpoint of the range for the second survey. Also, monthly income data were collected by income range, and we recoded the income variable reported for each respondent at the midpoint of the range. The 2005 monthly income and lottery expenditure data were expressed in real 2006 euros.

Table 2.2 shows summary statistics for participation and average monthly spending on the five lottery games, based on both of the LAE surveys.

TABLE 2.2 Summary statistics for participation in lottery games

Game	Monthly Expenditure Mean	Monthly Expenditure Std. Dev.	Regular Participation	Lifetime Participation
Lotería Nacional	5.57	42.28	16%	52%
Euro Millones	1.33	4.60	12%	25%
La Primitiva	6.09	70.63	32%	63%
El Gordo de la Primitiva	1.48	7.25	11%	29%
Bonoloto	1.87	23.88	11%	32%

The lifetime participation rate in these games is based on the answer to the question "Have you ever participated in …" that is found in both of the surveys. The "regular" participation rate is the fraction of respondents who reported playing the game "Every time there is a draw," "At least one time per week," or "At least one time per month." The average monthly expenditure is calculated for all households who reported playing that game. *La Primitiva*, a twice a week 6/49 lotto game, is the most popular lottery game in the sample, in terms of regular and lifetime participation and average monthly expenditure. The passive *Lotería Nacional* is the second most popular game in terms of lifetime participation and average monthly expenditure.

TABLE 2.3 Summary statistics for household characteristics

Variable	Mean	Std. Dev.	Min	Max
Age of Head of Household	46	17	18	93
Real Monthly Income (000s)	1.58	1.04	0.25	5.02
Male Head of Household	0.48	0.50	0	1
Single Head of Household	0.13	0.33	0	1
Years of Education	13.69	5.56	0	22
Employed Head of Household	0.66	0.48	0	1
# of different games played	3.86	2.74	0	10

Table 2.3 shows summary statistics for the household economic and demographic variables in the surveys. Income was deflated to real 2006 Euros using the Spanish Consumer Price Index and is expressed in thousands of Euros per month. Most individuals in the survey

reported playing multiple lottery games. 11% of the individuals in the sample reported never playing one of these five lottery games in their lifetime. The average monthly expenditure on all five lottery games reports on Table 2.2 is about 1.5% of the average monthly income reported on Table 2.3.

2.5 Empirical results and discussion

The two likelihood functions described above, equations (2.3) and (2.4) describe two alternative empirical models for explaining consumer participation in lottery games and expenditure on lotteries. The dependent variable in the Tobit model, equation (2.4), is expenditure on a particular lottery product; the double hurdle model, equation (2.3), has two dependent variables, a participation indicator for a particular lottery product and expenditure on that lottery product. A common vector of variables for explaining consumer participation in gaming markets and expenditure on lottery products has emerged in the literature. These explanatory variables include age and age squared to allow for a non-linear relationship between age and participation and expenditure, income, gender, marital status, employment status, and the level of education. This set of covariates has been used in every empirical study of consumer participation in gambling markets and expenditure on gambling goods.

Some studies include additional covariates when available, to explain observed participation in gambling markets and expenditure on gambling goods. For example, Scott and Garen (1994) had access to data on religious affiliation and prior participation in pari-mutual horserace betting in their survey of participation and expenditure on instant “scratch off” lottery ticket markets in Kentucky and Farrell and Walker (1999) were able to calculate an expected value of lottery tickets based on knowledge of the date when each survey was conducted and the details of the UK national lottery on those specific dates. We do not have access to data on religious affiliation information or know the exact date when each interview was conducted. However, we do have access to detailed data about the frequency of purchase of a number of different lottery products for each survey participant. We exploit this information to examine patterns of inter-related purchasing across these five lottery games. In particular, we add a vector of indicator variables that are each equal to one if that person reported playing that game either every week, or every time a draw took place to both empirical models and construct a variable for the total number of other lottery and sports betting games, not counting the five lottery games examined here, that each survey participant reported playing. These variables reflect the general interest that each survey participant has in gambling, as well as access to lottery outlets.

Again, we explain participation in specific lottery games and expenditure on these games using past participation in different lottery games as explanatory variables. Including explanatory variables indicating frequent participation in other lottery games raises the possibility that these explanatory variables are correlated with the unobservable equation error terms, u_1 and u_2, from above. This correlation could be due to a general proclivity for an individual to purchase lottery tickets of any type, for example. If such correlation exists, and these indicator variables are endogenous, then the estimators used here are inconsistent. While we cannot explicitly rule out this correlation, previous research on lottery participation have included similar explanatory variables. Scott and Garen (1994), when analyzing participation and expenditure on scratch-off lottery tickets, included an indicator variable for past participation in horse race betting as an explanatory variable. Also, the indicator variables refer to participation in different lottery games. For example, we explain current participation in the *Lotería Nacional*, and current spending on these tickets, with past frequent participation in *Euro Millones* and other different lottery games. If decisions to participate in different lottery games are independent, then these explanatory variables will not be correlated with the unobservable equation errors. Finally, if individuals interpret the participation questions as based on past participation but the expenditure questions as current expenditure, then the explanatory variables indicating participation in other lottery games will be predetermined at the point that current expenditure decisions are made, and the explanatory variables will be uncorrelated with the equation error terms.

Table 2.4 shows the results for the Tobit model, equation (2.4).[35] Recall that this model implicitly forces the effect of all of the explanatory variables on participation and expenditure to have the same sign. The signs of the estimated parameters on the explanatory variables generally conform with those found in the literature. Age is significant and positive, and age squared significant and negative, in four of the five games. This indicates an inverse-U shape to the function defining lottery ticket expenditure over the life cycle, with average monthly expenditure rising from youth to middle age, peaking in middle age, and declining thereafter. The Tobit results do not show a strong relationship between income and expenditure on lottery tickets, with the exception of expenditure on the *Lotería Nacional*. Most previous studies have found little systematic relationship between spending on lottery tickets and income. Males tend to spend more on lottery tickets than females, although this variable is only significant for *Euro Millones* and *La Primitiva*. Single persons spend less on lottery tickets than married persons, which is again consistent with previous results in the literature.

The relationship between monthly spending on lottery tickets and education is mixed in this sample. Monthly spending on the *Lotería Nacional* falls with education, but spending on *El Gordo de la Primitiva*, and to a lesser extent on *Bonoloto*, rises with the level of education. Most previous studies have found that spending on lotteries falls with the level of education. Participation in other gaming activities, including sports betting pools, is strongly associated with higher monthly spending on all five of these lottery games. This suggests that the five lottery games may generate positive consumption network externalities.

[35] The results for *La Primitiva* use only observations from the wave 1 survey to make the results comparable to the double hurdle model results shown below.

TABLE 2.4 Parameter estimates and p-values, Tobit model
Dependent variable is monthly expenditure on each game

	Lotería Nacional	***Euro Millones***	***La Primitiva***	***El Gordo***	***Bonoloto***
Age	3.599	0.218	1.128	0.008	1.96
	(.001)	(.174)	(.001)	(.972)	(.014)
Age2	-0.034	-0.004	-0.012	-0.001	-0.018
	(.001)	(.038)	(.001)	(.798)	(.031)
Income	8.021	0.358	-0.01	0.632	-1.54
	(.004)	(.425)	(.988)	(.353)	(.495)
Male	8.782	4.199	4.564	1.348	6.881
	(.095)	(.001)	(.001)	(.309)	(.101)
Single	-6.418	-1.205	-4.193	-2.856	-18.747
	(.435)	(.398)	(.056)	(.196)	(.01)
Years Ed.	-1.053	-0.113	-0.143	0.290	0.774
	(.044)	(.204)	(.287)	(.036)	(.074)
Employed	-0.862	-0.158	-0.465	1.238	-0.851
	(.905)	(.894)	(.798)	(.506)	(.885)
# of Other Gms.	12.103	2.64	2.325	3.728	13.309
	(.001)	(.001)	(.001)	(.001)	(.001)
Constant	-193.688	-24.577	-36.889	-40.134	-167.858
	(.001)	(.001)	(.001)	(.001)	(.001)
Frequently Plays:					
Lotería Nacional	---	2.598	3.791	2.559	5.596
	---	(.036)	(.09)	(.177)	(.354)
Euro Millones	5.19	---	3.079	9.135	27.248
	(.604)	---	(.276)	(.001)	(.001)
La Primitiva	17.697	5.048	---	9.823	15.852
	(.006)	(.001)	---	(.001)	(.002)
El Gordo	11.297	8.949	9.412	---	31.24
	(.292)	(.001)	(.001)	---	(.001)
Bonoloto	19.636	5.375	7.305	15.65	---
	(.051)	(.001)	(.008)	(.001)	---
sigma	93.125	13.28	19.993	20.051	62.499
	0.001	0.001	0.001	0.001	0.001
N	2458	2458	1412	2458	2458
Participants	645	411	556	410	406
Log Likelihood	-4472.8	-2170.29	-2870.278	-2301.89	-2709.08

The cross-effects of frequent participation in one lottery game on expenditure on other games sheds light on the relationship between spending and participation across games. Frequent participation in a particular game is an indicator variable, so the estimated parameter of 2.598 on the *Lotería Nacional* indicator variable in the *Euro Millones* Tobit model indicates that individuals who purchase *Lotería Nacional* tickets weekly spend an additional €2.5 per month on *Euro Millones* tickets. The effects are not entirely symmetrical – frequent purchase of

Euro Millones tickets does not lead to additional spending on *Lotería Nacional* tickets. Overall, these cross-effects suggest the presence of positive network externalities in spending on lottery tickets in Spain.

Table 2.5 shows the parameter estimates and P-values for the double hurdle model, equation (2.3). The left panel contains the results for the expenditure equation and the right panel contains the results for the participation equation. Both parts of the likelihood function were estimated simultaneously by maximum likelihood, and the estimator allows for the error terms in the participation equation and the expenditure equation to be correlated. Also, recall that the double hurdle model allows for the effect of the explanatory variables in the participation and expenditure equations to have different signs and sizes, unlike the Tobit model. In addition, Jones (2000) points out that double hurdle models, and Tobit models, are applicable to censored data where the zeros are generated because consuming zero units of that good is a utility maximizing outcome. This is likely the case here, where some households may attach negative utility to the consumption of gambling goods like lottery tickets (Scott and Garen, 1994). Note that the results for *La Primitiva* on this table are based only on data from the first survey conducted in 2005, and not pooled data from both surveys. This is because of convergence problems for the double hurdle model in this particular specification.[36]

We place an exclusion restriction on the double hurdle model in order to identify the participation equation, by including a variable reflecting the number of additional gambling activities reported in the participation equation and omitting this variable from the expenditure equation. The literature is generally silent on the issue of exclusion restrictions for double hurdle models; in this case, an exclusion restriction was needed to get convergence of the maximum likelihood estimator. The data set does not contain many variables suitable for use as instruments, so robustness tests of the exclusion restriction are difficult to perform. We tried one

[36] Flood and Glasjo (2001) discuss convergence problems when estimating double hurdle models with maximum likelihood.

alternative instrument, a variable reflecting the number of lottery games offered by ONCE, an alternative Spanish supplier of lottery products, that the individual reported playing in a group. ONCE tickets are sold in different locations and the proceeds from these games go to charity. The use of this alternative instrument did not change the results reported on Table 2.5.

In general, the double hurdle model results on Table 2.5 resemble the Tobit results on Table 2.4. Both participation and expenditure are largely unrelated to income and employment. Males participate in *Euro Millones* and *La Primitiva* more than females. Expenditure on most games falls with the level of education. The double hurdle model relaxes the assumption in the Tobit model that the signs on variables in the participation and expenditure functions are equal. The results on Table 2.5 contain several instances where this assumption is violated. For example, from Table 2.4, the Tobit results indicate that expenditure on the *Euro Millones* game is unrelated to the level of education. But the results on Table 2.5 indicate that participation in the *Euro Millones* game rises with income while expenditure on this game falls with income.

The interesting results in Table 2.5 relate to the network externalities in participation and in expenditure on lottery games. Table 2.5 contains some evidence of inter-related participation in lottery games. The total number of other lottery games played increases the probability that individuals purchase tickets in all five of the lottery games. Individuals who participate regularly in *El Gordo de la Primitiva*, a large-jackpot 5/54 plus 1/10 lotto with weekly drawings on Sundays are more likely to participate in *Euro Millones*, a large jackpot, multi-country 5/50 plus 2/9 lotto with weekly drawings on Friday. These two lottery games have similar structures and the largest jackpots of the five lottery games analyzed here. This relationship extends to expenditure: people who participate frequently in *El Gordo* tend to spend more on *Euro Millones* tickets, and people who participate frequently in *Euro Millones* spend more on *El Gordo* tickets. This evidence suggests that high jackpot games with low probabilities of winning appeal to a group of Spanish lottery players, and these individuals play both games and spend more on these games. The games do not “cannibalize” sales from one another. One reason for this pattern in participation and spending is that these lottery games can be interpreted as varieties of network consumption goods, and positive consumption network externalities explain the tendency to purchase both lottery goods. These results also confirm the results of numerous studies using aggregate data that indicate that lottery market participants like large jackpot, long odds games.

