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The Relationship between Betting and Lottery Play: A High Frequency Time-Series Analysis

by

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ABSTRACT

The substitutability of different gambling products is an important concern for any jurisdiction contemplating deregulation of its gambling sector. We apply a novel daily time-series data set of daily turnover from one of Britain's leading bookmakers to analyse potential substitution between lottery play and bookmaker betting. We find some evidence that bettors do substitute away from horse race, dog race and numbers betting when the effective price of lottery tickets is unusually low, i.e. when there is a rollover or Superdraw. This substitution has a highly specific pattern of timing that varies by sector. Our results further suggest that bettors rationally engage in forward-looking substitution within their betting portfolios.

Key Words: betting, bookmaker, lottery, substitution

THE RELATIONSHIP BETWEEN BETTING AND LOTTERY PLAY: A HIGH FREQUENCY TIME-SERIES ANALYSIS¹

Introduction

The on-line numbers game, lotto, accounts for over two-thirds of the turnover of the UK National Lottery, an important source of finance for investment in sectors such as the arts and sport. The game is similar in format to that offered by many American states. Draws take place twice weekly, on Wednesday and Saturday evenings. A player pays one pound to select six numbers in the range 1-49. If his selection matches the six winning numbers in the televised draw, he wins a share of the grand prize. If no player wins this jackpot, the money is 'rolled over' to the next draw. The size of jackpot on offer in lotto therefore varies not only with the number of tickets sold but also with whether (and how much) prize money has been rolled over from previous draws. In the British version of the game, further variation in prize levels between draws occurs because the operator is permitted to reserve some revenue to fund occasional promotional 'Superdraws' where extra money is added to the jackpot. As with rollovers, lotto on these occasions offers potential players better value: the expected value of holding a ticket can be as much as twice as high for some draws (those benefiting from a double rollover where the jackpot has been unwon two draws running) as for others.

A number of studies have documented and quantified the extent to which lotto sales respond when prize levels are increased because of a rollover or the declaration of a Superdraw.

Examples include Farrell, Morgenroth and Walker (1999) and Forrest, Simmons and Chesters (2002). Adapting a methodology first proposed in a US study by Gulley and Scott (1993),

¹We are grateful to the anonymous bookmaking company which provided the bulk of the data for our analysis. David Forrest acknowledges support, for this and other Lottery-related projects, from The Leverhulme Foundation.

such authors use their findings to draw inferences concerning the own-price elasticity of demand for lotto (where ‘price’ is identified with the expected loss from buying a ticket) and discuss implications for the policy question of whether average prize levels are appropriate to the goal of maximising turnover and therefore funds available to ‘Good Causes’.

The present paper also exploits information about rollovers and Superdraws but here the focus is on cross-price elasticities rather than own-price elasticity. We were supplied with over five years of daily data on turnover in five forms of gambling offered by a major national but, for commercial reasons, anonymous British bookmaker.² For each product type (such as horse race betting), we built a detailed model to account for variation in turnover and included terms to allow us to estimate the response of sales on the day of, and in the days running up to, lotto rollovers and Superdraws.³ The findings are striking in that some, but not all, forms of betting prove to be sensitive to the amount of prize money available in the lotto game. However, the existence of significant substitution effects depends critically on the timing of betting in relation to an anticipated rollover. These intertemporal effects can only be revealed by the type of high frequency data that we have available here. Lotto and certain forms of wagering are therefore demonstrated to be substitutes, dependent on time of betting, and this has policy implications discussed below.⁴ These substitution effects are particularly interesting as the United Kingdom moves forward on plans to further deregulate the gambling

² In further recognition of the commercial sensitivity of the information provided, we transformed the turnover data into index number format prior to empirical analysis. A sixth sector, slot machine play, is too small to be of interest in this study.

³ We tested also for any impact in the days following a rollover or Superdraw but found nothing significant and do not report the results.

⁴ Both lottery products and betting opportunities are widely accessible in Britain, in all but the most rural areas, but at different outlets. At the last official count in 2000, there were 8,732 bookmaker shops (quoted in Mintel (2003)). Bookmaker shops are not permitted to sell tickets for or accept side bets on National Lottery products. These are sold at post offices, many corner shops and nearly all supermarkets and petrol stations. According to Department for Culture, Media and Sport (2001), betting turnover in 1998, the middle year of our data period, was £8,404m. and sales of National Lottery products amounted to £5,376m.

sector opening up greater opportunities for access to established gambling products and entry of new betting opportunities.

