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

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Abstract We use data from two nationally representative Spanish surveys in 2005 and 2006 to investigate spending on lottery games. Estimates from Tobit and double hurdle models of participation in lottery markets and spending on lottery tickets find 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. Consumer spending on different lottery games exhibits inter-related consumption decisions. Also, the assumptions underlying the double hurdle model, but not the Tobit model, better describe consumer spending on lottery tickets in Spain.

Keywords Double hurdle model · Gambling · Lottery · Network externalities · Consumer spending

Mathematics Subject Classification (2000) D12 · C21 · D62

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

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over the past 20 years, and in part because the tax revenues generated by different gambling goods have become an important source of government revenue. However, little research has focused on patterns in consumer spending on related gambling goods like tickets for different lottery games. In this article we examine the relationship between consumer spending on three lottery games available in Spain (the *Loteria Nacional*, the *Euro Millones* game, and *El Couponazo de la ONCE*) using detailed micro-data on consumer spending. We find evidence of inter-related consumption decisions in consumer spending on lottery games in Spain.

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,[1] 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. (2000); Forrest et al. (2002, 2004), Walker and Young (2001), Garrett and Sobel (2001), 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 expenditure on gaming goods like lotteries. Studies of consumer spending on gambling goods using micro-data from detailed surveys generally focus on a single lottery product and include Scott and Garen (1994), Farrell and Walker (1999), Worthington (2001) 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 focuses on the coexistence of many lotto games with different formats, frequency, and prize structure, referring to the potential substitutability or complementarity among these competing games. Forrest et al. (2004) found some evidence of partial 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. 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.

Grote and Matheson (2006) found evidence of both complementarities and substitution between a single state lotto and a larger jackpot (highest payoff) multi-state lotto. This article can be thought of as an investigation of the micro-foundations of the results in Grote and Matheson (2006). Their discussion of the issue of substitutes versus complements in lottery games, based on their examination of the relationship between a multi-state and a single state lottery game, informs our analysis. The games we examine closely match those examined by Grote and Matheson (2006). We examine two competing passive lottery games in Spain, the *Loteria Nacional*, and *El Couponazo* de la ONCE, and a multi-nation active lottery, the *Euro Millones* game. *Loteria Nacional*, and *Euro Millones* tickets are sold at the same kiosks, but tickets

[1] In a lottery, if there are no winners of the top prize, it is usually added to the top prize in the next draw. This event is known as a rollover.

for *El Couponazo de la ONCE* are sold at different kiosks in Spain. Thus these may be competing games.

Whether a traditional lottery product is substituted by a new product is also tested in the literature. 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 horse racing 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.[2] Price and Novak (2000) included variables describing expenditures on other games in analyzing the purchase of alternative gambling products. They found that games are complementary and apparently, those who gamble on one game tend to gamble on others. Farrell and Forrest (2008) 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) found that UK lotto sales respond positively to increases in the *Euro Millones*—a European multi-country lotto game—jackpot. 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 article, 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, computed as the face value of a ticket minus the expected value of the bet's payoffs, for lottery tickets for our data, so we are unable to determine if any of the lottery goods are neither complements nor substitutes; 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 articles 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. However, each additional buyer also increases the probability of sharing the prize pool with multiple winners indicating a negative network externality. So there are two externalities from adding a player: a positive one, raising the jackpot available, and a negative one, increasing the probability of sharing the prize if winning so reducing the expected payoff. 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, so the first effect dominates the second. Furthermore, Forrest et al. (2002) suggested that individuals

[2] Clotfelter and Cook (1989) dealt with displacement and cannibalization 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.

prefer a large jackpot to a large expected payoff, so the positive network externality outweighs the negative one. As well, 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, or when the utility of consuming one product increases with the availability of compatible complementary products. An example of these indirect network externalities can be found in the study of related software and hardware systems in Gandal et al. (2000). In our case, different lottery games represent varieties, or compatible complementary products, 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 Lottery markets in Spain

According to a recent Gambling National Commission report, in 2006 Spanish people spent over € 28.8 billion on gambling, about € 646 per inhabitant. Nearly 60% of this spending on gambling went to private gambling activities like casinos, 33% to public lotteries and over 7% 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.[3]

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 *Loteria 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 *Loterias y Apuestas del Estado* (LAE)—the Spanish National Lottery Agency—and *Euro Millones*, a European multi-country lotto game. ONCE operates 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 three lottery games. Lottery tickets are widely available throughout Spain and tickets can be purchased at any LAE or ONCE outlet. LAE offers five different lottery games that run throughout the week, and ONCE offers four different games, but we focus only on two LAE games and one ONCE game here: the *Loteria Nacional* a (passive) draw lottery game available through LAE that is played every Thursday and Saturday *Euro Millones*, a multi-country lottery available through LAE with a 5/50 plus 2/9 format that has a weekly drawing on Fridays and *El Cuponazo de la ONCE*, a passive draw lottery game available through ONCE that is played every Friday. The price of tickets varies

[3] In 2004 total Spanish lottery turnover (total sales) was almost € 8.5 billion, 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*).