TABLE 2.5 Parameter estimates and p-values, Double Hurdle model
Dependent variables are monthly expenditure and participation

	Monthly Expenditure					***Monthly Participation***				
	LN [a]	**EM [b]**	**LP [c]**	**EG [d]**	**B [e]**	**LN [a]**	**EM [b]**	**LP [c]**	**EG [d]**	**B [e]**
Age	1.416	-0.406	0.544	1.023	2.33	0.250	0.088	0.096	-0.046	-0.022
	(.403)	(.290)	(.180)	(.169)	(.404)	(.030)	(.093)	(.076)	(.300)	(.551)
Age2	-0.011	0.004	-0.006	-0.009	-0.019	-0.002	-0.001	-0.001	0.001	0.001
	(.556)	(.370)	(.179)	(.183)	(.495)	(.039)	(.065)	(.203)	(.346)	(.581)
Income	15.327	1.373	-0.823	0.499	-11.618	-0.336	-0.234	0.670	0.016	0.187
	(.001)	(.269)	(.387)	(.826)	(.150)	(.271)	(.126)	(.067)	(.899)	(.088)
Male	13.798	8.355	6.684	-3.074	12.429	-0.991	-0.502	-0.537	0.204	-0.093
	(.107)	(.001)	(.001)	(.468)	(.389)	(.130)	(.095)	(.098)	(.397)	(.609)
Single	13.853	1.055	-5.326	1.272	-11.314	-0.404	-0.652	0.310	-0.177	0.022
	(.269)	(.776)	(.115)	(.847)	(.625)	(.557)	(.12)	(.633)	(.624)	(.939)
Years Ed.	-2.334	-0.626	-0.554	-0.06	-0.451	-0.058	0.074	0.051	0.014	0.015
	(.005)	(.004)	(.019)	(.898)	(.730)	(.235)	(.014)	(.241)	(.615)	(.360)
Employed	-14.791	1.986	-0.918	3.872	7.236	1.277	-0.272	0.424	-0.344	-0.216
	(.206)	(.496)	(.738)	(.453)	(.712)	(.145)	(.488)	(.318)	(.25)	(.392)
# other games	---	---	---	---	---	1.587	0.296	0.511	0.147	0.107
	---	---	---	---	---	(.003)	(.001)	(.001)	(.001)	(.001)
Constant	-165	-3.89	-15.29	-46.83	-91.21	-5.056	-1.708	-4.168	1.404	0.404
	(.001)	(.674)	(.142)	(.013)	(.177)	(.010)	(.115)	(.003)	(.205)	(.638)
Frequently Plays:										
LN [a]	---	8.87	7.74	2.90	25.91	---	-0.555	-0.324	0.085	-0.158
	---	(.001)	(.007)	(.512)	(.073)	---	(.088)	(.583)	(.769)	(.401)
EM [b]	18.00	---	2.36	11.36	30.84	0.226	---	6.155	-0.014	-0.089
	(.200)	---	(.440)	(.014)	(.046)	(.863)	---	(.958)	(.965)	(.684)
LP [c]	35.76	1.771	---	11.69	6.90	0.063	0.681	---	0.259	0.210
	(.001)	(.552)	---	(.015)	(.710)	(.913)	(.075)	---	(.356)	(.373)
EG [d]	15.87	6.98	10.10	---	-15.92	2.148	3.266	5.465	---	12.471
	(.271)	(.034)	(.001)	---	(.394)	(.171)	(.003)	(.977)	---	(.933)
B [e]	36.91	3.60	9.24	5.04	---	5.432	0.84	2.214	9.226	---
	(.005)	(.125)	(.002)	(.292)	---	(.950)	(.250)	(.330)	(.999)	---
ρ	-0.124	-0.529	-0.107	-0.873	-0.950					
N	2458	2458	1412	2458	2458					
Participants	645	411	556	410	406					
Log Likelihood	-2948	-1587	-2242	-1625	-1839					

NOTES: [a] *Lotería Nacional*. [b] *Euro Millones*. [c] *La Primitiva*. [d] *El Gordo de la Primitiva*. [e] *Bonoloto*.

Clear differences exist in the estimated effect of age and age squared on lottery participation and expenditure for the Tobit and double hurdle models. From the Tobit results on Table 2.4, expenditure on *Lotería Nacional*, *La Primitiva*, and *Bonoloto* exhibit an inverted-U pattern, initially rising with age and then falling. The results from the double hurdle model, shown on Table 2.5, differ in that participation, but not expenditure, in the *Lotería Nacional* and *La Primitiva* show an inverted-U pattern. Expenditure is not related to age or age squared in the double hurdle results. The differences highlight the effect of allowing the effect of the explanatory variables on participation to differ from their effect on expenditure, and illustrate one of the advantages of the double hurdle model over the Tobit model. We estimated all models with the age squared term omitted, but this did not have much effect on the results.

Table 2.5 contains little evidence of substitution in participation in the Spanish lottery market. There is weak evidence that individuals who frequently purchase *Lotería Nacional* tickets are less likely to purchase *Euro Millones* tickets, but the P-value (0.088) indicates very marginal statistical significance in a sample this large. These two games are quite dissimilar. *Lotería Nacional* is a passive, relatively expensive game with a relatively small jackpot, while *Euro Millones* is an active, relatively inexpensive game with large jackpots. The *Lotería Nacional* drawings take place on Thursday and Saturday while the *Euro Millones* draw takes place on Friday, so some temporal substitution may take place in this case.

Overall, Table 2.5 contains quite a bit of evidence of positive network externalities in expenditure across Spanish lottery games. Frequent participation in the *Lotería Nacional* is associated with more spending on three of the four active lotto games, and frequent participation in each of the four active lottery games is associated with increased spending on at least two of the other games studied. The evidence suggests that much of the related activity takes the form of increased spending on multiple games, not in increased participation. This evidence is consistent with Guryan and Kearney's (2005) finding that gambling on lotteries is addictive, based on the economic definition of addiction. Again, these results are valid only if the indicator variables for past participation in other lottery games are uncorrelated with the equation error terms, ε_i and ν_i.

As discussed above, the Tobit model can be expressed as a special case of the double hurdle model where the coefficients of the double hurdle participation and expenditure equations are restricted to be identical. These restrictions provide a method for testing the specification of the two models. If LL_r is the maximum of the log-likelihood function for the restricted (Tobit) model and LL_u is the maximum of the unrestricted (double hurdle) model log-likelihood function, then the statistic

$$LR = -2[LL_r - LL_u]$$

has a chi-square distribution with degrees of freedom equal to the number of unrestricted parameters minus the number of restricted parameters, 9 in this case. The null hypothesis is that the restrictions are correct; in this case, the null hypothesis is that the restrictions that reduce the double hurdle model to the Tobit model are correct. This null hypothesis can be rejected at the 1% level for each of the five lottery games analyzed. The results of these tests indicate that the Tobit model is mis-specified and the double hurdle model is more appropriate for each Spanish lottery game. García and Labeaga (1996) report similar results favouring double hurdle models over Tobit models based on this test using data for Spanish cigarette smoking.

The literature on lottery participation based on aggregate data contains little evidence of substitution between different gambling activities, and no evidence of substitution between different lottery games. In general, the introduction of new lottery games, or additional draws of existing games does not reduce aggregate sales of lottery tickets. Our evidence sheds new light on the mechanism that generates these results. Our results suggest that varieties of games with similar characteristics are more likely to be purchased in combination. One explanation for this behavior is the presence of positive consumption network externalities in lottery games.

The introduction of a new game with similar characteristics induces existing players to participate in the new draw or game, and to spend more on the existing and new game because of these externalities. Also, the probability of participation in a given lottery game rises with the number of other games played. This suggests that the introduction of new games induces existing players to buy tickets in the new game, and to spend more on that game than new players.

2.6 Closing comments

We use a novel data set on consumer spending on five different lottery games in Spain to investigate the inter-related purchase of tickets for different lottery games. The parameter estimates from a Tobit model and a double hurdle model of consumer spending on lottery both suggest that positive consumption network externalities exist in Spanish lottery markets. Frequent participation in one of the five lottery games is associated with higher spending on at least two of the other games, but not with an increased probability of participation in the other games. In addition, because the signs of the estimated parameters on some variables in the participation equation differ from the signs on the estimated parameters in the expenditure equation, and a likelihood ratio test rejects the restrictions associated with the Tobit model, the double hurdle model appears to be a better choice than the Tobit model for analyzing lottery expenditure in this setting.

Our results have important implications for increasing understanding of consumer behavior and for the design of lottery policy. The evidence of a complementary relationship between different lottery games suggests the presence of consumption network externalities in this setting. Positive consumption network externalities would help to explain why the introduction of additional lottery games does not "cannibalize" existing games. Frequent participation on one lottery game does not increase the probability of participating in any other specific lottery game, not does it reduce the probability of participating in any other specific lottery game. However, the total number of other lottery games played increases the probability of participation in all of the lottery games. The evidence is consistent with the presence of positive consumption network externalities in lottery games. More importantly, frequent participation in one lottery game is associated with additional monthly spending on other games. The complementary nature of consumer spending on different lottery games is intensive, and not extensive.

In terms of lottery policy, the complementary nature of consumer spending on different lottery games, combined with the fact that the government is a monopoly supplier of lottery games in most settings, suggests that lottery games may be undersupplied. A monopoly supplier of any good or service will restrict supply to realize monopoly rents. The complementary nature of consumer spending on different Spanish lottery games can be interpreted as a network externality, since frequent participation in one game is associated with higher expenditure on other games. If this network externality is not accounted for in designing a lottery policy, then total revenues from all lottery games may be increased by increasing the number of lottery games offered by a monopoly government supplier.

No new lottery games were introduced between wave 1 and wave 2 of the LAE surveys analyzed here, so we cannot draw any inferences about the exact effect of the introduction of a new lottery game on consumer spending. Future research, either based on additional survey data from Spain, or on data from a different setting, will be needed to completely understand the effects of the introduction of a new lottery game on existing consumer spending on lotteries.

Chapter III

Evaluating the effects of game design on lotto sales: A case study from Spain

3.1 Introduction

Country-wide lotto games in Spain are managed by a public institution, *Loterías y Apuestas del Estado* (LAE), which is also responsible for the National Lottery (a passive lottery), the football pools and some games related to horse racing. The first lotto game in Spain, *La Primitiva*, was introduced in 1985. LAE subsequently added new lotto games with similar design: *Bonoloto* in 1988 and *El Gordo de la Primitiva* in 1993.

In addition to these domestic lotteries, players can also participate in *Euro Millones*, a multi-state lotto game with very long odds (approximately 1:80m) against winning a share of the first prize. LAE was one of the three European lottery companies responsible for introducing *Euro Millones* in 2004. It is now offered across nine countries.

The three domestic lotto games provide opportunities for Spaniards to gamble across the whole week since there is a draw for one or other of them every night. In addition, the *Euro Millones* draw takes place on Fridays. All four variants of the lotto game are designed so that the probability of winning a large prize is very small, and so frequent rollovers occur and large jackpots accumulate. Tickets for all games can be purchased at LAE outlets, widely available throughout Spain. The price of a ticket varies depending on the game. *Bonoloto* costs €0.50 per bet, *La Primitiva* costs €1, *El Gordo de la Primitiva* costs €1.50 and *Euro Millones* costs €2. In all games, bettors can select their own numbers or, alternatively, choose a randomly generated combination. A prize of some amount is awarded when there are a minimum of two or three winning numbers out of a maximum of five, six or (in the case of *Euro Millones*) seven, according to the rules of the particular game. All winnings are tax free and paid out immediately (rather than as an annuity, as is common in the US).

For many years, LAE operated its various domestic lotto games with different ticket prices, different draw frequencies and different prize structures, but always with the same 6/49 format[37] and the same 45% takeout rate.[38] This policy allowed LAE to achieve a reasonable level of lottery sales.[39] Nevertheless, in 2005, LAE introduced modifications to the design of one of its games, *El Gordo de la Primitiva*. The usual 6/49 format was changed to 5/54 + 1/10. This meant that players now chose five numbers from a set of 54 and one number from a set of ten. The new two-panel format made it much harder to win a share of the grand prize, odds having lengthened from approximately 1:14m (under 6/49) to 1:32m. At the same time, other features of the game were also altered. For the first time, LAE guaranteed the size of the pool for the grand prize (a minimum of €5m, irrespective of the level of sales for a particular draw). And it added new lower tier prize levels. The entry fee, however, remained at €1.50. LAE hoped, of course, that the new set of rules would stimulate sales of *El Gordo de la Primitiva*. Here, we use weekly data for draws of the game between 1997 and 2008 to evaluate changes in demand for *El Gordo de la Primitiva*.

The structure of the chapter is as follows. The next section reviews the background to the game, describing its rules and how these changed and how levels of ticket sales evolved over time. Then an economic model of demand is presented and the main empirical findings reported. Finally, we offer conclusions that may be drawn from this unusual experiment of varying the structure of a pre-existing lotto game.

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[37] 6/49 means that a player must select 6 numbers from a set of 49. When the draw takes place, six balls are taken randomly from a set of 49 without replacement. The player wins a share of the grand prize if the six numbers he selected correspond to the numbers on the six balls drawn.

[38] The multi-state *Euro Millones* has a takeout rate of 50%.

[39] In 2004 LAE lottery games turnover (total sales) was almost €8.5b, over €194 per inhabitant - compared with about €116 for the UK National Lottery and €143 for the National Lottery in France -. (Sources: *Study of Gambling Services in the Internal Market of the European Union* and *2004 LAE Annual Report*).

3.2 Background to the game

El Gordo de la Primitiva was introduced on October 31, 1993 as a monthly 6/49 lotto game similar in format to that offered in many jurisdictions worldwide. It was found subsequently that sales were heavily concentrated in the few days before each draw and this was taken as an indication that a weekly frequency would be more in accordance with customer demand. Consequently, LAE made the game a weekly event from October 12, 1997, the start date for the data series we employ in modelling.

As with other lotto games, the basis of *El Gordo de la Primitiva* was pari-mutuel (i.e. the amount allocated to prizes was a fixed percentage of total revenue). Players had to choose six numbers from the set 1 to 49. If the selection made exactly matched the six main numbers drawn, the player shared in the jackpot prize. In the early years of the weekly draw, this was typically about €0.5m where there was no rollover from previous draws; but the jackpot could increase to as much as €12m through rollovers when several weeks had passed without a winner. There were also a number of lower prize tiers (an additional ball was drawn to be used in determining who was entitled to certain of these) for matching fewer than the complete set of numbers. The price of a unit bet was €1.50 and 55% of total revenue was allocated to the prize fund.