Most of the existing literature on the relationships between different forms of gambling focuses on displacement effects when a new gambling medium is introduced or made more widely available. For example, Gulley and Scott (1989) and Thalheimer and Ali (1995) found that American lotteries had a negative impact on pari mutuel racetrack turnover though Paton, Siegel and Vaughan Williams (2004) found no structural break in the demand for betting that could be associated with the introduction of the UK National Lottery. Forrest (1999) reports that the British lottery did however have a marked impact on the football pools which had offered a similar high prize, long odds product. Lotteries in turn have been shown to be susceptible to the appearance of new forms of gambling. Using monthly data from 1993-8, Siegel and Anders (2001) show Arizona state lottery sales falling in response to increasing opportunities for slot machine play at Indian casinos.

The literature from which these examples are drawn is concerned with displacement effects. But investigating whether, for example, a new lottery drew consumer expenditure away from racetrack betting is quite distinct from asking whether the two forms of gambling are substitutes in the sense of the cross-price elasticity being positive once the new regime of both being available is firmly in place. On this aspect of the relationship between different gambling media, the literature is almost silent, presumably because of lack of price data or lack of adequate variation in price. However, two studies attempt to exploit the variation in effective lotto price associated with the phenomenon of rollovers. Purfield and Waldron (1999) find that rollovers of the Irish lotto raise both lotto sales and the volume of side betting (with a major Irish bookmaker) on which numbers will be drawn. The complementary

relationship is interesting in that it may arise because lotto buyers respond to value in the draw itself by purchasing more tickets but also take advantage of the greater emphasis on small prize, high probability wagers in the side betting market to create a lottery portfolio that accords with their preferences over variance and skewness in returns. The results pertain however to the special case on betting on the lotto game itself and do not give any clue as to how mainstream betting is affected by an effective price reduction available at the lottery booth.

In the second study to use rollover induced variation in the effective price of lotto to illuminate the relationships between gambling sectors, Paton, Siegel and Vaughan Williams (2004) employ monthly data on UK betting tax revenue. They model the response of UK betting volumes as recorded by Customs and Excise to lotto 'price' (i.e. expected loss from one play). However, because only monthly data were available, the price variable had to be constructed from averaging across up to nine draws which raises problems over the weighting that should be given to different draws whose sales will vary substantially according to whether or not there is a rollover. Further, the reliance on monthly data aggregates away much of what may be interesting in terms of the impact of lottery events on betting patterns. The present study has the advantage of daily turnover data that is also disaggregated according to different forms of wagering. The nature of substitution from the betting sector to lotto can therefore be revealed in greater and more reliable detail.

Establishing whether different forms of gambling are more or less close substitutes is relevant to a number of areas of public policy. New legislation in Britain will expand the range of gambling opportunities available to bettors. Concerns have been expressed in sections of the media and by some politicians that further deregulation of gambling in Britain might generate

a substantial increase in ‘addicted’ or ‘problem’ gamblers who may impose social costs through the increased medical and counselling services that might be required. However, it is possible that the introduction of new gambling products might lead to substitution within some individuals’ gambling portfolios. For example, increased casino gambling may occur partly at the expense of reduced horse race betting. We cannot test this conjecture as data are not available but evidence of substitution from our bookmaker’s data set can shed light on whether there is a *rational* response to changes in effective price of one gambling product (lotto play) with gamblers substituting between gambling sectors.

Our study can also inform some more specific policy questions. For example, the UK Government may wish to impose a tax regime that protects the lottery and the funds available to ‘Good Causes’ from erosion by new forms of gaming if bettors are demonstrated to be price sensitive in their allocation of spending across the gambling sector. A committee of members of parliament has proposed the removal of the 12% turnover tax on National Lottery products⁵ but, if some of the saving were channelled into higher prize funds, this may damage the betting industry and the sport of racing that is dependent on it, again depending on cross-price elasticities. For those who implement competition policy, the degree of substitutability between different modes of gambling is also important. In 1998, a merger between two of the three largest British bookmakers was rejected on the ground of the level to which it would raise the concentration ratio in the betting industry. The Monopolies and Mergers Commission viewed betting as a distinct industry whereas the parties to the merger had argued that betting in fact faced strong competition from the National Lottery. The controversy over how tightly to define the industry was uninformed by empirical evidence.