Table 1 Spanish lottery games features

Game	Average jackpot (€ 2006)	Price (€)	Takeout rate
Loteria Nacional (Thursday)	1,200,000	3	0.30
Loteria Nacional (Saturday)	3–5,000,000	6–12	0.30
Euro Millones	50,940,123	2	0.50
El Cuponazo de la ONCE	9,000,000	3	0.5038

depending on the game played. *Euro Millones* costs 2 €. *Loteria Nacional* tickets cost from 3 to 12 € depending on the draw. *El Cuponazo de la ONCE* tickets cost 3 €. Lottery tickets can be completed by choosing numbers or by buying a randomly generated set of numbers. The takeout rate—the proportion of sale revenues that is not returned in the prize pool—is 0.50 for *Euro Millones*, while the percentage of sales revenues devoted to prizes is 49.62% for *El Cuponazo* and 70% for *Loteria Nacional*. Prizes are awarded when there are a minimum of one or two winning numbers out of a maximum of 5 or 7, according to each lottery game. Table 1 contains basic information about these three lottery games.

Euro Millones is a European multi-country lotto game, which was created by the French, Spanish and UK lottery associations and launched in February 2004. It is played in Spain, Austria, Belgium, France, Ireland, Luxembourg, Portugal, Switzerland, and the United Kingdom. The jackpot is usually much larger than other lottery games; a rollover (no winner) on this lottery can produce enormous prizes after just a few rollovers. The stakes from the players in all the countries is pooled and the minimum jackpot is € 5 million.

The passive *Loteria 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 selling in multiple "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 *Loteria Nacional* distributes 70% of the total amount wagered 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 both winnings and sales.

Both *Euro Millones* and *Loteria Nacional* tickets can be bought at the official LAE outlets. They are blue and have a distinctive sign outside. There are more than 10,650 LAE outlets in Spain. ONCE lottery tickets are sold on the street by authorized cupón sellers, as well as in any of the 8,000 green ONCE kiosks located around Spain. These kiosks are clearly identified by the word "ONCE" and can be found along main

thoroughfares, at airports, and in shopping malls. ONCE points of sale employ the blind or partially sighted, which is one of the main goals of ONCE. The cupón sellers, whether in the street or in kiosks, use electronic reading devices connected to the ONCE's database to check each winning number, as well as the authenticity of the cupón. Major (tax-exempt) cash prizes are paid directly into bank accounts once the winner has established contact with the organization through its delegations throughout Spain.

Although ONCE now has several gaming products available, their traditional product, and one of the most visible aspects of ONCE, is the charity lottery ticket known throughout Spain as a cupón. Sales of this lottery product is the main source of income for ONCE and can pay huge tax-exempt cash prizes to winers. The draw has different tickets for different days of the week, a special weekend ticket as well as special tickets with higher prizes, usually by season. *El Cuponazo*, one of the cupóns, is drawn on Friday and costs 3 €. *El Cuponazo* is drawn as a five-digit number and it is sold into multiple "series." Prizes vary based on how many of the five digits a particular cupón has, or the amount of numbers it has plus the "series" number. The digits have to be matched from left to right in order to win. The lowest prize is effectively a refund of the 3 € that was used to purchase a ticket and the jackpot (maximum prize) is € 9,000,000.

LAE and ONCE tickets are sold at separate locations. Two of the games are passive draw game where ticket buyers cannot choose numbers, and one is an active draw game where ticket buyers can pick numbers. The draws for *Euro Millones* and *El Cuponazo de la ONCE* take place on Friday and the draws for the *Loteria Nacional* take place on Thursday and Saturday. As these games are relatively independent in terms of sales outlets and characteristics, and have draws close to one another during the week, these games can potentially generate indirect network externalities since they are compatible complementary products. Detailed survey data about individuals' participation in each of these games provide us with a unique setting in which to investigate the inter-related spending on different lottery games at the individual level. Previous research on spending on alternate lottery games has been carried out using aggregated data that obscures any inter-related purchases.