The prize fund was first used to pay fixed value prizes: the refund of the ticket price[40] and the lowest prize category, which had a fixed reward of €15.03. The amount remaining in the prize fund was then divided between prize pools for the jackpot and other prize tiers, in proportions specified in the rules of the game. At each tier, winners would share whatever amount was in the relevant pool. If there were no winners of the jackpot, the amount devoted to

[40] The number for the refund prize (this prize was introduced by LAE in 1991 for all state-operated lotto games) is drawn from a special lottery drum including just ten balls numbered from 0 to 9. Under the old game design (6/49) a random number between 0 and 9 was mechanically assigned to each ticket, and that was the number determining entitlement to a refund of the ticket price. Thus, the probability of winning the refund was given by exactly 0.1 and so 10% of total revenue was used up on this prize.

this category rolled over to augment the jackpot pool in the next week's draw; but if there were no winners in any particular prize tier below jackpot level, the amount in the pool would be transferred to the next prize category below. Thus all funds in the prize pools below jackpot level were always paid out after each draw.

On February 6, 2005, LAE introduced a major modification to the design of the game by changing its usual 6/49 to a 5/54 + 1/10 format. So now a bettor had to choose five numbers from the set 1 to 54 plus an additional number from a second matrix consisting of ten numbers from 0 to 9. This second matrix, besides determining winners for a number of prize categories, would also fix the number for the refund, a very popular prize among Spanish gamblers. Due to the change in format, the number of possible combinations increased from 13,983,816 to 31,625,100, making the game much more difficult to win. LAE also redesigned the distribution of the prize fund between prize tiers. Before there had been five levels of prize (apart from the refund) but now there were to be eight.

In addition, LAE introduced a guarantee that the amount in the jackpot pool for any draw would never be below €5m. If sales for a particular draw were insufficient to generate this amount, LAE would make up the difference, using a reserve fund paid for by reducing the proportion of revenue allocated each week to the prize fund.

Table 3.1 summarises differences in the rules of the game before and after the redesign.

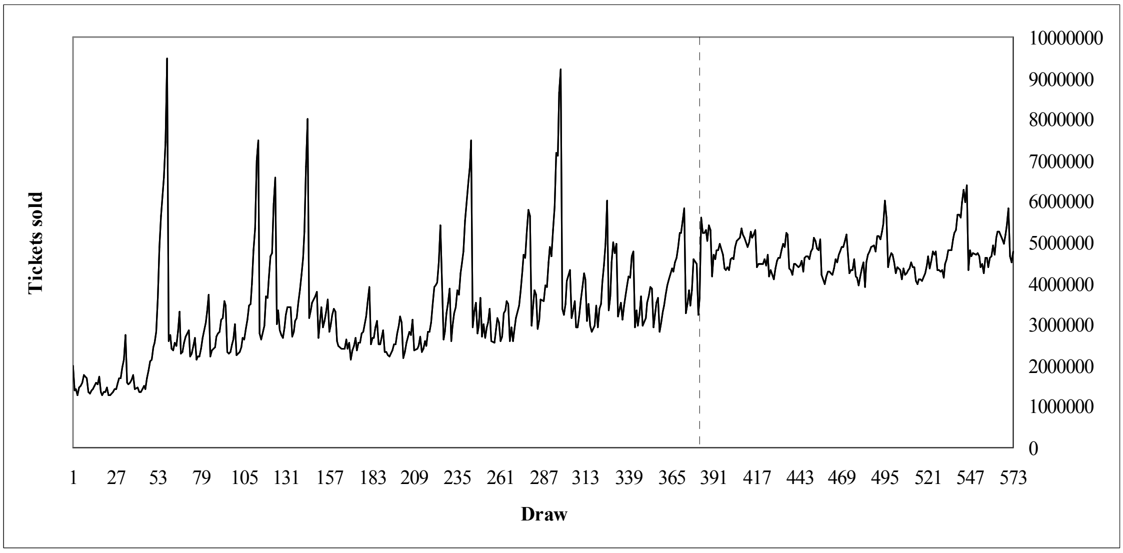
Figure 3.1 shows the number of tickets sold at each draw from when weekly frequency was introduced in 1997. A vertical line at draw 382 marks the structural break associated with the change in game design in 2005. It is clear that there was a marked reduction in the degree of variability in weekly sales figures. For example, in the twelve months prior to the change of design, weekly sales ranged between 2.8m and 5.8m tickets (standard deviation 0.74m, coefficient of variation 0.189). In the subsequent twelve months, the number of tickets sold ranged from 4.1m to 5.6m (standard deviation 0.37m, coefficient of variation 0.079).

TABLE 3.1 Rules of *El Gordo de la Primitiva*

	Before February 6, 2005	**After February 6, 2005**
Format	**6 / 49**	**5 / 54 + 1 / 10**
Drawing frequency	weekly	weekly
Ticket price (€)	1.5	1.5
Take-out rate	0.45	0.45
Prize categories	5	8
Share of the prize pool [a]		
Jackpot	0.55 [b]	0.22 [c]
2nd category	0.05	0.33
3rd category	0.16	0.06
4th category	0.24	0.07
5th category	€ 15.03	0.08
6th category	-	0.26
7th category	-	0.20
8th category	-	€ 3
Odds of winning		
Jackpot	7.151×10^{-8}	3.162×10^{-8}
2nd category	4.291×10^{-7}	2.846×10^{-7}
3rd category	1.845×10^{-5}	7.747×10^{-6}
4th category	0.000969	6.972×10^{-5}
5th category	0.0177	0.000372
6th category	-	0.00335
7th category	-	0.00583
8th category	-	0.0524

NOTES: [a] 55% of total income goes into the prize pool, but 10% goes to a fund for the refund of the ticket price prize and the remaining 45% is then distributed among prize categories. [b] Once the total amount devoted to the flat prize for the 5th category is deducted from 45% of total income, the remaining amount is distributed among prize categories (including the jackpot). [c] 22% of total income goes directly into the jackpot prize pool. The remaining 23% of total income – after deducting the total amount devoted to the flat prize for the 8th category – is distributed among lower categories.

FIGURE 3.1 Sales of *El Gordo de la Primitiva* since weekly frequency was introduced



Of course, week-to-week variation in sales is of much less interest to the operator than aggregate sales over the year. Comparing *average* weekly sales in the twelve month periods either side of draw 382, there was an increase of 23.6%, from 3.9m tickets to 4.8m. LAE therefore appears to have made a correct judgement on whether the redesign would increase its revenue from *El Gordo de la Primitiva*. It should be noted that LAE had not been pressured into reform by falling sales. Figure 3.1 shows no falling off in the level of interest of players prior to 2005.

To understand how LAE was able to benefit from increased overall sales from the game, we consider sales within 'draw cycles', a term coined by Matheson and Grote (2005) A draw cycle is a series of drawings that ends when there is a drawing for which one or more tickets sold match the winning numbers. So, a new cycle begins in the sales period immediately after the jackpot has been won. Prior to the reshaping of *El Gordo de la Primitiva* in 2005, the jackpot pool at this point contained only the relevant percentage of sales revenue from that first draw in the new cycle. However, under the new regime, €5m is guaranteed to be in the prize fund. If the jackpot is not in fact won in the first week, the full €5m is then carried over to the next draw[41] and the jackpot then grows week by week, until a winner is found and that particular cycle therefore reaches its end.

Examining ticket sales within cycles is useful because, while in the long-run, ticket sales with a fixed proportion of revenue devoted to prizes are likely to be affected by several economic variables such as population, income or the availability of other gambling activities, within a single draw cycle ticket sales are likely to be influenced by the expected return. The relationship between sales and expected return may therefore be revealed by information on how sales evolve through a draw cycle.

In order to obtain a more precise impression of the pattern of sales within a draw cycle than would be possible from scanning Figure 3.1, we regressed sales of *El Gordo de la Primitiva* on a set of dummy variables representing position in the draw cycle. We also included corresponding slope dummies to represent change associated with the 'new format' in the game (from draw 382). The model also included two lags of the dependent variable, a trend, and a shift dummy controlling for draws under the new format. At this stage, the model did not contain information on the expected value of a ticket or the size of jackpot. Results are reported in Table 3.2 and Table 3.3 interprets the results to show how sales increased with position in the cycle under the old and new regimes.

The results show that, within a single draw cycle, first week sales are much higher under the new format; but sales then increase more slowly than in the old game through the following weeks (the change in game design also raised the average length of a cycle, a consequence of the jackpot being harder to win). The gains in sales are greatest in week 1 because extra is paid into the jackpot pool under new arrangements for a €5m jackpot; but of

[41] The guarantee has always been binding in week 1 of a cycle, i.e. sales have never been high enough that there was no need to add to the amount paid into the jackpot pool from current week ticket sales.

course, the bonus paid into the jackpot at the beginning of the cycle remains in the pot until a winner is found and therefore continues to exert an influence.

TABLE 3.2 Draw cycle position dummy variables (ordinary least squares)
Dependent variable is number of tickets sold

Control variables	Coefficient	p-value
Bets lagged 1 week	.601	.000
Bets lagged 1 week * new format	- .052	.725
Bets lagged 2 weeks	.064	.091
Bets lagged 2 weeks * new format	.039	.776
Trend	1953.134	.000
Trend * new format	- 1699.988	.016
New format	1303977	.023
Cycle position dummies		
Week two	800411.7	.000
Week two * new format	- 413951.5	.040
Week three	988008.8	.000
Week three * new format	- 464216.3	.014
Week four	990966	.000
Week four * new format	- 445803.7	.021
Week five	1041837	.000
Week five * new format	- 602954.3	.002
Week six	1088757	.000
Week six * new format	- 575523.6	.006
Week seven or more	1704042	.000
Week seven or more * new format	- 1019330	.000
Constant	- 310816.4	.001
Adjusted R^2	0.858	
Sample size	573	

TABLE 3.3 Sales and predicted difference in sales at different points in the draw cycle: New format compared with old format.

Sales	Before February 6, 2005	After February 6, 2005		
Average	3,271,544.96	4,714,087.59		
Standard Deviation	1,308,203.92	458,840.21		
Average length of cycle (weeks)	3.88	4.98		
Effect of position in cycle	**Change in sales compared with first week Old format**	**New format**	**Difference in sales new-old formats [a]**	**Cumulative difference in over cycle**
First week			+ 1,303,977	+ 1,303,977
Second week	+ 800,412	+ 386,460	+ 890,026	+ 2,194,033
Third week	+ 988,009	+ 523,793	+ 839,761	+ 3,033,764
Fourth week	+ 990,966	+ 545,162	+ 858,173	+ 3,891,937
Fifth week	+ 1,041,837	+ 438,883	+701,023	+ 4,592,960
Sixth week	+ 1,088,757	+ 513,233	+ 728,453	+ 5,321,413
Seventh week	+ 1,704,042	+ 684,712	+ 284,547	+ 5,606,060

NOTE: [a] Predicted differences in sales between new and old formats are calculated from coefficient estimates on new format and week-new format interaction terms in Table 3.2. For example, the predicted difference in sales in second week = 1,303,977 – 413,951 = 890,026. Calculations abstract from trend terms.

From a commercial point of view, the increase in *average* sales between the two sub-periods clearly validates the decision by LAE to reform *El Gordo de la Primitiva*. However, the findings with respect to patterns of sales within a draw period suggest that the experience might enable more general lessons to be learned about the preferences of lottery players. We therefore explore insights to be gained from applying an established model of lotto demand to the data generated from *El Gordo de la Primitiva*.

3.3 The economics of the demand for lotto

As in Spain, so in most jurisdictions worldwide, the take-out rate on lotto games is high, intended to maximise net revenue for government or worthy causes nominated as beneficiaries of the lottery. The academic literature on modelling demand for lotto has been shaped by this goal of maximising revenue. Typically it aims to test whether net revenue could be increased were consumers to be offered either improved or else worse value for money. In other words, as for most commodities, demand modelling in this area has focussed on price elasticity of demand.

An immediate practical difficulty is that, in most data sets, no variation in the face value of a ticket is observed (often this has been set to one unit of local currency ever since a game was introduced). This is true also in our data set where entry into *El Gordo de la Primitiva* has remained at €1.50 throughout.

Gulley and Scott (1993) proposed a way out of this difficulty. They recognised that the structure of a lotto game produced regular variation in value for money because rollovers improved the prizes available in a draw such as to raise the expected value of a ticket. If the effective price of a ticket is identified with the expected loss from purchasing it,[42] then a demand curve may be estimated by regressing the number of tickets sold on *effective* price. By exploiting the ripples created by rollovers, the approach would then permit elasticity of demand to be calculated and inference drawn on whether current take-out rates were appropriate for maximising the net revenue available for government or good causes. The problem of endogeneity (effective price is itself influenced by ticket sales because the probability that the jackpot prize is won by someone and therefore paid out increases with the number of tickets) could be addressed with estimation by two-stage least squares, with amount rolled into the current draw as instrument for effective price. Mainly working with data from the United Kingdom or individual American states, a number of authors have followed this approach, typically concluding that elasticity of demand with respect to effective price was close to the level consistent with net (of prizes) revenue maximisation. (Scott and Gulley, 1995; Walker, 1998; Farrell and Walker, 1999; Farrell et al., 1999; Forrest et al., 2000b).

[42] Effective price equals the face value (i.e. entry fee) *minus* the expected value of prizes for a single ticket.

One problem with this established methodology is that it risks estimating a spurious demand curve. Variations in effective price are generated by rollovers and these in a sense create a new game each time. This is because all of the rollover from a previous draw is paid into the jackpot pool. Thus a rollover draw has a very different prize structure to a non-rollover draw: a higher proportion of the expected value of a ticket comes from high prizes. Given that there is no measure of prize structure in the model, some of its effects may be picked up by the effective price term, giving a biased and misleading coefficient on effective price.

Here, we first estimate the familiar effective price model, adapted to the unusual case of a data set that includes a major design change in the game. This will permit general insights to be obtained into the debate on the adequacy of the Gulley-Scott model.