⁵ This ‘lottery duty’ is distinct from the additional hypothecated levy, of 28% of turnover, to support ‘Good Causes’.

Here we set out to provide empirical evidence concerning the link between these two types of gambling product.

Data

A large bookmaker whose retail network gives national coverage provided daily data for the volume of business transacted at shop outlets⁶ during the period from January 1, 1996 to June 5, 2001. For purposes of the analysis below, we converted all data to 'real' pounds according to the all items retail price index of June, 2001.

A complication was that the period was marked by a gradual move towards more regular Sunday opening of bookmaker shops. The data therefore sometimes recorded Sunday business but sometimes there was no business to record. Our model of turnover was to include lagged dependent variables and in fact revealed a degree of habit formation such that the amount staked on any one day reflected, at least for some products, the amount bet the day before and on the same day the previous week. It was therefore appropriate to make the data consistent by treating each week as having the same number of days. Accordingly, we aggregated Saturday and Sunday data as if the weekend were a composite 'day'. To account for the boost to turnover when there was in fact Sunday opening, we then included in our models a dummy variable set equal to one if the 'day' actually covered two days when the shops were open for business.

⁶ Telephone and Internet wagering and on-track betting were therefore excluded.

Our analysis relates to three types of gambling offered at the shops. The total amounts wagered were provided for betting on horse racing, dog racing and numbers games⁷. Each of these sectors offers virtually daily betting opportunities and can be thought of as potential substitutes to lottery play.

The bookmaker also provided a wealth of data relevant to modelling turnover for the three sectors, for example measures of the quantity and quality of each day's racing programme, the dates of major sporting events and the dates on which the range of numbers games on sale were altered. Data on the incidence of National Lottery rollovers and Superdraws and the amounts by which the jackpot prize was augmented on each occasion were retrieved from the archive held at www.merseyworld.com.

Model

We began our model specification by testing for unit roots in the data. Augmented Dickey-Fuller tests clearly rejected the null hypothesis of an I(1) non-stationary process in favour of stationarity for two of our sectors. The test statistics for our betting sectors, based on 12 lags without trend, were -3.74 , -4.21 and -2.62 for horses, dogs and numbers respectively, to be compared with a critical value of -2.86 at 5 percent significance and -2.57 at 10 percent. Although the unit root test for numbers only rejects the null of non-stationarity at 10 percent, we are inclined to accept stationarity based on low power of the test and inspection of the autocorrelation function. Overall, we conclude that differencing the data and search for cointegrating relationships were not required.

⁷ Numbers games are based on daily draws commissioned by a consortium of bookmakers or on the drawings of foreign lotteries. Bookmakers also offer betting on soccer games and sports events such as the US Open and the Wimbledon tennis tournament. These sectors relate to events that are more sporadic and more heterogeneous

However, we did find evidence of serial correlation and heteroskedasticity in the data which would bias standard errors downwards and make our t statistics too large, undermining inference. To deal with these problems, we adopted the Newey-West correction of standard errors⁸. For each of the three sectors of the business, we estimated turnover with the following model:

$$\text{TURNOVER}_{it} = F(\text{constant, } \mathbf{TURNOVER}_{i, \text{lagged}}, \text{WEDNESDAY BONUS, WEDNESDAY BONUS}_{t+1}, \text{WEDNESDAY BONUS}_{t+2}, \text{SATURDAY BONUS, SATURDAY BONUS}_{t+1}, \text{SATURDAY BONUS}_{t+2}, \mathbf{CONTROLS}_{it})$$

TURNOVER_{it} refers to sales in sector i on date t . $\mathbf{TURNOVER}_{i, \text{lagged}}$ is a vector of one or more lagged values of turnover in sector i . Lagged values of turnover may be relevant because of the tendency to habit formation present in the consumption of many goods. We focus here on two lags: previous day and same day last week. If previous day's turnover is higher then today's turnover may be lower as bettors have spent (and most likely lost) a greater part of their weekly 'betting budget'. Also, in some sectors, bettors appear to display habit persistence week to week; for example, increased numbers turnover on a given Saturday is followed by greater numbers turnover on the following Saturday.

than the betting opportunities offered in horse and greyhound racing. We therefore do not pursue analysis of soccer and sports betting here.