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, but inter-related decisions. Suppose that g is an individual's expenditure on a gaming good like lottery tickets, c is an individual's expenditure on all other goods and services, and e is money 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 individual's risk aversion in this model. Although gambling has been treated in the literature as an addictive good and some empirical studies include lags of expenditure on lotteries in

the regression of current sales to capture addiction, for example Walker (1998), this approach can have econometric implications since a lagged dependent variable is often significant in accounting for expenditure on all sorts of goods, including goods which are not addictive. As other features of signal addiction may complicate unnecessarily the analysis we opt to simplify the theoretical model not allowing for gambling addiction. Lottery tickets are simply treated as a good that individuals purchase. Based on this constrained utility maximization problem, it is straightforward to derive an expression relating purchase of lottery tickets to explanatory variables through a demand function

$$g_i^* = \beta' X_i + \varepsilon_i \tag{1}$$

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

$$I_i^* = \alpha' Z_i + \nu_i \tag{2}$$

where I_i^* is an unobservable indicator variable that determines whether 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. α and β are vectors of unobservable parameters to be estimated.

Modeling 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 α and β depends on the joint distribution of ε_i and ν_i and the dominance concept developed by Jones (1989). We assume that ε_i and ν_i are distributed as a bivariate normal random variables with zero means, constant variances and a coefficient of correlation 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. Garcia and Labeaga (2006) show that the likelihood function for this model is

$$\begin{aligned} L_{\mathrm{DH}} = \prod_{1} & P(\nu_i > -\alpha' Z_i) P(\varepsilon_i > -\beta' X_i | \nu_i > -\alpha' Z_i) f(g_i | \varepsilon_i > -\beta' X_i, \\ & \nu_i > -\alpha' Z_i) \prod_{0} (1 - P(\nu_i > -\alpha' Z_i) P(\varepsilon_i > -\beta' X_i | \nu_i > -\alpha' Z_i) \end{aligned} \tag{3}$$

where $\prod_0$ is the product operator applied to observations where $g = 0$, $\prod_1$ 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 (1989), we assume that the censoring mechanism in this case is

$$g_i = 1(I_i^* = 1)\max(g_i^*, 0) \tag{4}$$

where $1(A)$ indicates the occurrence of event A. In other words, in order to observe an individual purchasing a positive quantity of lottery tickets there must be no abstention from gambling ($I_i^* = 1$) and no corner solution ($g_i^* > 0$). Jones (1989) also discusses the case of first hurdle dominance, when the participation decision dominates the consumption decision. This condition rules out corner solutions, as it requires that anyone who would participate in the activity is always observed participating. The presence of first hurdle dominance indicates that the Heckman sample selectivity model should be used. We assume that both abstentions and corner solutions exist in our data, ruling out first hurdle dominance.

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

$$g_i = \max(g_i^*, 0) \tag{5}$$

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. Garcia and Labeaga (2006) show that in this case of corner solutions, the Tobit model

$$L_{\mathrm{T}} = \prod_1 P(\varepsilon_i > -\beta' X_i) f(g_i | \varepsilon_i > -\beta' X_i) \prod_0 (1 - P(\varepsilon_i > -\beta' X_i)) \tag{6}$$

applies. Again, $\prod_0$ is the product operator applied to observations where $g = 0$, $\prod_1$ is the product operator applied to observations where $g = 1$, and $f(\cdot)$ is the pdf for a normal random variable.

A comparison of Eqs. 3 and 6 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 $\alpha' = \beta'$, so 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 Eqs. 1 and 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 Eq. 3 when ε_i and ν_i are independent, or the full double hurdle model, Eq. 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 Eqs. 1 and 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.

4 Data description

Our data come from two computer-assisted random digit dial telephone interview surveys administered by *Loteras 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 individuals participated in the first survey and 1,205 individuals participated in the second survey. Although many identical questions appeared on each survey, there were a few differences between the two surveys. The exact age of each individual 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 €.

Table 2 shows summary statistics for participation and average monthly spending on the three lottery games we examine, based on both of the LAE surveys.

The occasional 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 individuals who reported playing that game. The passive *Loteria Nacional* is the most popular

Table 2 Summary statistics for participation in lottery games

Game	Monthly expenditure		Regular participation (%)	Occasional participation (%)
	Mean	Std. dev.		
Loteria Nacional	5.57	42.28	16	52
Euro Millones	1.33	4.60	12	25
El Cuponazo de la ONCE	2.03	7.48	26	25

Table 3 Summary statistics for individual characteristics

Variable	Mean	Std. dev.	Min	Max
Age	46	17	18	93
Real monthly income (000s)	1.58	1.04	0.25	5.02
Male	0.48	0.50	0	1
Single	0.13	0.33	0	1
Years of education	13.69	5.56	0	22
Employed	0.66	0.48	0	1
Number of different games played	3.86	2.74	0	10

game in terms of occasional participation rate and average monthly expenditure. *El Cuponazo* is the most popular in terms of regular participation.