3.4 Calculation of effective price

Before the design change in February, 2005, 55% of the sales revenue from a draw was paid the prize pool. Of this, 10% was allocated to paying for the bottom prizes, the refund of the ticket price. The remaining 45% first had to pay for the fixed prizes (€15.03) for those with three 'correct' numbers. Of the amount of money then left over, 55% was allocated to the jackpot pool and 45% for lower tier prizes pools. Following Cook and Clotfelter (1993) the expected value (*EV*) of a holding a ticket is the amount of the prize pool adjusted by the probability of having a winning ticket and divided by the expected number of winners. We adapt this to reflect the detailed rules for *El Gordo de la Primitiva*. Expected value was then calculated as follows:

$$EV = (0.45(0.45R\text{-}15.03\pi_3 Q) + (1-(1-\pi_1)^Q)J)/Q + 15.03\pi_3 + 0.1P \qquad (3.1)$$

where R is total sales revenue, Q is the number of tickets sold and P is the nominal price of a ticket (1.50). The probability of winning the jackpot (approximately 7.151 x 10^{-08}) and the probability of correctly guessing three numbers (approximately .01765) are represented by π_1 and π_3 respectively. The jackpot (J) is defined as:

$$J = 0.55(0.45R - 15.03\pi_3 Q) + B \quad (3.2)$$

where B is the rollover from a previous draw without winners.

From February, 2005, the rules of *El Gordo de la Primitiva* were altered substantially. As before, 10% of total revenue was allocated to paying for the refund-of-ticket-price offered to the ten percent of tickets which qualified. The new bottom tier flat rate prize was only €3[43] and this was the next charge on the prize fund. This was taken out of the 23% of sales revenue now earmarked for all lower tier prizes. All that meant that 22% of sales revenue was to be earmarked for jackpot prizes. However, this was split. Only half of it was paid into the jackpot pool for the current draw. The other half went to a fund used for topping up the jackpot pool to €5m in any draw where this was necessary (as it always was in the first week of a draw cycle). Taking into account all these new features, expected value was now calculated as:

$$EV = (0.23R - 3\pi_2 Q + (1-(1-\pi^{new}{}_1)^Q)J)/Q + 3\pi_2 + 0.1P \quad (3.3)$$

where $\pi^{new}{}_1$ is the probability of winning the jackpot in the new format (approximately 3.162 x 10^{-08}) and π_2 is the probability of correctly guessing 2 + 0 (approximately .05243) in the 5/49 + 1/10 format. The jackpot (J) is now defined as:

$$J = \max\ [\{0.22(0.5R) + B\},\{5m\}] \quad (3.4)$$

[43] This was paid to those with two correct numbers from the first matrix and an incorrect choice of number from the other panel.

After both sets of expected value calculations (pre- and post- design change), effective price was calculated as the difference between the nominal price of a ticket (€1.5) and the expected value of the prize distribution - as defined by (3.1) or (3.3) -. The expected value increases with the amount of the rollover and decreases with the difficulty of the game. The new design greatly reduced the probability of winning the jackpot while the guarantee on the jackpot pool served to increase jackpot size.

3.5 Estimation and empirical findings

We use draw-to-draw data on sales and rollovers of *El Gordo de la Primitiva* from October 12, 1997 to September 28, 2008 (573 draws are included) in order to evaluate the effect on ticket sales of the changes introduced by LAE on February 6, 2005.

For any one draw the sales equation is:

$$Q = \text{f}(\text{constant}, Q_{-1}, Q^{new}_{-1}, Q_{-2}, Q^{new}_{-2}, trend, trend^{new}, new, effprice, effprice^{new}) \quad (3.5)$$

The dependent variable (Q) is the number of tickets sold. As suggested by Walker (1998), among others, we consider two lags of the dependent variable (Q_{-1}, Q_{-2}) to control for habit persistence in lotto play. We also include a trend (draw number) in the demand equation.

To control for the impact of the change in game design we define a dummy variable (*new format*) that takes the value 1 for all draws under the new format. We also allow this variable (*new format*) to interact with the remaining covariates, for example $trend^{new}$ equals *trend* multiplied by *new format*.

Since expected value depends on sales, *effective price* is endogenous to the demand function. This implies that it would be inappropriate to estimate the model by ordinary least squares. Following Gulley and Scott (1993) we estimate the model by two stage least squares.

We use the amount of the rollover, its interaction with the *new* dummy variable, and a dummy variable relating to the guaranteed prize[44] as instruments. We find all of these are valid instruments because they appear to satisfy the criterion of exogeneity as well as relevance. The proposed set of instrumental variables is exogenous according to the Sargan J-test (p-value= .215).

Estimation results are reported in Table 3.4.[45] Strong habit effects are captured by highly significant coefficients on the lagged dependent variables and the coefficient estimates on the corresponding interaction terms show that there was no change in this following the change in game design.

TABLE 3.4 Estimation results for the demand equation for *El Gordo de la Primitiva*
Dependent variable is number of tickets sold

	Coefficient	p-value
Effective price	- 4603552	.000
Effective price * new format	2917419	.000
Bets lagged 1 week	.279	.000
Bets lagged 1 week * new format	.046	.670
Bets lagged 2 weeks	.101	.000
Bets lagged 2 weeks * new format	- .049	.600
Trend	1910.228	.000
Trend * new format	- 2405.459	.000
New format	- 485651.5	.428
Constant	4842924	.000
Adjusted R^2	0.903	
Sample size	573	

[44] This variable refers to draws when LAE raised the jackpot prize to €5m. So it takes value one when there is an extra payment into the jackpot fund from the operator.

[45] With the size of the jackpot pool included instead of effective price, as in Forrest et al. (2002), results are very similar except that the coefficient estimate on *new* is now positive. The estimates of the jackpot model are available on request.

The insignificance of the shift dummy, *new format*, indicates that there was no outward or inward shift in demand associated with the relaunch of the game. On the other hand, the upward trend in sales evident in the first sub-period appears to have been halted, or even reversed, by the changes introduced by LAE.

As is invariably true in exercises such as this, the effective price variable attracts a strongly significant, negative coefficient, indicating that the demand curve is indeed downward sloping and that lotto players are indeed responsive to value for money. However, the interesting point here is that the corresponding interaction term is also strongly significant. Its positive sign (and the large magnitude of the coefficient estimate relative to that on effective price) suggests that sales were much less responsive to effective price under the new arrangements for the game- which incorporated both a change in prize structure and lengthening of the odds against winning the jackpot.

Essentially, then, the results indicate that, when other conditions of the game changed, there was a new and steeper demand curve. Estimation without taking into account the presence of new conditions for the game would have yielded a spurious single demand curve defined in effective price-quantity space and any calculations of elasticity based on it would be biased. This has worrying implications for the usefulness of the effective price model as this is clear evidence that buyers are not indifferent to matters such as prize structure. Of course, the two demand functions implicitly estimated by our model are themselves open to this criticism: omission of prize structure from the model implies that it is likely to yield misleading conclusions given that the variation in effective price observed is caused by rollovers which themselves also cause variation in prize structure.

Our finding underlines the need to develop further the second generation of demand studies. Forrest et al. (2002) demonstrated the relevance of prize structure by including size of jackpot alongside effective price in a demand model estimated on data from the United

Kingdom. However, they note that collinearity was a practical obstacle to obtaining reliable estimates on how sales respond separately to the two changes associated with a rollover, the fall in effective price and the greater weighting of the top tier prize in the expected value of a ticket. We encountered this problem when attempting such an exercise with the present data set.

Walker and Young (2001) proposed an alternative tack, modelling demand as depending on the probability distribution of prize amounts that might be won from a single ticket. The distribution was to be summarised by the mean (expected value), variance and skewness. They employed data from the principal game in the United Kingdom National Lottery and found that sales patterns responded positively to mean (i.e. expected value), negatively to variance and positively to skewness.[46] However, the precision of their coefficient estimates was low. This is likely to have been due to collinearity. Once again, the problem is that all variation in the data is induced by rollovers and, in this case, rollovers always move mean, variance and skewness together and always with a similar relationship to each other. This problem could potentially be resolved where a design changes produces exogenous impacts on mean, variance and skewness. Our data for *El Gordo de la Primitiva* includes such a design change and therefore offers a more promising basis for evaluating player preferences than that available to Walker and Young.

Accordingly we regressed sales on the mean, variance and skewness of the prize distribution. While the mean (or expected value) of the prize distribution is readily calculated as in (3.1) and (3.3) above, this is not so straightforward in the case of variance and skewness. We therefore used simulation to derive values for variance and skewness.

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[46] Walker and Young (2001) recognised that mean, variance and skewness were endogenous to the extent that they were influenced by, as well as influencing, sales. Despite this, they were compelled to estimate by ordinary least squares because of there being too few potential instruments relative to the number of endogenous regressors. Nevertheless, they argued that the estimates will be little affected because variation in sales will not have influenced mean, variance and skewness very much within the range of sales figures experienced in the data period.

If we assume that choice of numbers is uncorrelated across players, the numbers of winners at the various prize levels are independent binomial random variates. As the number of players is very large, and the probability of a win is small, to an excellent approximation we can take the number of winners as independent Poisson random variates.

The computation of the moments of the distribution of winnings was carried out by Monte Carlo simulation. Given the sales for any particular draw, and the known probabilities of winning the various prizes, random numbers of winners were generated using the NAG (Numerical Algorithms Group) Routine G05MEF (see Phillips, 1987). Using the lottery rules for payouts, the total payout from each prize pool was computed, and hence the expected values of the payout per player and its square and cube were estimated as described in Baker and McHale (2009). The moments of payout per player were found as the average of one million simulations per draw, and then converted to mean, variance and skewness.

TABLE 3.5 Ordinary Least Squares estimation results for the demand equation for *El Gordo de la Primitiva*
Dependent variable is number of tickets sold

	Coefficient	p-value
Bets lagged 1 week	.330	.000
Bets lagged 2 weeks	.062	.006
Trend	1048.231	.000
Trend * new format	-1360.47	.008
New format	-4216453	.000
Mean	5094809	.000
Variance	-721.776	.000
Skewness	3205.333	.000
Constant	-1.42e07	.000
Adjusted R^2	0.9257	
Sample size	573	

Table 3.5 reports the results for a sales equation with mean, variance and skewness as covariates. As before, we included two lags of the dependent variable and a trend (and its

interaction with the dummy variable that controls for the change in game design) in the estimated equation.[47]

The results show that, as in Walker and Young (2001), sales are a statistically significant function of each of mean, variance and skewness. Sales increase with the mean, decrease with the variance and increase with the skewness of the prize distribution.[48] So, players' appetite for the lottery product appears not to be explained by their being risk loving (indeed demand is a negative function of risk, as proxied by the variance of the return) but rather by a preference for skewness. The change in format will have affected sales throughout a draw cycle because the rule change produced a different pattern to the accumulation of funds in the jackpot pool and therefore skewness and the other moments evolved differently over time under the new rules.

Similar results as in the effective price model are found for the coefficients on the lagged dependent variables. So the role of habit remains as before. By contrast, the shift dummy variable (signifying the new rules to be in force) becomes significant and negative, rather than insignificant, as in the effective price model. This change has a ready interpretation. In the old (effective price) model, there are omitted variables, such as skewness, which would have represented the structure of prizes. The coefficient estimate on the dummy variable *new format* will therefore have picked up some of the effects on sales from, for example, typically greater skewness in returns; it will also have reflected views of players on how, for example, they like having to choose numbers from two different matrices. But in the new (mean-variance-skewness) model, the distribution of returns is more fully represented and the negative coefficient estimate on the dummy may plausibly be interpreted as reflecting variation in sales due to non-financial aspects of the game being regarded as less attractive than before. This may

[47] We omitted the corresponding interaction terms between lags and the dummy because these interaction terms were decidedly non-significant in results above for the effective price model.

[48] Similar preferences for horse bettors were inferred by Golec and Tamarkin (1998).

also explain why the upward trend in sales appears (just as in the results from the effective price model) to have been put into reverse by the redesign of the game.[49]

In spite of these negative changes in the underlying demand for *El Gordo de la Primitiva*, the raw data show that sales were nevertheless significantly higher following the change in the rules. Together, the results from the position-in-cycle model and from the mean-variance-skewness model demonstrate that the new format was successful because, *despite* weaker underlying demand, it offered players, through the early stages of a draw cycle, more attractive packages in terms of the probability distribution of financial returns purchased through a ticket. Evidently, sales suffered under the old regime because draws early in the cycle, while little different in terms of mean return (expected value), offered much lower skewness (reflected in jackpot size) than after the reform.

A more general finding is, of course, that the results from the mean-variance-skewness model reveal that the odds and the prize structure indeed matter (as is reflected in the strong significance of mean, variance and skewness). The effective price model ignores prize structure and results from it therefore fail to help us understand how reform of this Spanish game impacted positively on sales. It would similarly fail to generate useable predictions if applied to lottery markets where a lottery corporation was considering relaunching a game with new rules. For this reason, research needs to move on from the first generation of lotto demand studies to a focus on characteristics of the prize structure as well as on the effective price of a ticket.

[49] An alternative (partial) explanation for the sign of the shift dummy is that the change in format allowed "entrapped" players to quit the game. This refers to those who play the same set of numbers each week and who fear to miss a draw because of the regret they would experience if their numbers won when they hadn't played (Wolfson and Briggs, 2002). When format changed, long-term players were no longer tied to their old numbers and could stop playing or else switch to having their entry chosen by the computer and buying tickets less regularly.

3.6 Summary and conclusions

Economists have shown an interest in modelling lotto demand almost since the introduction of the game in the US. Their focus, for a long time, was on the influence on sales of the value for money (expected value) offered by a ticket. More recently, the literature has acknowledged that players are in fact likely to be influenced not only by the amount handed out in prizes but also by the structure of prizes. It has been proposed that prize amounts and prize structure together can be captured by the values of mean (expected value), variance and skewness that describe the probability distribution of possible prizes available to a single ticket in a given draw. These values vary from draw to draw, primarily because of the influence of rollovers. With draw-by-draw data, players' preferences can then be inferred from estimation of a statistical model in which sales in a draw depend on the values of mean, variance and skewness offered in that draw. Results from the model could be used as an input into forecasting the effects of changes in prize structure or game design on sales.