⁸ A lag structure of six was applied to the error term. Results are robust to choice of fewer lags. We include a lagged dependent variable in our models but it does not follow that OLS regression results will be inconsistent in the presence of both lagged dependent variable and serially correlated errors. See Wooldridge (2003, pp394-395) who advises against having both a lagged dependent variable in a model and a specific model of serial correlation in the errors. Consistency of OLS estimates is preserved, however, with standard errors that are robust to serial correlation.

The National Lottery variables, WEDNESDAY BONUS and SATURDAY BONUS, reflect that the behaviour of potential players may be influenced by any bonus money added to the jackpot both on the day of the draw (when tickets may be purchased up to 7.30 p.m.) and on the two preceding days. For example, it is known on Wednesday evening whether anyone has won the lotto jackpot for that day's draw. If there is a rollover, the amount of prize money to be carried forward to Saturday is known immediately and will inform decisions on how many tickets to buy during Thursday, Friday and Saturday. Similarly, if lotto and betting are substitutes, there may be an impact on bookmaker turnover on Thursday, Friday or Saturday. Suppose £ x is rolled over to Saturday. For the observation corresponding to the Thursday, SATURDAY BONUS _{$t+2$} is then equal to x and the other lottery variables have the value zero. For observations corresponding to that Friday and that Saturday, it is SATURDAY BONUS _{$t+1$} and SATURDAY BONUS respectively that are set equal to x . Coefficient estimates on SATURDAY BONUS _{$t+2$} , SATURDAY BONUS _{$t+1$} and SATURDAY BONUS therefore measure the impacts on bookmaker turnover (per pound of money added to the Saturday jackpot) on the Thursday, Friday and Saturday of a week in which the Saturday lotto draw has become especially attractive.

BONUS is the amount of money in the form of rollover and Superdraw funds that augments the jackpot prize. The restriction that impacts of rollover and Superdraw on betting turnover are treated as identical is imposed here because of low numbers in the rollover and Superdraw categories and is plausible in that rational bettors would treat an addition to the jackpot prize as equivalent, regardless of source⁹. Adding rollover and Superdraw together gives greater precision in our estimates partly because of the greater number of 'bonus' events but also because aggregation gives greater variation in the value of the BONUS

variables. The separation of BONUS effects by Wednesday and Saturday draws reflects the findings of Forrest *et al.* (2002) that UK lotto turnover responded differently to movements in effective price and jackpot prize according to whether it was a Wednesday or Saturday draw.

CONTROLS is a vector of control variables specific to the particular bookmaker product. For each betting sector i , a large number of control variables were included to account for the substantial day to day variation in the volume of betting transactions. These controls include number of betting shops open on a given day, a weekly time trend, dummy variables for month and day of week, variables to represent quality and quantity of events in a particular betting sector and variables which capture possible substitution or complementarities in other betting sectors. A full list of all control variables is provided in the Appendix. In our model specification we adopted a general-to-specific modelling procedure where controls were deleted if they were not significant at the 10 per cent level. All models contain at least one lagged dependent variable.

Results

Horse Race Betting

Table 1 reports OLS regression estimates for daily turnover in what is by far the largest branch of the betting business, horse race wagering. The results confirm that Saturday was easily the most popular day for betting and show that the Spring and midsummer months were busier than the Autumn and Winter. Two dummies were used for June according to whether or not it was an even numbered year. In the June of an even numbered year, a month

⁹ A caveat is that rollovers and Superdraws may be accompanied by different levels of advertising expenditure

long international football tournament (the World Cup or European Championship) is held and there appears from our results to be strong substitution of football betting for horse betting on these occasions.

The number of shops operated by the company on each day is included as a control; variation was due to branch openings and closures and acquisitions of shops owned by smaller bookmakers. As noted above, turnover figures for the weekend were treated as occurring on a single day but a dummy variable identifies which weekends include Sunday opening. Horse race betting turnover is found to be positively associated with shop openings.