Table 3 shows summary statistics for the socio-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 is about 1.5% of the average monthly income reported on Table 3.

5 Empirical results and discussion

The two likelihood functions described above, Eqs. 3 and 6 describe two alternative empirical models for explaining consumer participation in lottery games and expenditure on lotteries. The dependent variable in the Tobit model, Eq. 6, is expenditure on a particular lottery product; the double hurdle model, Eq. 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 horse race 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, ε_i and v_i, 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. Price and Novak (2000) estimated a regression model dealing with the relationship between expenditures on a particular lottery product and purchases of other lottery products. They regressed per capita expenditure on individual lottery game on the per capita expenditure on games other than lottery, among other covariates, to measure the purchase of alternative products. Also, the indicator variables refer to participation in different lottery games. For example, we explain current participation in the *Loteria Nacional*, and current spending on these tickets, with past participation in *Euro Millones* and *El Cuponazo de la ONCE*. 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 4 shows the results for the Tobit model, Eq. 6. Starred parameters are significantly different from zero at the 5% level. 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, for all three 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 *Loteria Nacional*. Most previous studies have found little systematic relationship

Table 4 Parameter estimates and standard errors: Tobit model

Variable	Loteria Nacional	Euro Millones	El Cuponazo
Age	1.565*	0.367*	0.664*
	0.371	0.172	0.182
Age^2	−0.015*	−0.005*	−0.006*
	0.004	0.002	0.002
Income	2.248*	0.269	−0.394
	1.088	0.491	0.533
Male	5.659*	5.971*	−1.497
	2.031	0.947	0.986
Single	−6.108	0.021	0.610
	3.743	1.801	1.820
Years of education	−0.285	−0.206	−0.106
	0.204	0.096	0.100
Employed	−0.417	−0.191	2.196
	2.823	1.287	1.396
Household size	−1.325	0.802	0.895
	1.007	0.447	0.485
Big prize	2.704	3.991*	3.569*
	2.007	0.944	0.986
Loteria Nacional	–	7.311*	10.42*
	–	0.980	1.043
Euro Millones	14.98*	–	9.271*
	2.465	–	1.182
El Cuponazo	18.27*	7.546*	–
	2.179	0.990	–
Observations	2,425	2,425	2,425
Participants	638	410	635
Log likelihood	−3886	−2242	−3370

*Significant at 5% level

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 *Loteria Nacional*.

The relationship between monthly spending on lottery tickets and education is not significant in this sample. Most previous studies have found that spending on lotteries falls with the level of education. Participation in the other types of games 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.

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. Recall that the vector of explanatory variables are equal to one if an individual

participates in a particular lottery game. So the parameter of 7.311 on the *Loteria Nacional* indicator variable in the *Euro Millones* Tobit model indicates that individuals who purchase *Loteria Nacional* tickets weekly spend an additional 7.3 € per month on *Euro Millones* tickets. The effects are not entirely symmetrical—purchasing *Euro Millones* tickets frequently does not lead to additional spending on *Loteria Nacional* tickets. Overall, these cross-effects suggest the presence important inter-related expenditure decisions on spending on lottery tickets in Spain.

Table 5 shows the parameter estimates and standard errors for the double hurdle model, Eq. 3. Started parameter estimates are significantly different from zero at the 5% level. 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 individuals may attach negative utility to the consumption of gambling goods like lottery tickets, like in the model developed by Scott and Garen (1994). Note that an exclusion restriction has been placed on the double hurdle model. The variable reflecting individuals who reported that the most important feature of a lottery game, in terms of participation in the game, was large prizes has been omitted from the expenditure equation. The literature is silent on the issue of exclusion restrictions for double hurdle models; in this case, an exclusion restriction was useful to get convergence of the maximum likelihood estimator. Since this survey question was about the effects of features of lottery games on participation, it should explain participation but be unrelated to unobservable factors that affect expenditure.