A practical problem in obtaining numerical estimates that identify players' preferences over mean, variance and skewness is that all three measures typically change significantly only as a result of a rollover. But this implies that all three always move together in a synchronised fashion. This problem of 'collinearity' makes separate identification of the influence on sales of mean, variance and skewness in returns somewhat problematic.

The problem is overcome in the present chapter by focusing on a lotto game from Spain that featured a major design change such that the probability of winning the jackpot was reduced sharply but with compensation offered in the form of a new guarantee on jackpot amount and extra tiers of small prizes. This reform introduced exogenous changes in the package of mean, variance and skewness offered to players from draw to draw, over and above the impact from regular rollovers.

The design change proved successful for the operator in terms of its effect on sales. The demand equation estimated above shows why: players like value for money (expected value), dislike the risk of not winning (variance) and appreciate extreme values of possible positive returns (skewness). The longer odds in the new format of the game introduced by the operator catered to their preference for skewness by generating longer periods over which large jackpots could accumulate and by making it less likely that jackpot winners would have to share the prize with others.

In many jurisdictions, lotto games have declined in popularity over time. The Spanish experience suggests that one way of making a game more attractive might be actually to make it harder to win. LAE's experiment of lengthening odds did indeed yield a rise in annual sales. Other national operators might therefore re-evaluate whether the formats of their games might usefully be changed in the direction of making it harder to win the jackpot. Such repackaging must, however, proceed cautiously because a change to a harder game also impacts *negatively* on sales through the variance variable. The numerical representation of players' preferences derived from a model of sales, such as that estimated above, in which sales depend on mean, variance and skewness can be an input into the evaluation of whether a particular design change would in fact be likely to raise or lower sales. More precise representation of preferences is likely when it is possible, as here, to employ data from a game where there has already been a design change.

Chapter IV

Football pools sales:
How important is a football club in the top divisions?

4.1 Introduction

The issue of the importance of the economic impact of a professional sports team on a geographical area has been extensively analysed in the empirical sports economics literature. No definite conclusion about the importance of this effect has been reached, and in some cases the effect is estimated to be negative. Most of these studies focus their attention on the effect of the main activity of the club (playing games) but far less attention has been given to the extent to which the sports gambling industry of a particular geographical area can be affected by the presence of a professional team in the top division. Thus even though the relation between sport consumption and sport gambling has also been discussed in the literature[50] - gambling is expected to be a complementary good with many sports -, the empirical evidence is limited. In this chapter we analyse the effect on sales of football pools (*La Quiniela*) in a particular geographical area in Spain (a province) of having a professional football team.

The appearance of *La Quiniela* in the 1946-47 season was a milestone in the history of gambling in Spain, as until then the *Lotería Nacional*[51] was the only available lottery-type game. *La Quiniela* is a government-operated pari-mutuel game in which prizes are a percentage of the total revenue and in which players have to choose the final results for a list of football matches among three alternatives: home win (1), draw (X), and away win (2). The share of revenues not distributed as prizes could be interpreted as an implicit tax on Spanish football pools' players.

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[50] Forrest and Simmons (2003) review the relationship between gambling and sport.

[51] Beginning in 1812, the *Lotería Nacional* is a very famous lottery game with weekly draws in Spain.

To measure the effect of having a professional football club in the top division on sales of *La Quiniela* we estimate a demand equation based on the same economic framework of the empirical models in the lotto demand literature,[52] as has been done by García and Rodríguez (2007) in a previous chapter about *La Quiniela* in Spain. In this framework the economic variables considered to explain football pools sales are the effective price and the jackpot (the maximum prize).

Using annual data at a provincial level, we also control for the effect of other variables, such as income, population, the composition of the coupon[53] and the number of football teams in the top divisions. The empirical results reinforce previous findings by García and Rodríguez (2007) in terms of the relevance of the composition of the coupon and the joint significance of the two economic variables we mentioned above. We also find a significant effect of the presence of a football club in either the First or Second Division of the Spanish football league on sales of *La Quiniela* and we identify the bets in this game as a normal good bringing some evidence of *La Quiniela*, as an implicit tax, being regressive.

The chapter is organized as follows. The next section describes the structure of the game *La Quiniela* and its evolution over recent years. In Section 3 we present the economic framework for the demand equations we specify. The variables used in the empirical analysis are described in Section 4. The estimation methods and the main empirical results are discussed in Section 5. We finish with a summary of the more relevant conclusions.

4.2 Football pools in Spain

La Quiniela is managed by a public institution, *Loterías y Apuestas del Estado (LAE)*, which also manages most of the lotteries in Spain. For several years *La Quiniela*, together with

[52] A review of this literature can be found in Clotfelter and Cook (1990), Walker (1998) and Forrest (2003).

[53] Football pools' promoters use this name when referring to the paper grids which gamblers fill in to bet on the results of football matches.

the *Lotería Nacional* and the *Organización Nacional de Ciegos Españoles (ONCE)* lottery (a daily draw) were the only legal betting games available in Spain. Ever since 1985, *La Quiniela* has been competing with another lotto game, *La Primitiva*, and all the new games launched by LAE with a similar structure.

The exceptional importance of the football pools industry in Spain lies in the scope of its economic and social benefits. In the beginning, Spanish charity organizations were the main institutions favoured by the funds obtained through sport betting. Later, these benefits were distributed to other institutions. During the 1950´s, sports organizations began to receive a share of total revenue and in the 1980´s the claims of professional football teams were considered. Also, special events like the Football World Cup in 1982 or the Olympic Games in Barcelona in 1992 benefitted from football pools, as did the *ADO* (the Spanish Olympic Sports Association) program. Generally speaking, the funds obtained have the objective of promoting sports activities. The Spanish Royal Decree of February 20, 1998, established the current distribution of *La Quiniela* revenues. The Spanish Professional Football League (*LFP*) receives 10% (in 2005 this amounted to approximately €50 million), the National Council of Sports gets 1%, and 10.98% goes to the provincial governments in order to promote social activities and sport facilities. The Public Exchequer takes in 23% of total revenues, once the administration and distribution expenses have been discounted.

Although *La Quiniela* shares some characteristics with lotto games in that both are pari-mutuel games, it is not a lottery in the sense that the winning combination is not the outcome of a draw but is instead related to the final results of several football matches. To win the maximum prize players must correctly guess the results of all 14 matches included in the coupon. It has been this way since the beginning of *La Quiniela* with exception of the period between the beginning of the 1988-89 season and the end of the 2002-03 season when 15 instead of 14 matches were included in the coupons. This extra match (*El pleno al 15*) to win the maximum prize was introduced again in the 2005-06 season. Up to the 1988-89 season, bettors that succeeded in correctly picking 14, 13 and 12 results won prizes. In addition, if there were no winners of the maximum prize, those picking 11 correct results also won a prize. Since then, if there are no winners of the first prize, the quantity of this prize rolls over, and since the 1991-92 season those who get 11 results correct have won a prize. A lower prize for players just picking 10 correctly was also introduced in the 2003-04 season.

The distribution of revenues devoted to prizes (about the 55% of total revenues) among categories has changed over time. In 2005, 12% was assigned to those guessing correctly 14 results, 10% was for those that in addition got *El Pleno al 15*, and 24% was shared out equally among those who guessed correctly 13, 12 and 11. Finally, 9% went to those who got 10 results right.

Now, according to *LAE* information the sales revenue of *La Quiniela* is about €500 million, slightly less than 2% of the total amount of gambling revenues in Spain. However, the evolution of the bets played in *La Quiniela* has shown a considerable variability over time. Figure 4.1 shows the number of coupons sold since the 1970-71 season. We can observe substantial variability in football pools spending, with bets ranging from 5,000 million in the 1979-80 season to 749 million in the 1989-1990 season. Although part of this variability can be explained by changes in the nominal price the large fall in sales, close to 80%, between the year 1985 and 1990 can largely be explained by the appearance of *La Primitiva* on the Spanish gambling market.[54]

With regard to the price, in 1970 the price of a *La Quiniela* bet was €0.03, whereas since the 2003-04 season the price has been €0.50. Between these two dates the real price has

[54] This also happened in the case of British football pools (Forrest, 1999).

been characterized by a negative trend, but the last change introduced in the 2003-04 season, where the price increased by 66% (from €0.3 to €0.5), reversed this trend.[55]

FIGURE 4.1 Number of coupons

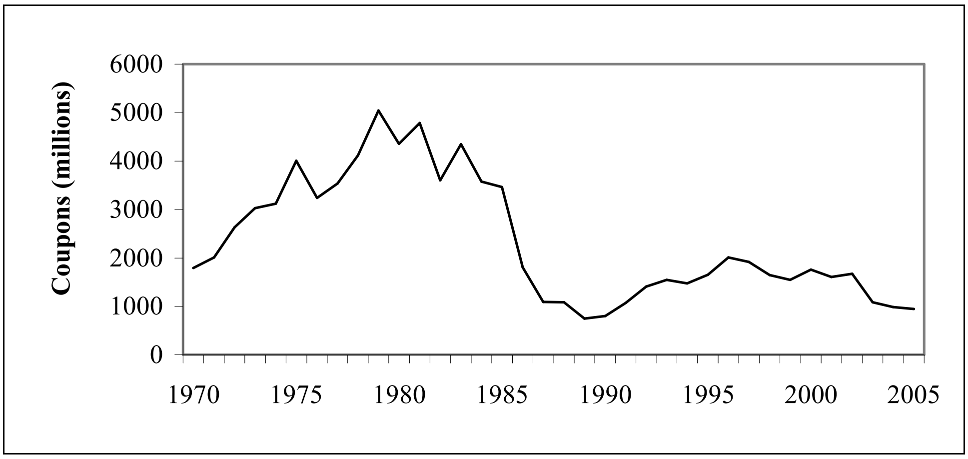
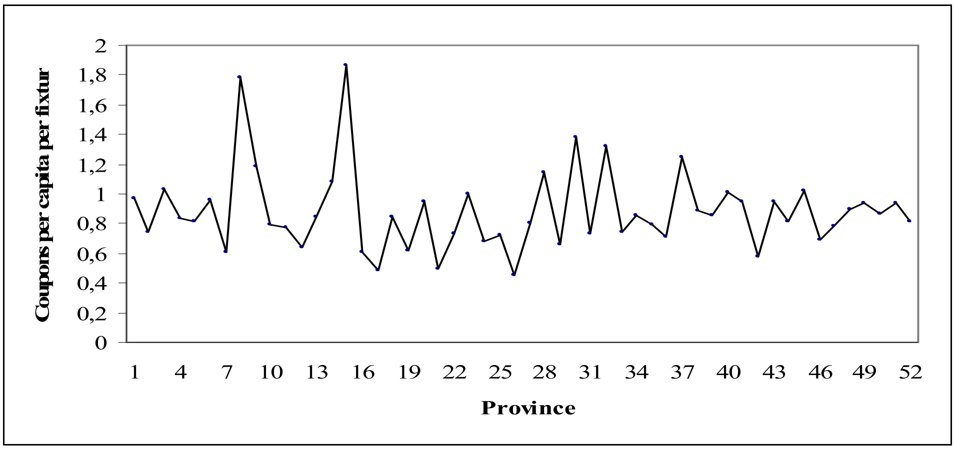


FIGURE 4.2 Number of coupons sold by province



With respect to the provincial variability of *La Quiniela*, Figure 4.2 plots the average number of coupons per fixture per capita in each province (including autonomous cities) during

[55] A detailed analysis of the evolution of price, as well as other variables related to *La Quiniela* can be found in García and Rodríguez (2007).

the 1985-2005 period. The overall average is 0.88, with two provinces (Balearic Islands and the autonomous city of Ceuta) having a particularly high average (well above 1.5). This probably corresponds to the influence of some outliers due to the effect of sales corresponding to bets made by large groups of bettors (*peñas*).

The evidence from Figure 4.1 and Figure 4.2 show that the dependent variable in our empirical model (the number of coupons sold) has enough variability in both dimensions to allow us to distinguish between temporal and geographical effects.

4.3 Economic background

In this chapter we develop a model that nests two economic models proposed in the empirical literature on the demand for lotto. The effective price model, based on expected utility theory, has been the most frequently used in this type of analysis.[56] Within this theoretical framework 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.

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 (Q), i.e.,

[56] Empirical applications of the effective price model appear in Cook and Clotfelter (1993), Gulley and Scott (1993), Scott and Gulley (1995), Walker (1998), Farrell et al. (1999), Forrest et al. (2000b) and García and Rodríguez (2007).

$$EV = (1 - P)\ J/Q \tag{4.1}$$

with the jackpot defined as

$$J = B + (1 - \tau)\ Q \tag{4.2}$$

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.

La Quiniela is a peculiar game in which the results of the matches are not usually chosen in a random way given that the bet has to do with the results of a set of football matches. Thus, the composition of the coupons is relevant, meaning that each bet has different winning probabilities. The probability of having a winning ticket (π) is therefore not known exactly *ex ante*, depending instead on the forecast (1, X, or 2) chosen for each match included in the coupon. Additionally, there is the issue of conscious selection which is probably more important than in lotto games (Farrell et al, 2000). Given that there are no data available for these *ex ante* probabilities, we will assume that they are the same for all tickets and we will disregard the problem of conscious selection. Consequently, the probability of not having a winning ticket (P) is:

$$P = (1 - \pi)^{Q} \tag{4.3}$$

Notice that P decreases with both the number of tickets sold (Q) and the difficulty of the game (π). Also, according to the definition of the jackpot in expression (4.2) the expected prize increases with the amount of the rollover and decreases with the take-out rate. An increase of sales will have two effects: on the one hand, the prize will increase with sales, but on the other hand, the expected number of winners also increases, dominating the first effect. The difficulty of the game has a negative effect on the expected prize.

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.[57] Forrest et al. (2002) specify an alternative model where the jackpot is the main economic variable on the demand for lotto. This model 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. Rather than the effective price they propose using the amount of the top prize as the main economic variable affecting sales.