‘Week number’ was our trend variable and attracted a large and significant negative coefficient. Horse race betting declined in popularity over the data period. However, beyond our sample there was a sharp increase in business reported from late 2001 onwards, partly in response to the overall reduction in betting tax imposed in October 2001 (Paton *et al.* 2004)¹⁰.

The quantity and quality of the horse racing on offer is naturally of extreme importance in determining turnover. Quantity was captured by a series of variables, all highly significant: the total number of runners (and its square) in British races that day; the number of British televised races and the number of British, Irish and foreign races broadcast by satellite television to bookmakers (but not to domestic households). Results imply that more races were associated with increased horse race betting but the result from the quadratic form for runners suggests diminishing returns. The number of runners at which betting turnover is

and different levels of publicity.

¹⁰ There was a fundamental change in tax regime in October 2001, four months after our sample period ends. Betting duty was previously a turnover tax of 6.75%. This was replaced by a 15% tax on bookmaker take-out. Effectively the tax burden on betting was halved and Paton, *et al.* (2004) relate the consequent improvement in value to bettors to the subsequent rapid increase in betting turnover.

maximised corresponds with approximately the number engaged on the busiest day of the year.

Quality was also important to bettors. This was captured by the total purse money available in that day's British races and this variable attracted a large and significant positive coefficient. Dummy variables were used to account for the increases in betting that occur during certain major events that generate strong interest. Thus, the Grand National Steeplechase, held at Liverpool in the Spring, is the biggest betting event of the year and bookmaker shops were also very busy with horse betting during major 'Festivals' (Ascot, Goodwood, Cheltenham).

We included as regressors both current day and lagged one-day values for the proportions of favourites and second-favourites that won in British horse races. All four coefficient estimates were positive and highly significant. British bookmakers typically hold unbalanced books such that they pay out more in winnings when races are won by short-odds runners.¹¹ An increase in the proportions of winning favourites and second favourites will raise payouts on the day (and on the next day for clients who leave the shop before the race and collect their winnings later). We interpret the positive coefficients as reflecting a significant propensity of horse bettors to reinvest these gains into further wagering.

A final group of controls recognised the influence of other events outside horse racing. Various special football events such as the FA Cup Final, played on a Saturday afternoon in May, and England playing Scotland in the 1996 European Championship impacted negatively on horse betting. This may not be due exclusively to substitution between football and horse betting: high profile football draws large television audiences and may therefore keep bettors

at home. The number of British dog races was also a significant negative influence but this will reflect direct substitution as television is not a factor in that sport.¹²

The inclusion of this comprehensive set of control variables allowed us to build a model that accounted for the bulk of the variation in horse race betting that occurred over the 1,672 days for which volume was recorded: the value of R^2 was .96.

Our main focus of attention is the substitution between lottery play and horse race betting. Coefficients on lottery variables that are significant and negative at 5 percent or better are shown in bold in Table 1. The significant impacts of high prize lotto draws on horse betting occur one day and two days before a Saturday bonus draw and two days before a Wednesday bonus draw. Hence, adverse impacts on horse race betting occur outside the weekend on Monday, Thursday and Friday. Our interpretation of these results is as follows. Saturday is the biggest day of the week for horse betting. Saturday horse betting is a significant leisure pursuit for most horse bettors. Most would go to the betting shop every Saturday. They do not appear to change their habits in response to the day being one when lotto is offering improved value. However, Thursday and Friday betting are more discretionary. Betting shops are less busy than on Saturday. Some bettors appear to respond to an upcoming Saturday special draw by substituting lotto tickets for Thursday and Friday horse race betting.

¹¹ The Royal Commission on Gambling (1978) put it thus: if one of the fancied horses wins, the bookmakers lose but if one of the outsiders win, they win. The situation appears not to have changed since bookmaker firms' annual reports tend to attribute periods of depressed profits to unusual runs of wins by favourites.

¹² Our models distinguish between dog races at meetings beginning in the morning and those later in the day. Morning races, held before horse meetings start, are subsidised by the betting industry to extend the betting day. We found that numbers of morning and afternoon greyhound races had similar sized negative coefficients and so we combined these into total greyhound races in the horse race equation.