In general, the double hurdle model results on Table 5 resemble the Tobit results on Table 4. Participation, but not expenditure, in the *Loteria Nacional* and *El Cuponazo* show the usual inverted-U relationship to age. Both participation and expenditure are largely unrelated to income and employment, except for the *Loteria Nacional*. Males participate in *Euro Millones* 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 5 contain several instances where this assumption is violated. For example, from Table 4, the Tobit results indicate that expenditure on the *Euro Millones* game is unrelated to the level of education. But the results on Table 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 5 relate to the existence of inter-related participation and expenditure decisions in Spanish lottery games. In terms of participation, *Euro Millones* participation is more likely if individuals play either the *Loteria Nacional* or *El Cuponazo*, but participation in the other two games is not more likely for any games. This asymmetry suggests that passive draw players also like active draw games,

Table 5 Parameter estimates and standard errors, double hurdle model

	Monthly expenditure			Participation		
	Loteria Nacional	Euro Millones	El Cuponazo	Loteria Nacional	Euro Millones	El Cuponazo
Age	0.832	0.155	−0.045	0.135	0.073	0.098*
	0.690	0.230	0.296	0.082	0.055	0.041
Age^2	−0.007	−0.003	0.001	−0.001*	−0.001	−0.001*
	0.007	0.003	0.003	0.001	0.001	0.000
Income	4.207*	0.516	−0.997	−0.379	−0.121	0.087
	1.589	0.626	0.742	0.252	0.206	0.125
Male	4.726	6.165*	−0.917	0.234	0.020	−0.262
	4.495	1.243	1.412	0.852	0.401	0.233
Single	−4.540	2.032	2.035	−0.175	−0.939	−0.205
	5.976	2.424	2.621	0.883	0.716	0.419
Years of education	−0.316	−0.429*	−0.048	0.011	0.098*	−0.015
	0.305	0.141	0.156	0.044	0.044	0.027
Employed	1.658	−1.249	2.413	−0.514	0.461	−0.053
	4.074	1.633	2.064	0.856	0.444	0.368
Household size	−2.110	1.070	1.680*	0.215	−0.118	−0.148
	1.506	0.602	0.733	0.344	0.189	0.112
Big prize	–	–	–	0.592	1.365*	0.371*
	–	–	–	0.506	0.513	0.162
Loteria Nacional	–	5.006*	8.452*	–	1.726*	0.030
	–	1.435	1.400	–	0.785	0.254
Euro Millones	11.64*	–	6.317	5.465	–	−0.052
	3.244	–	1.536	197	–	0.350
El Cuponazo	13.65*	5.906	–	6.024	1.166*	–
	3.167	1.313	–	213	0.570	–
N/participants	2,425	2,425	2,425	638	410	635
Log likelihood	−3878	−2234	−3305			

*Significant at 5% level

and perhaps the larger jackpots generated by the multi-country *Euro Millones* game. The fact that *Loteria Nacional* participation is not more likely for *Euro Millones* players means that the convenience of buying thee tickets at the same outlet does not matter much to ticket buyers.

Table 5 contains little evidence of displacement in participation in the Spanish lottery market. There is weak evidence that individuals who frequently purchase *Loteria 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. *Loteria 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 *Loteria 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 5 contains quite a bit of evidence of of inter-related participation and expenditure decisions across these three Spanish lottery games, which could be interpreted as evidence of indirect network externalities. Participation in the *Loteria Nacional* is associated with more spending on both the other games, and participation in both *Euro Millones* and *El Cuponazo* are associated with greater expenditure on the *Loteria Nacional*. 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 the Guryan and Kearney (2010) 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. The difference between the maximum of the log-likelihood function for the restricted (Tobit) model and the maximum of the unrestricted (double hurdle) model log-likelihood function 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 analyzed. Garcia and Labeaga (2006) report similar results favoring 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 displacement between different gambling activities, and no evidence of displacement between different lottery games. Apart from Grote and Matheson (2006) who found that the introduction of a multi-state game reduces participation in states' own lotto games, the introduction of new lottery games, or additional draws of existing games, is not expected to reduce aggregate sales of lottery tickets.[4] Our evidence sheds new light on the mechanism that could generate 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

[4] However, Grote and Matheson (2006) also found a correlation between state lotto sales and sales for the multi-state game and the combined sales for the two games exceeded the sales for the previous game alone.

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.

6 Summary and conclusions

We use a novel data set on consumer spending on three 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 three lottery games is associated with higher spending on at least one 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 inter-related purchase of different lottery games suggests the presence of indirect network externalities in this setting. Positive indirect 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, nor 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 inter-related nature of consumer spending on different lottery games is intensive, and not extensive.

In terms of lottery policy, the inter-related 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 inter-related 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.

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