As the effective price model and the jackpot model have different implications in terms of policy changes in the structure of prizes, we will consider, as in García and Rodríguez (2007), the specification of a model including both variables (the effective price and the jackpot), whose identification is discussed in the empirical results section.

4.4 The determinants of sales of *La Quiniela*

To carry out the empirical exercise we use an annual panel data set for all the Spanish provinces (52 in total, including the two autonomous cities) for the period from 1985 to 2005 in order to identify the determinants of the average number of bets per fixture per capita for *La Quiniela*. Descriptive statistics of the variables used in the estimation of the demand equations are reported in Table 4.1.

[57] Empirical evidence for the lotto in the UK seems to contradict this (Forrest et al., 2002)

TABLE 4.1 Descriptive statistics

	Mean	*Standard Deviation*
Number of coupons per capita and per fixture	0.882	0.496
Effective price (€)	0.129	0.030
Jackpot (thousands €)	2555	8865
Gross household income per capita (thousands €)	9.989	2.362
Population (thousands)	775	947
Number of football clubs in the First Division	0.384	0.612
Number of football clubs in the Second Division	0.398	0.593
Number of fixtures without First Division teams	4.286	2.354

NOTE: All economic variables are in real terms (base year 2001).

In Table 4.2 we report the amount of the face value (*FV*) – the price of a bet - and the definition of the effective price (*EP*) and the jackpot (*J*) for each fixture in the sample period we consider. Notice that the rollover (*B*), introduced in the 1988-89 season, is taken into account in the definitions of these variables.[58] As mentioned in the previous section, to calculate the expected prizes we have to weight prizes by the probability of having at least one winner of each prize (1-P). Given that *La Quiniela* is not a draw and given the presence of conscious selection processes, we approximate this probability by the proportion of fixtures with winners of a particular prize (P_{14} and P_{15} for the prize of 14 and 15 correct guesses, respectively) for the whole sample period (0.928647 and 0.7953529, respectively). Since the 1991-92 season, when the amount of the prize corresponding to 11 correct guesses is below a certain quantity, winners of this prize do not receive the amount and the total corresponding to this pool is rolled over. In this way we approximate the probability of the prize for 11 correct guesses not rolling over (P_{11}) by the proportion of fixtures with prize for those correctly guessing 11 results (0.964045). The same was applied to the prize for those who guess 10 correctly in the 2005-06 season, so we

[58] Given that we are dealing with annual data, we use the average yearly value per fixture of EP, J and B in the estimation procedure.

approximate the probability that the amount for this prize does not roll over, P_{10}, in the same way as we did for P_{11} (0.968254). Furthermore, during the 1986-87 and 1987-88 seasons a new prize for those correctly guessing all the results at half time was introduced. This new prize reduced the amount devoted to prizes for the correct guess of the end-of-match results, except in the case where there were no winners of this new prize. We approximate this probability (P_{noHT}) in a similar way as we did for the other probabilities.

To control for the impact of the presence of a professional football team in a province on the volume of sales of *La Quiniela* in that province we define a variable which captures the number of teams in the First Division and another one for teams in the Second Division. Given the Spanish professional football league promotion and relegation system the number of teams in the top divisions in a province varies across provinces and throughout time. As we use yearly data whereas the football pools season in Spain starts in August and ends in June or July the following year, it is possible for a team to be in a certain division for only half a year. Thus, we can consider that there are two "mid-seasons" in every year. This way, the variable that controls for the presence of First Division teams in each province takes the value zero if a province does not have a team in this division the whole year and 0.5 for each "mid-season" and team in the First Division. The same values are used in the case of the variable that controls for the number of Second Division teams.

In order to capture the geographical effects in the demand for football pools, we include the provincial household gross income per capita, as well as that of the population, in the estimations to control their possible effects on sales of *La Quiniela*. Also, following García and Rodríguez (2007), we consider the relevance of controlling for the number of fixtures in which First Division teams are not included in the coupon to account for the importance of the illusion of control in *La Quiniela*, where bettors use their knowledge on Spanish football teams to try to correctly guess the results of the matches included in the bet.

TABLE 4.2 Definition of the face value, the jackpot and the effective price

Season	*Face Value (FV)*	*Jackpot (J)*	*Effective Price (EP)*
1985-86	€ 0.09	J=(0.50325/3)R	EP=FV-0.50325R
1986-87 1987-88	€ 0.12	J=(0.44/3)R+P_{noHT}0.063R	
1988-89		J=0.25R+B	EP=FV-[(0.3R+P_{14}*0.15R+P_{15}(0.1R+B))/Q]
1989-90 1990-91	€ 0.18		
1991-92 to 1993-94			EP=FV-[(P_{11}*0.1R+0.2R+P_{14}*0.15R+P_{15}*(0.1R+B))/Q]
1994-95 to 1997-98	€ 0.24		
1998-99 to 2002-03	€ 0.30		
2003-04 2004-05	€0.50	J=0.15R+B	EP=FV- [(0.4R+P14*(0.15R+B))/Q]
2005-06		J=0.22R+B	EP=FV- [P_{10}*0.09R+0.24R+P_{14}*0.12R+P_{15}(0.1R+B))/Q]

NOTE: R = total revenue (number of bets times the face value); B = the rollover; Q = sales. An empty cell means no change in the definition of the variable with respect to the previous period.

Finally, we consider the potential impact of unobserved individual (provincial) effects in the models to capture other features of the geographical distribution of the demand for *La Quiniela* apart from income and the population. We do this by including provincial dummies in the demand equation, which is equivalent to using the within-group estimator. It should be pointed out that although the within-group estimator of a dynamic linear model with panel data is inconsistent in the case where the number of time periods is short (Nickell, 1981), we rely on asymptotic results for both individuals and time periods tending towards infinity, which imply that as the number of time periods increases, the bias tends to zero. In particular, the asymptotic bias becomes very small (not relevant in relative terms) when the number of time periods is around 20, as in our case (we have 21 periods), according to the expression of the asymptotic bias for a simple autoregressive model (Nickell, 1981).

4.5 Empirical results

Given that the dependent variable (number of coupons per fixture and per capita) is included in the definition of both economic explanatory variables (the effective price and the jackpot) we estimate the model by instrumental variables. We use the amount of the rollover, its square, and the number of rollovers as instruments. Moreover, we also consider the number of fixtures throughout the year to instrument both variables (the effective price and the jackpot). All of these are clearly exogenous variables because they have been previously determined. As proposed in García and Rodriguez (2007), the use of a polynomial of order two of the instruments ensures the matrix of instruments to be of a sufficient rank to obtain consistent estimates, as well as allowing us to simultaneously include both variables (the effective price and the jackpot) in the model and estimate their effect consistently.[59]

Following the empirical literature on lotto demand we also consider, as in Forrest et al. (2002), two versions of the model differing in terms of the economic variables which are included in the specification. In one of them we use the effective price as the main economic determinant of sales, while in the other we include the amount of the jackpot. The estimation results of these models are reported in Appendix A.

Additionally, Walker (1998) suggests that in the case of lottery there are reasons (addiction, inertia or habit) to expect sales in one period to be correlated with sales in the next one. We consider dynamic versions of the model by adding lags of the dependent variable allowing us to get both short- and long-run conclusions.

[59] Following Kelejian (1971), the nonlinearity in variables (but linearity in parameters) of the model allows us to use polynomials of the original instruments and the predetermined variables to form the final set of instruments.

In Table 4.3 we report the results of the estimation of the model including two lags of the dependent variable, whose coefficients are allowed to be different for each province.[60] The unobserved geographical effects are controlled by including dummies for each province.[61]

According to the results the coefficients of the economic variables have the expected sign: negative for the effective price and positive for the jackpot. It is important to point out that both coefficients are significant, which means that this specification is preferred to the other specifications considered in the literature, where only one economic variable is included (see Appendix A). As found in García and Rodríguez (2007) using fixture data, the goodness of fit measures are better when eliminating the effective price variable compared to what happens when eliminating the jackpot variable.

TABLE 4.3 Estimation results for the demand equation for *La Quiniela*
Dependent variable is number of coupons per fixture per capita sold (log)

	Coefficient	p-value
Effective price (log)	-0.378	0.000
Jackpot (log)	0.299	0.000
Gross household income per capita (log)	0.191	0.015
Population (log)	-0.130	0.181
Number of teams in the First Division	0.044	0.009
Number of teams in the Second Division	0.021	0.057
Number of fixtures without First Division teams	-0.020	0.000
Adjusted R^2	0.930	
Sample size	988	

NOTE: All the economic variables are in real terms.

[60] We test these coefficients to be equal and non-significant and reject both null hypotheses.

[61] The estimates of all the coefficients of these variables are available on request.

In Table 4.4 we report the estimated elasticities (short and long run) for the effective price and the jackpot.[62] Since we allowed for a different dynamic structure for each province, the long run elasticities have geographical variation, which is significant. The effective price elasticity varies from –0.571 to –1.275 with an average close (and not significantly different) to –1, implying that LAE behaves in a revenue–maximizing way. The long run jackpot elasticity is also significant, varying from 0.452 to 1.008 with an average of 0.714, implying that changes in the jackpot have substantial effects on sales.

As mentioned in the introduction, the primary objective of the chapter is to evaluate to what extent having a club in the top division has an influence on the amount of coupons of *La Quiniela* sold in the corresponding province. The evidence in Table 4.3 shows that having a team in the province competing in the First Division increases the sales per capita of *La Quiniela* by approximately 4.5% in the short run and 10.8% in the long run. This means that in terms of revenue from *La Quiniela* for LAE, it is more profitable to have teams in the top division in those provinces with a large population suggesting a relation of complementarity between household consumption of football and betting on football, as it is proposed in Forrest and Simmons (2003). This positive effect is also found when we consider teams in the Second Division. In that case the increase in sales is slightly above 2% but it is only significant at the 10% level. In any case, the difference between the coefficients of the variables capturing the number of teams in a particular division is significant and the effect is more important for the number of teams in the First Division. Betting on football appears to be more exciting when locals can also bet on the local team. The coupon is more attractive for an individual when it includes games (in general, First and Second Division games) which are played by teams which are geographically close to that individual.

[62] Given the functional form chosen for the demand equation the estimated coefficient of the economic variables in logs could be interpreted as short run elasticities. Long run elasticities are calculated by dividing these coefficients by 1 minus the sum of the lagged coefficients of the dependent variable.

A more general aspect of the composition of the coupon has to do with whether games of First Division clubs are included or not. Since we are dealing with annual data we proxy this variable by the number of fixtures without these clubs obtaining a highly significant negative effect, i.e. the presence of First Division teams in *La* Quiniela increases the number of bets.[63]

TABLE 4.4 Estimated elasticities

	Effective price	***Jackpot***	***Gross household income per capita***
Short run	- 0.378	0.299	0.191
Long run	- 0.903 (-0.571; -1.275) *0.132*	0.714 (0.452; 1.008) *0.104*	0.457 (0.289; 0.645) *0.067*

NOTE: The value for long run elasticities is the average of the elasticities of the provinces. The range of the variation of the long run elasticities is shown in parentheses. The standard deviation is in italics.

Given that we have panel data of provinces we considered some socio-economic variables to capture the geographical dimension. Gross household income per capita and population are the variables included, both having geographical and time variability. The results show a positive and significant effect for the income variable though with an elasticity (both short and long run) clearly below one, i.e. *La Quiniela* is a normal good, although the demand is not very sensitive to changes in income. The estimated income elasticities show, as in Clotfelter and Cook (1990), that per capita sales increase less than proportionately with income which makes *La Quiniela*, as an implicit tax, regressive.

Finally, with respect to the population variable we obtain a negative effect, meaning that provinces with a large population have smaller sales per capita of *La Quiniela*. This could reflect a larger supply of alternative leisure activities (substitutes for *La Quiniela* and gambling in general) in highly-populated provinces. It should be pointed out that this effect becomes

[63] This result goes in the same direction as that in García and Rodríguez (2007) using fixture data.

significant if we do not include the set of dummies for the provinces. Thus, part of the geographical variability of the population is captured by these dummies, although the sign of the coefficient is not affected. This is also the case for the effect of the income variable, which also has a large geographical variability. We reject the null hypothesis of the non-significance of the coefficients of the provincial dummies (p-value = 0.000).

4.6 Concluding remarks

In this chapter we estimated a dynamic panel data model in order to measure the impact of having a football team in the top divisions (First and Second Division) on Spanish football pools (*La Quiniela*) sales at a provincial level. We also analysed the main economic determinants of the demand for football pools in Spain controlling for geographical effects given the nature of the data we use. We considered a model in which both usual economic variables – the effective price and the jackpot - are simultaneously included in the demand equation for *La Quiniela*. The model is estimated by instrumental variables.

Evidence on the complementary character of the relation between Spanish football consumption and betting on Spanish football is shown. The empirical findings are robust enough to conclude that, in the long run, having a football team in the top divisions causes a significant impact on sales of football pools in a province. In particular, having a team in the First Division implies a long run increase in *La Quiniela* sales of approximately 10.8%.

On the other hand, the composition of the coupon also appears as an important determinant of sales, since not including First Division teams in the coupon implies a reduction in sales of 4.7% in the long run. This has to do with the active role of bettors in *La Quiniela* in that they use their knowledge on football teams to try to guess the results of the matches included in the coupon.

Finally, we identify a significant effect for some socio-economic variables referred to the province. In particular, we find *La Quiniela* bets to be a normal good and regressive as we estimate a positive (less than one) and significant income elasticity.

APPENDIX A. Estimation results for the demand equation for La Quiniela (Effective price model and Jackpot model)
Dependent variable is number of coupons per fixture per capita sold (log)

	Effective price model		***Jackpot model***	
	Coef.	**p-value**	**Coef.**	**p-value**
Effective price (log)	-0.527	0.000		
Jackpot (log)			0.348	0.000
Gross household income per capita (log)	0.845	0.000	-0.249	0.000
Population (log)	0.195	0.058	-0.478	0.000
Number of teams in the First Division	0.030	0.100	0.049	0.004
Number of teams in the Second Division	0.021	0.089	0.022	0.052
Number of fixtures without First Division teams	-0.053	0.000	-0.015	0.000
Adjusted R^2	0.915		0.925	
Sample size	988		988	

NOTE: All the economic variables are in real terms.