The high volume of betting on horses on Saturday makes Monday a popular day for collection of winnings. Bettors may then recycle their money with the bookmaker but the propensity to do so is reduced when lottery retailers are offering a better value product than usual that same Wednesday. The relative importance of special lotto draws for Monday horse race betting is shown in Table 2. This displays the short-run percentage impact on average betting turnover on a particular day from the occurrence of a rollover or Superdraw, on Wednesday or Saturday as appropriate, from zero to its average value over the sample. We see that the largest proportionate adverse effect on horse betting is from a Wednesday bonus to Monday betting, estimated at -3.54% . This reflects both the larger coefficient on WEDNESDAY BONUS (t+2) and the smaller average size of bonus on Wednesday compared to Saturday. There are smaller proportionate impacts from Saturday bonus draws on to Thursday betting (-2.37%) and Friday betting (-2.08%). When these proportionate effects are converted into absolute turnover reductions we find that the largest adverse impact in the horse race sector is from a Wednesday bonus draw to Monday turnover.

Dog Race and Numbers Betting

Column 2 of Table 1 shows results from an OLS model of dog race betting turnover. The overall fit is less than for horse racing but still substantial with R^2 equal to 0.80. The impacts of control variables on dog race turnover appear plausible. Saturday was again the peak day for betting and December was the busiest month, partly reflecting that dog racing is less prone than horse racing to the frost and waterlogged courses that plague the winter horse racing season. The weekly trend was again downwards although this was offset by the positive impact of greater numbers of shop openings. The number of dog races impacts positively upon betting with a larger impact in the afternoon relative to mornings. A higher

rate of winning favourites encouraged dog race betting, a parallel result to horse race betting. Impacts from other sports are broadly adverse. For example, a greater number of horse races shown to households lowered betting, presumably because potential bettors stayed at home¹³. Also, a greater number of horse races transmitted to betting shops reduced dog race betting.

There is only one significant source of adverse impact from special lottery draws on dog betting which is from a Wednesday bonus draw on Mondays. From Table 2, the proportionate impact is -6.58%. Again, this may reflect the importance of Monday as a day for collection and re-investment of winnings from the weekend. The absence of a broader set of lottery draw impacts is evidence that dog race betting is a sector of bookmaker business that is more immune to events that impact on other betting sectors.

In contrast to dog race betting, numbers betting is predicted to be a close substitute to lotto play, largely because the games are very similar. From column 3 of Table 2 we see that there is no discernible trend in this sector although again greater shop openings are associated with higher volume of business. Some sporting events appear complementary to numbers betting (number of dog races and the football World Cup, for example). Other sporting events displace numbers betting (the Grand National and Wimbledon tennis final, for example, both of which are more likely to be viewed at home rather than in the betting shop).

There appear to be measurable effects on betting business in the numbers sector from Wednesday and Saturday lottery bonus draws, on the same day. Outside the day of the draw, the only other marginally significant negative impact on numbers betting is from a Saturday

¹³ Betting by personal visit to a retail shop was (and still is) the dominant mode of betting transaction.

bonus draw on Thursday. Proportionate same-day impacts on numbers turnover of an average sized Wednesday or Saturday bonus draw are estimated at -1.53% and -3.07%.

Conclusions

Betting and lotteries are very different products. The former (except for numbers games) is an activity requiring skill where participants have to seek out value whereas the latter is a game of pure chance. Betting, unburdened by the requirement to fund Good Causes and with keen competition between suppliers, offers a much higher mean return but without the skewness in returns which seems fundamental to the appeal of lotto. Betting attracts only a minority of the population whereas more than one half of adults play lotto. Betting is regarded as 'hard' gambling because there is often opportunity to chase losses but lotto is almost never regarded as a source of social problems. For all these reasons, it would not be surprising if clients of bookmakers and of the National Lottery were self-contained groups supporting products that were scarcely in competition with each other.

Our empirical estimates reveal three broad patterns to bettors' responses to changes in value of lotto tickets brought about by special draws. First, the dog race sector is largely impervious to changes in effective price of lotto tickets, with the notable exception of response of Monday turnover to a special lotto draw on Wednesday. Second, there are significant impacts on numbers betting volume on the same day as a lottery rollover. These contemporaneous effects are in line with the close substitutability of numbers play for lotto play. Third, horse race bettors show evidence of forward-looking behaviour in relation to the effective price of lotto tickets. Moreover, the impact on horse race betting turnover is confined to 'off-peak' midweek betting which we view as more discretionary and less rooted in habit. The impact of

Wednesday rollover on Monday horse race betting is the strongest in absolute terms of all the negative effects on betting turnover that we have identified. Since horse turnover is comfortably higher than that of all the other products combined, bookmakers will be very concerned about the ability of the National Lottery to take business from them. In terms of business lost, the reduction of Monday horse turnover when there is a Wednesday bonus draw is our most relevant finding. More generally, the losses of turnover induced by special lottery draws could well be a factor in the lobbying by UK bookmakers for rights to operate lottery games under further deregulation of the UK gambling sector.

Overall, we detect some significant responses by bettors in the bookmaking sector when rollovers make lotto effectively cheaper. This makes it more plausible: that gambling should be treated as a single industry; that the decline in lotto sales since 2001 is partially explained by the Government's abolition of betting duty in 2001; that legislators should not be surprised if future deregulation, by reducing the price or increasing the accessibility of low-taxed forms of gambling, should take business from the high-taxed National Lottery; that bookmakers' monopoly power is by no means as strong as the concentration ratio in betting narrowly defined might suggest; and that bettors are not creatures merely of habit but respond to value just like consumers of goods in other, less stigmatised parts of the economy.

Table 1**OLS Betting Turnover Estimates***Dependent variable is real daily turnover by sector*

Variable	(1) Horse Race	(2) Dog Race	(3) Numbers
<i>Turnover (t-1)</i>	0.061 (5.49)	0.110 (6.65)	0.102 (4.58)
<i>Turnover (t-6)</i>			0.457 (6.66)
<i>Shops</i>	0.060 (9.30)	0.020 (7.28)	0.012 (2.47)
<i>Week</i>	-0.114 (12.37)	-0.063 (19.54)	
<i>Lottery Variables</i>			
<i>Wednesday Bonus</i>	-0.165 (0.58)	-0.204 (0.67)	-0.449 (2.67)
<i>Wednesday Bonus (t+1)</i>	0.054 (0.16)	-0.277 (1.40)	-0.137 (0.85)
<i>Wednesday Bonus (t+2)</i>	-1.025 (2.55)	-0.723 (5.29)	-0.202 (0.69)
<i>Saturday Bonus</i>	-0.493 (1.39)	0.060 (0.43)	-0.989 (2.54)
<i>Saturday Bonus (t+1)</i>	-0.550 (2.08)	-0.168 (1.62)	-0.072 (0.56)
<i>Saturday Bonus (t+2)</i>	-0.510 (2.11)	-0.093 (1.36)	-0.389 (1.76)

Control Variables	(1) Horse Race	(2) Dog Race	(3) Numbers
Horse race variables			
<i>Prize money</i>	0.101 (8.95)		
<i>Total runners</i>	0.394 (17.45)	0.083 (9.79)	0.052 (3.39)
<i>Total runners squared</i>	-0.00025 (9.21)	-0.00006 (5.86)	-0.00009 (3.58)
<i>Grand National</i>	514.4 (27.68)	-28.71 (12.91)	-24.28 (2.28)
<i>Big meeting</i>	42.71 (5.01)		
<i>TV races</i>	3.65 (8.03)	-2.05 (16.15)	-0.583 (2.17)
<i>Bookmaker non-TV races</i>	1.51 (2.84)	-1.74 (10.50)	-1.64 (5.24)
<i>Bookmaker non-TV races squared</i>	-0.026 (1.90)	0.010 (2.20)	0.039 (3.78)
<i>Foreign races</i>	1.26 (3.97)	-0.47 (5.79)	
<i>1st favourite won</i>	0.190 (3.90)		
<i>2nd favourite won</i>	0.301 (5.15)		
<i>1st favourite won (t-1)</i>	0.271 (6.32)		
<i>2nd favourite won (t-1)</i>	0.224 (4.12)		
Dog Race Variables			
<i>Morning dog races</i>		0.638 (8.62)	
<i>Afternoon dog races</i>		0.934 (14.31)	
<i>Total dog races</i>	-0.673 (5.68)		0.248 (2.22)
<i>Winning dog favourite</i>		0.034 (1.65)	
Football Variables			
<i>Bank holiday football</i>	51.61 (4.78)		-28.89 (3.63)
<i>Bank holiday Scottish Football</i>		7.19 (3.20)	
<i>England in tournament match</i>	-16.63 (1.94)		
<i>World Cup Final</i>		-7.34 (4.09)	11.71 (1.94)
<i>England v Scotland (Euro 1996)</i>	-41.63 (7.25)	6.91 (4.85)	-50.42 (6.76)