Conclusions and extensions

Games of chance where money is at stake have existed throughout history. Economists have been puzzled by the wide acceptance of these – often unfair – gambles by individuals that seem to be risk averse in other contexts. The easiest way to explain the prevalence and extension of gambling with the theory of consumer choice is to assign to the process of gambling some intrinsic utility.

The main questions asked are: who plays? why are people willing to pay for a given type of gambling?, and how does the entire set of game characteristics influence the demand for gambling?. Given that takeout rates differ across gambles, the game features will influence demand, yet, the expected loss of taking part should play an important role. The problem of insufficient variation of the takeout rate in a given gamble is overcome by considering rollovers in pari-mutuel gambles (in this case, lotteries and football pools).

Spain could be considered a nation of gamblers. Spaniards bet a higher proportion of their income than almost any other nation – it is estimated that Spanish gambling has a turnover of over €30 billion a year, equal to around €686 per head or some 4.6 per cent of the average net household income - previous economic analysis of demand in the Spanish gambling market is limited.

This thesis offers four main contributions to empirical economics in regard to the demand for gambling, based on the particular case of state-operated lotteries and football pools in Spain. The first contribution was a review of the state of empirical research on the demand for lotteries focusing on its main empirical findings. Previous papers represent a rich source of knowledge and a number of empirical findings have emerged in the literature, but nobody has summarized all these results in a single essay.

We summarized the empirical findings of a number of relevant studies, including a bibliography to aid in future research on demand for lottery. We argued that the empirical literature on the demand for lotteries contains evidence developed from two distinct data sources. Seminal papers use two data sources: cross-sectional data from surveys of consumers to analyze the determinants of household participation in and expenditure on gaming goods like lotteries as well as the regressive character of the implicit state tax included in the lottery price; and aggregate data from repeated drawings of one or more lottery games to examine, among others, the effects of phenomena like rollovers or the introduction of new lottery games following one, or all, of the proposed model in the economic literature: the effective price model, based on expected utility theory, the jackpot model, and the mean-variance-skewness model.

A future meta-analysis could extend this survey by generalizing the results in the population of studies. This type of analysis leads to a shift of emphasis from single studies to multiple studies. A meta-analysis would emphasize the practical importance of the results instead of the statistical significance of individual studies under a given single set of assumptions and conditions.

It is hoped that the empirical results presented here demonstrate that the traditional effective price for lotto demand approach may omit important explanatory variables, namely those representing bettors' perception about second and third (and perhaps even higher) moments of lotto's payoff. The moments of the prizes distribution, including mean, variance, and skewness, play critical roles in an individual's gambling decision. The traditional "effective price" approach only considers the first moment of the bet but ignores important variables such as variance and third moment when the price structure (which affects the third moment of a lotto's payoff) may be a far more important factor in the demand for lotto. The literature could make real progress by creating or designing models that fits these requirements.

The second chapter of this thesis contributes to the empirical analysis of household gambling expenditures. Spending on gambling is investigated using data from two nationally representative Spanish surveys on consumer spending on five different lottery games in Spain, and focusing on the inter-related purchase of tickets for different lottery products. Estimates from Tobit and double hurdle models of participation in lottery markets and spending on lottery tickets found that frequent participation in one game is not associated with an increased or decreased probability of participating in other games, but is associated with increased spending on other games. So consumer spending on different lottery games exhibits consumption network externalities which would help to explain why the introduction of additional lottery games does not “cannibalize” existing games. Also, the assumptions underlying the double hurdle model, but not the Tobit model, better describe consumer spending on lottery tickets in Spain.

These empirical findings could be complemented with a specific analysis of how income affects the amount spent in each game. This is a relevant issue both in fiscal and social terms determining whether a particular game is regressive or not. This requires estimation of an Engel curve for each lottery game. Additionally, since the surveys include a random sample of all residents of Spain, one could make a preliminary analysis of geographical aspects of spending distribution

The third contribution of the thesis was an evaluation of the effect of a change in lotto game features, besides the ticket price, on tickets sales. In that empirical exercise draw level data on sales and rollovers (573 draws were considered) of *El Gordo de la Primitiva* were used in order to evaluate the effect of the changes in the game design introduced by LAE on ticket sales. Initial results indicated that the change introduced in the game design allows the lottery operator to achieve higher and steadier ticket sales.

A demand equation including the effective price as main covariate is first estimated. In this model the effective price of a ticket changes with rollovers. However, rollovers do not only affect the expected value of a ticket, but also higher moments. Because rollovers typically affect only the grand prize, the distribution of the pool among classes changes. This means that the game design is not really fixed in this respect. Accordingly we also regressed sales on the mean, variance and skewness of the prize distribution.

The results from the mean-variance-skewness model demonstrate that the new format was successful because, despite weaker underlying demand, it offered players more attractive packages in terms of the probability distribution of financial returns purchased through a ticket. A more general conclusion is, of course, that the results from the mean-variance-skewness model reveal that the odds and the prize structure indeed matter (as is reflected in the strong significance of each of the moments). The effective price model ignores prize structure. For this reason, research needs to move on from the first generation of lotto demand studies to a focus on characteristics of the prize structure as well as on the effective price of a ticket.

The empirical evidence also suggested that, at least in the Spanish case, high jackpot games with low probabilities appeal to more lottery players. Lottery operators should take this into account when designing new games. Furthermore, in many jurisdictions lotto games have declined in popularity over time. The Spanish experience suggests that one way of making a game more attractive might be actually to make it harder to win.

It should be noted that, in addition to *El Gordo de la Primitiva*, LAE operates two other domestic lotto games (*La Primitiva* and *Bonoloto*) which provide opportunities for Spaniards to gamble across the entire week since there is a draw for one or other of them every night. Because these draws occur on adjoining days over the course of the week, have large jackpots and frequent rollovers, are designed with a small probability of winning a large prize, and are widely available through the same retail networks, these lotto games are expected to be either potentially substitutes or complements in consumers' purchases. Then, a natural extension of this chapter should be trying to measure the response of the demand for a particular lotto game to a change in the expected return on a different (competing) lotto game. The effectiveness of the design of lotto games portfolio depends strongly on the direction and the magnitude of the response of the demand for lotto games in their expected returns.

Finally, chapter 4 was an empirical investigation of the importance of a football club in the top divisions in football pools sales. Football pools were included in this analysis of the demand for gambling for two main reasons: because its relative importance in the Spanish gambling market, where for many years *La Quiniela*, along with the *Lotería Nacional* and the ONCE lottery were the only betting games available in Spain; and because football pools are a long-odds high-prize gambling product which shares some characteristics with lotto games in that both are pari-mutuel gambles.

However, football pools are not a lottery in the sense that the winning combination is not the outcome of a draw but is instead related to the final results of several football matches. Previous research on the demand for football polls has found the composition of the list of games included in the coupon to have a relative importance on sales. So, both the traditional economic models in the lotto demand literature (the effective price model and the jackpot model) are merged in an attempt to evaluate the effect of having a professional football team in the Spanish First or Second Division in a certain province on the amount of sales of football pools in Spain.

We showed that having a club in the top divisions has a significant effect on sales of football pools. Moreover, previous results using fixture (round) data are confirmed in this chapter. Evidence of the complementary character of the relation between Spanish football consumption and betting on Spanish football is also provided and found *La Quiniela* bet is found to be a normal good and, as implicit tax, regressive.

Although this research found football pools sales to be influenced by game characteristics, such as the overall expected value, the jackpot, the composition of the list of games in the coupon, and also the presence of professional football teams, these findings could be improved by analysing how football pools should be optimal operated and designed. This research could be extended by simultaneously analysing the demand for other games managed by LAE, due to the potential substitutability between them. Additionally, it would be interesting to analyse the separability of the expenditure on these games by families with respect to other types of expenditures, in order to be more precise about the implications of changing the structure of the game and that of the prizes.

Two things should be kept in mind when interpreting the results of this dissertation. First, although gambling is unfair, it has expanded dramatically in the last decades providing economists with an increasing interest in analyzing why risk averse expected utility maximizing individuals play different gambles. The Spanish gambling market has also been part of this worldwide phenomenon. However, applied economic analysis to the Spanish case is limited. Second, this thesis tried to provide some empirical evidence about demand for gambling in Spain by focusing on state-operated lotteries and football pools. Thus, we found that, among other things, consumer spending on different lottery games in Spain exhibits consumption network externalities, and high jackpot games with low probabilities appeal to more Spanish players. Finally, we showed a relation of complementarity between spending on football pools and the consumption of Spanish football. Future work relating to these findings would lead to a more thorough understanding of the economics of the demand for gambling.

Resumen y conclusiones en español

Existen varias razones que justifican el interés por la economía del juego. Por un lado, está la importancia económica de un sector que tras experimentar una profunda liberalización y expansión mundial a lo largo de las últimas décadas se ha convertido en un bien de consumo extremadamente popular con elevados niveles de participación y gasto en gran número de países. Por otro lado, el sector público parece haber encontrado una importante fuente de financiación alternativa en este sector que le ha permitido obtener fondos adicionales, sin la necesidad de establecer nuevos impuestos o incrementar los ya existentes, a través de un efecto de tipo impositivo asociado a la participación en el juego.[64] Finalmente, desde la perspectiva del análisis económico puede parecer una cierta contradicción el atractivo por el juego para agentes que se supone son maximizadores de utilidad y aversos al riesgo. Esta tensión entre los supuestos de la teoría económica y el comportamiento observado en consumidores de todo el mundo ha inquietado durante décadas a un gran número de economistas motivando la realización de diversos estudios y ensayos académicos acerca de los determinantes de la demanda de juego, principalmente en Estados Unidos y el Reino Unido.

No obstante, aún cuando el sector del juego en España ha participado también de esta expansión mundial- en el año 2007 el sector del juego en España representaba el 2,9% del Producto Interior Bruto -, apenas ha suscitado el interés del análisis económico. Aparte de los estudios de Garvía (2000 y 2007) en los que se analizan el mercado del juego en España desde la perspectiva de la denominada nueva sociología económica o aspectos mas concretos del mismo, como el juego colectivo, la evidencia empírica es muy limitada (con la excepción de Mazón, 2007).

[64] En la medida en que, actualmente, buena parte de las loterías son gestionadas desde el sector público, la parte no repartida en premios de cada euro jugado (*takeout rate*) puede ser entendida como un impuesto implícito sobre el precio de la apuesta.

Atendiendo a la naturaleza de la gestión de la oferta, el sector del juego en España puede estructurarse en tres grandes bloques; incluyendo los juegos de envite, suerte y azar gestionados por empresas privadas (casinos, bingos y máquinas recreativas), los gestionados por Loterías y Apuestas del Estado (LAE) y los juegos gestionados por la Organización Nacional de Ciegos Españoles (ONCE). Según el último Informe Anual del Juego en España (S.G. de Estudios y Relaciones Institucionales. S.G.T. Ministerio del Interior, 2008), en el año 2007 los españoles gastaron más de 30 mil millones de euros en el juego, lo que supone un gasto anual de unos 685 euros por habitante; cifra nada despreciable si tenemos en cuenta que representa el 4,6% de la renta familiar neta disponible. [65] Asimismo, destaca también el hecho de que es el gasto en juegos de gestión privada la partida con un mayor peso (60% del gasto total en juego), superior incluso a los juegos de gestión pública (LAE) que prácticamente alcanza los 10 mil millones de euros; siendo la *Lotería Nacional* el juego con mayor aportación al total de ingresos de LAE (cifra superior a los 5,5 mil millones de euros). Todas las cifras anteriores claramente están por encima de la contribución al gasto en juego de los productos gestionados por la ONCE (2,17 mil millones de euros).

Sin embargo, hay que tener en cuenta que la naturaleza de los diferentes juegos es muy distinta; no sólo por el grado de participación de los jugadores, sino también por su conexión con algunos deportes. Por otro lado, los juegos difieren tanto en su organización, que comporta diversas probabilidades de éxito, como en su estructura de premios, lo que se traduce en un precio efectivo de la apuesta (precio nominal de la apuesta menos el valor esperado de la distribución de premios) distinto en cada caso. Así, en el caso de los juegos de gestión privada, el gasto real (gasto realizado menos premios obtenidos) representa el 26,25% del gasto total

[65] No se incluyen en dichas estadísticas las cifras correspondientes a juegos menores como las apuestas hípicas o las efectuadas en canódromos o frontones, ni tampoco las loterías de premio instantáneo y otras existentes en algunas comunidades autónomas (Lotería de Catalunya). En cualquier caso, su importancia relativa es escasa.

realizado, siendo este porcentaje en promedio del 36,42% para los juegos gestionados por LAE y del 52% en el caso de los administrados por la ONCE.

Todas estas consideraciones ponen de manifiesto la importancia que el sector del juego tiene en la economía española.

Desde el punto de vista del análisis económico se podrían resumir en tres el tipo de cuestiones que motivan gran parte de la investigación desarrollada para el juego. En primer lugar, ¿quién juega? En segundo lugar, ¿por qué la gente juega? Finalmente, ¿hasta qué punto los aspectos ligados a las características de un determinado juego influyen en la demanda que ese juego genera?

En esta tesis doctoral se analizan las tres preguntas anteriores en el caso particular de los juegos de lotería y apuestas deportivas de gestión pública en España. En concreto, se presta atención a los factores que explican la participación y el gasto en juego, atendiendo también a posibles externalidades de red en el consumo de los juegos considerados. Además, se analizan los determinantes de la demanda que genera un determinado juego prestando especial atención a cómo los cambios en el diseño del juego, mas allá de cambios en el precio de la apuesta, afectan a dicha demanda. Finalmente, y dada la conexión existente entre determinados juegos y algunos deportes, se estudia el caso concreto de la demanda de apuestas deportivas en España (*La Quiniela*). Adicionalmente se presenta una revisión del estado de la literatura económica sobre la demanda de loterías, destacando sus conclusiones más relevantes.