<i>England v Scotland (World Cup qualifier)</i>		3.86 (1.70)	
<i>Scotland in Euro 1996</i>	-30.54 (3.53)	-11.57 (8.70)	
<i>FA Cup Final</i>	-29.72 (2.62)		
<i>European club match</i>	5.14 (2.01)		
<i>Other sports events</i>			
<i>Wimbledon mens final</i>			-25.44 (7.36)
<i>Rugby League Cup Final</i>		9.14 (2.45)	
R^2	0.96	0.80	0.96
N	1672	1675	1610

Note: Absolute t statistics in parentheses obtained from Newey-West standard errors. All equations also contain day of week dummies, month dummies and a constant. Numbers equation also contains six sub-period dummy variables for types of numbers game in operation.

Table 2

Short-run percentage impacts of a bonus draw on betting turnover

Day of turnover	Horse Race	Dog Race	Numbers
<i>Wednesday bonus</i>			
Same day			-1.53
Monday	-3.54	-6.58	
<i>Saturday bonus</i>			
Same day			-3.07
Friday	-2.37		
Thursday	-2.08		

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Appendix: list of control variables

Shops: number of shops open

Week: weekly time trend

Month dummies: January to November with December excluded; June is split into June with no international football tournament and June with World Cup or European Championship

Day of week dummies: Monday to Saturday with Wednesday excluded plus a dummy indicating that shops were open on Sunday (where Sunday turnover is included in Saturday figures)

Prize money: total prize money offered in UK horse racing that day deflated by RPI

Total runners: total number of runners in UK horse races

Grand National: dummy for the day of the Grand National Steeplechase (normally a Saturday)

Big meeting: dummy for a day of one of the major Festival horse race meetings at Ascot, Goodwood or Cheltenham

TV races: number of UK horse races broadcast on terrestrial television that day

Bookmaker non-TV races: number of UK horse races broadcast solely to bookmaker shops by satellite TV

Foreign TV: number of foreign (including Irish) horse races relayed to bookmaker shops by satellite TV

1st favourite won: proportion of UK horse races won that day by the favourite

2nd favourite won: proportion of UK races won that day by the second-favourite

Morning dog races: that day's number of UK dog races at meetings with a morning start

Afternoon dog races: that day's number of UK dog races at meetings with an afternoon start

Total dog races: sum of *Morning dog races* and *Afternoon dog races*

Winning dog favourite: proportion of dog races won that day by the favourite

Bank holiday football: dummy for a public holiday with a full English football programme

Bank holiday Scottish football: dummy for day of a public holiday in Scotland only, with full Scottish football programme

England in tournament match: dummy for a day during the World Cup or European Championship when the England football team is playing

World Cup Final: dummy for day of the World Cup Final

England v Scotland (Euro 1996): dummy for day when England played Scotland in the European Championship 1996 football tournament

England v Scotland (World Cup qualifier): dummy for two days when England played Scotland in the World Cup qualifying competition

Scotland in Euro 1996: dummy for days when Scotland played in the 1996 European Championship

FA Cup Final: dummy for day of the FA Cup Final (normally a Saturday in May)

European club match: dummy for a day when a British club is playing in a European competition (not the Final, normally Tuesday, Wednesday or Thursday)

Wimbledon mens final: dummy for Final of Wimbledon tennis tournament (on a weekend in July)

Rugby League Cup Final: dummy for the day of the Rugby League Cup Final

The following variables were initially included in a general specification but dropped as their coefficients were not significant at 10 percent in any turnover sector equation:

FA Cup round: dummy for a day when a round of the FA Cup (other than the final) is played

Football games: total number of Premier League and Division One football games in England that day

England club final: dummy for a day when an English club appeared in a European cup final

Rugby Union: dummy for a day when England played in rugby union's international tournament

Open golf: dummy for the period of the British Open Golf Championship