Los antecedentes del análisis económico del juego tiene su origen en Estados Unidos con la irrupción en la economía norteamericana de las loterías estatales a lo largo de los años sesenta y setenta; tras más de siete décadas en las que el juego gestionado por los estados era ilegal. Los primeros trabajos académicos sobre la demanda de lotería trataban de dar respuesta a cómo el nivel de renta afectaba al gasto realizado en este tipo de juegos - hecho que no tiene por qué ser homogéneo para todas las loterías existentes - y si el impuesto implícito que se supone sobre el consumo de lotería presentaba un carácter progresivo, regresivo o neutro. En este sentido, el trabajo de Clotfelter (1979) es pionero en este tipo de literatura; aunque son los trabajos de Clotfelter y Cook (1987, 1989) los que realmente tratan, por primera vez y con información de tipo individual, el análisis del carácter regresivo o no del impuesto implícito en los juegos de lotería.

Desde entonces han sido múltiples los estudios que han tratado de replicar los análisis de Clotfelter y Cook para distintos países (o estados), siendo de destacar la atención prestada a la especificación econométrica de los modelos de gasto en loterías en la medida en que los determinantes de participar en el juego y aquellos que influyen en la cuantía del gasto puedan ser distintos o, aun siendo los mismos, sus efectos puedan ser diferentes.

En concreto, el segundo capítulo de la tesis hace referencia al estudio de la participación y el gasto en cinco juegos de lotería (*Lotería Nacional*, *La Primitiva*, *Bonoloto*, *El Gordo de la Primitiva* y *Euro Millones*) gestionados por LAE. Para ello se utiliza, siguiendo la literatura empírica previa, una base de datos individuales; en este caso correspondiente a las dos encuestas que la empresa Servicios Técnicos de Loterías del Estado (STL) ha realizado en los años 2005 y 2006 acerca de los hábitos de juego (juegos de lotería fundamentalmente) de los españoles. El empleo de este tipo de información permite analizar qué aspectos hay detrás de la participación en los diferentes juegos considerados, así como de su intensidad, medida a través del volumen de gasto efectuado. Con este objetivo se estiman modelos econométricos adecuados al tipo de variable dependiente a analizar (modelo Tobit y modelo doble valla), dedicando especial atención a las posibles externalidades de red derivadas del consumo de productos muy cercanos y relacionados entre sí, como son los juegos de lotería gestionados por LAE.

Las conclusiones obtenidas sugieren la existencia de externalidades de red positivas en el consumo de loterías. La participación frecuente y el gasto en un determinado juego de lotería no están asociados con una mayor o menor probabilidad de participar en otros juegos, pero sí con un mayor gasto en estos juegos. Estos resultados podrían complementarse en un futuro con la estimación de elasticidades renta para los diferentes tipos de juegos. Cuestión relevante para tratar de analizar el carácter impositivo (implícito) regresivo, progresivo o neutro de estos juegos.

Por otra parte, la preocupación acerca de por qué la gente juega a la lotería, no ha sido ni es patrimonio único del análisis económico sino también de psicólogos y sociólogos que han dedicado especial atención al tema. Las aportaciones en este terreno las podríamos resumir en tres planteamientos teóricos alternativos que tratan de explicar por qué la gente juega, aunque con distintas implicaciones desde el punto de vista normativo. Por un lado, están los planteamiento basados en la *prospect theory* (Kahneman y Tversky, 1979) en el sentido de que los individuos en lugar de actuar de acuerdo a las verdaderas probabilidades de obtener el máximo premio, tienden a sobrevalorar estas probabilidades, por lo que la forma de actuar de los agentes es distinta de la que se esperaría a partir de la teoría de la utilidad esperada.

Una segunda explicación de por qué juegan los individuos se encuentra en los planteamientos, ya lejanos en el tiempo, de Friedman y Savage (1948); en el sentido de que la función de utilidad de los individuos es un tanto peculiar, puesto que es cóncava inicialmente, para luego pasar a ser convexa y finalmente volver a ser cóncava. La idea es que los individuos toman sus decisiones de jugar o no en un área en la que son amantes del riesgo por lo que están dispuestos a aceptar apuestas un tanto "injustas".

Finalmente, un tercer planteamiento (Conlisk, 1993) incorpora un elemento novedoso a la hora de explicar la decisión de apostar o no apostar, no únicamente en términos de la utilidad esperada en cada escenario, sino añadiendo un término de utilidad (de diversión) al hecho de apostar. Así, la diferencia entre el precio nominal de la apuesta y el valor esperado de la distribución de premios (pérdida esperada o precio efectivo) suele interpretarse como el precio asociado a la diversión derivada del juego. En este sentido, el modelo más empleado en la literatura ha sido el que considera el precio efectivo como el principal determinante económico de la demanda de loterías. Sin embargo, la estimación de este modelo presenta algunas dificultades en la medida en que el precio efectivo es endógeno, siendo de entrada el importe del bote el único instrumento disponible.

La principal limitación del modelo del precio efectivo se produce ante una situación en la que existan varias categorías de premios. En este caso, un hipotético cambio en la estructura de premios no tendría efecto alguno sobre el valor esperado de la distribución de premios y por tanto sobre la demanda generada por este juego. No obstante, es de esperar que los apostantes no sean indiferentes a la estructura de premios. Así, en el marco empírico ha ido adquiriendo mayor presencia la idea de que no es tanto el precio efectivo, sino el premio máximo (*jackpot*), lo que explica el número de apuestas efectuadas (Forrest et al., 2002). Este modelo alternativo descansa sobre el planteamiento inicial de Clotfelter y Cook (1989) según el cual con cada apuesta los jugadores están comprando un sueño (una esperanza), y ese sueño tiene que ver con el premio máximo.[66]

Sin embargo la estimación de modelos en los que el precio efectivo y el *jackpot* son incluidos simultáneamente en la especificación (como es el caso de García y Rodríguez, 2007) puede plantear ciertos problemas de colinealidad. En este sentido, Walker y Young (2001) proponen un nuevo modelo en el que las variaciones observadas en la demanda de un determinado juego de lotería son explicadas a partir de la distribución de probabilidad de los

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[66] García y Rodríguez (2007) proponen explotar el carácter no lineal en las variables de estos modelos para estimar ecuaciones de demanda para las loterías en las que simultáneamente el precio efectivo y el premio máximo aparezcan como factores explicativos.

premios ofrecidos, capturando el efecto de dicha distribución con la inclusión en la especificación de sus tres primeros momentos estadísticos (media, varianza y simetría).

Todas estas cuestiones hacen referencia a los factores que explican por qué los individuos apuestan, y en especial, a aquellos que hacen referencia a la estructura del formato del juego y de los premios del mismo. En el capítulo tres de la tesis se propone un análisis de demanda específico para uno de los juegos de lotería gestionados por LAE, a partir de la información correspondiente a cada uno de los sorteos de dicho juego. El uso de datos de carácter temporal permite la inclusión en la especificación de variables relativas al precio efectivo y al premio máximo, así como a los momentos estadísticos de segundo y tercer orden de la distribución de premios. Asimismo, este análisis individualizado ofrece una primera valoración de cómo puede afectar al número de apuestas efectuadas un cambio en la estructura del juego (con efectos sobre la dificultad de acierto en el mismo) o un cambio en la estructura de premios, tanto si afecta a la cantidad total a repartir como si es neutro en ese sentido, aunque con una distribución de premios distinta.[67]

En concreto, empleando datos agregados a nivel de España para una muestra de los sorteos de *El Gordo de la Primitiva*[68] (573 observaciones) se estima una función de demanda en la que en una primera etapa el precio efectivo es considerado como el principal determinante del volumen de apuestas efectuadas.[69] El principal objetivo de este ejercicio empírico es analizar como cambios en el diseño del juego, aún cuando el precio de la apuesta no varía, afectan a la demanda del mismo. Los primeros resultados sugieren que el modelo del precio efectivo puede

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[67] Un ejercicio de estas características ya ha sido realizado para La Quiniela en España por García y Rodríguez (2007).

[68] Se ha optado por focalizar el análisis específico de la demanda de juegos de lotería en este juego en concreto pues las modificaciones introducidas por LAE en el año 2005 respecto al diseño del mismo, cambiando el tradicional formato de lotto 6/49 por un más complicado 5/54 + 1/10, ofrecen un excepcional marco de trabajo no disponible en la literatura económica previa.

[69] También se ha estimado el mismo modelo pero incluyendo además del precio efectivo el premio máximo (jackpot) como determinante de la demanda de apuestas. Sin embargo, el coeficiente estimado para la variable *jackpot* no es estadísticamente distinto de cero. Esto puede ser debido a la alta correlación encontrada entre ambas variables – 0,57 –.

ofrecer estimaciones sesgadas al no tener en consideración los cambios provocados en la estructura de precios. En este sentido, se estima una especificación alternativa en la que los momentos de primer, segundo y tercer orden (media, varianza y simetría) de la distribución de premios son incluidos como principales variables explicativas de la variación observada en las ventas del juego. En general, los resultados obtenidos sugieren que el cambio en el diseño del juego introducido por LAE ha permitido alcanzar un mayor y más estable nivel de ventas y que una buena forma de aumentar el atractivo de un determinado juego es incrementar su dificultad ofreciendo al mismo tiempo un premio más alto.

Además, los resultados obtenidos en los capítulos dos y tres de la presente tesis doctoral parecen sugerir, al menos en el caso de la lotería española, una cierta preferencia de los jugadores por juegos con un premio máximo elevado y con pocas probabilidades de acierto.

Evidentemente, la extensión natural del análisis anterior sería la de evaluar el nivel de complementariedad o sustituibilidad entre los diferentes juegos de lotería gestionados por LAE, ejercicio que ofrecería un análisis más preciso de cómo cambios en la estructura de un juego afectan no sólo a éste sino también al resto de los juegos. Para ello sería necesario estimar un sistema de ecuaciones de demanda dinámico, que por su carácter más general, tendría un detalle de especificación menor para cada uno de los juegos en comparación al modelo considerado en el ejercicio anterior, pero sería más completo en cuanto a las interrelaciones entre los mismos.

El interés en analizar el efecto que las características socio-económicas y demográficas puedan tener sobre la demanda de juego así como otros factores propios de cada área geográfica supone una importante motivación para la realización de un estudio de demanda en el que la información tenga un grado de agregación intermedio entre los datos individuales, que no permiten incorporar la dimensión temporal, y los datos agregados a nivel de toda España, que no permiten estimar en forma precisa los efectos de estas variables, dado que su cambio en el tiempo es menos acusado. En el capítulo cuatro de la tesis se analiza desde esta perspectiva el caso particular de las apuestas deportivas (*La Quiniela*) gestionadas por LAE.

El análisis de este tipo de juegos activos es interesante porque, aunque comparten algunas características con el resto de los juegos tipo lotto previamente analizados (en ambos casos se trata de juegos pari-mutuel),[70] no constituyen un juego de azar puro en el sentido de que la combinación ganadora no es el resultado de un sorteo sino que se relaciona con el resultado final de un cierto evento deportivo. Así, puede esperarse una cierta relación de complementariedad entre la demanda de apuestas deportivas y el consumo del deporte en concreto.

Por otro lado, el estudio de este tipo de juegos permitirá obtener nuevas conclusiones sobre otros factores a considerar en el análisis de la demanda de los juegos gestionados por LAE. De este modo, en este ejercicio empírico se utiliza la información de apuestas e importes jugados a nivel provincial, conjuntamente con la información socio-económica y demográfica disponible para las zonas geográficas (provincias) consideradas. El modelo econométrico empleado tiene en cuenta el carácter de panel de datos (zonas geográficas y tiempo) de la información a utilizar.

En la línea de García y Rodríguez (2007) se estima un modelo de demanda de apuestas para *La Quiniela* en el que se fusionan los dos modelos mas empleados tradicionalmente en la literatura económica sobre la demanda de loterías: el modelo del precio efectivo y el modelo del jackpot; considerando además el efecto sobre la demanda de características propias del juego, como la composición de la lista de encuentros incluidos en el cupón, o el efecto sobre el volumen de apuestas en una determinada provincia de la presencia (o no) de un equipo de fútbol profesional. En este sentido, los resultados obtenidos sugieren una cierta complementariedad

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[70] Un tipo de juego en el cual la recaudación total obtenida a través de las apuestas realizadas se divide entre aquellos que tengan apuestas ganadoras (después de descontar impuestos, cargos y otras deducciones).

entre ambas variables. También se confirman los resultados obtenidos en estudios previos sobre la demanda de apuestas de *La Quiniela* considerando datos agregados a nivel de sorteo.

En resumen, aunque la demanda de juego parece contradecir los supuestos de maximización de la utilidad y aversión al riesgo planteados desde la teoría económica, su consumo se ha expandido extraordinariamente por todo el mundo a lo largo de las últimas décadas. El mercado del juego en España no ha permanecido al margen y su demanda también se ha visto inmersa en esta fuerte tendencia mundial. Sin embargo, apenas se encuentran estudios que desde el punto de vista de la teoría económica traten de analizar este fenómeno. Esta tesis doctoral, siguiendo los modelos económicos propuestos en la literatura empírica, trata de contribuir a la comprensión y análisis de los factores determinantes de la demanda de juego - loterías y apuestas deportivas de gestión pública (LAE) - en España.

En concreto, los principales resultados obtenidos revelan la existencia de externalidades de red en el consumo de loterías públicas en España, así como una cierta preferencia por los juegos que ofrecen un extraordinario *jackpot* asociado a una elevada dificultad de acierto. Asimismo, parece existir - en el caso español - una cierta complementariedad entre la demanda de apuestas deportivas y el consumo de determinados deportes, como el fútbol.

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