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Trading as Gambling

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This paper offers evidence from three different samples consistent with investors substituting between playing the lottery and gambling in financial markets. In the United States, increases in the jackpots of the multistate lotteries Powerball and Mega Millions are associated with significant reductions in small trade participation in the stock market. California-based discount brokerage clients and German discount brokerage clients are significantly less likely to trade during weeks with larger lottery prizes in the California and German lotteries, respectively. Variation in lottery prizes affects speculative trading in more lottery-like securities such as individual stocks and options, but not trading in bonds and mutual funds. Trading that is likely associated with long-term savings motives, such as trading in retirement accounts, does not respond to lottery jackpots, either. The negative relation between trading activity and jackpots is stronger for individuals who are more likely to play the lottery.

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1. Introduction

This paper explores whether a desire to gamble can explain trading by individual investors. Trading—like betting in more conventional gambling venues such as the lottery—offers thrills that may appeal to sensation seekers. In addition, placing bets in financial markets can generate skewed payoffs, which gamblers may find attractive. Skewness preferences and sensation seeking have been used to explain lottery participation and exploited in advertising by retail brokers (see Barber and Odean 2002). Pavalko (2001), Statman (2002), and Shiller (2005) liken trading to gambling in general, and playing the lottery in particular. Grinblatt and Keloharju (2009) argue that sensation or thrill seeking, a stable psychological attribute suggested by Zuckerman (1994), underlies both the propensity to gamble and the propensity to trade in financial markets.

It is challenging, however, to empirically identify gambling-motivated trading. This paper's identification strategy is based on the premise that if trading is a form of gambling, then it vies with other forms of gambling for gamblers' attention, dreams, and dollars. Thus, there should be an observable substitution effect between trading and more overt types of gambling such as playing the lottery. Specifically, this paper conjectures that large lottery jackpots will depress the trading activity of individual investors, because large jackpots will entice at least some investors to meet their gambling needs by playing the lottery, leaving these investors with no need to place bets in financial markets during the same period.

This paper uses three different samples to examine the relation between lottery jackpots and trading in financial markets. The first data set relates small trade participation in the U.S. stock market between 1998 and 2004—which can be calculated using the Trade and Quote (TAQ) database—to jackpots in the widely played U.S. multistate lotteries Powerball and Mega Millions. The second sample relates trading activity of California-based retail brokerage clients in the widely used data set introduced by Barber and Odean (2000) to jackpots in the California Super Lotto between 1992 and 1996. The third sample examines the sensitivity of trading among German retail brokerage clients between 1995 and 2000 to jackpots in the national German lottery; the sample is based on the same data set used by Dorn and Sengmueller (2009).

In all three samples, variation in lottery prizes explains variation in retail trading activity. Lottery prizes are significantly negatively related to trading activity, controlling for known determinants of trading such as past returns and day-of-the-week effects. A one-standard-deviation increase in the logarithm of the combined Powerball and Mega Millions jackpot is associated with a statistically significant 0.6% drop in

U.S. small trade participation, defined as the daily fraction of trading volume stemming from trades valued at \$5,000 or less, averaged across TAQ stocks. In the two brokerage samples, where trades can be unambiguously identified as retail trades, a one-standard-deviation increase in jackpots is associated with a statistically significant 1%–2% drop in trading activity of individual stocks and options. These effects are quantitatively similar to those associated with a one-standard-deviation increase in one-week-lagged market returns.

Each data set allows for the substitution hypothesis to be refined in ways suggesting that the results are not merely spurious. For example, U.S. small trade participation is significantly negatively related to the sum of Powerball and Mega Millions jackpots, the Powerball jackpot by itself, and the Mega Millions jackpot by itself—even though Powerball and Mega Millions jackpots are essentially uncorrelated.

In the U.S. and German discount brokerage samples, the substitution hypothesis can be sharpened using investor- and trade-level attributes. For example, variation in German lottery jackpots should affect the trading activity of German clients but not the trading activity of clients residing abroad. Similarly, California lotto jackpots should affect the trading of Californian clients but not the trading of clients residing in other states. The data are consistent with these conjectures.

One would expect the substitution effect to be stronger for trading in more lottery-like securities, for trading that is more likely motivated by gambling, and for the trading activity of individuals who are more likely to participate in the lottery. The data are consistent with these conjectures as well. In the U.S. broker sample, lottery jackpots are significantly negatively related to the trading of individual stocks and options in taxable accounts but not to trades in retirement accounts or mutual funds. In the German broker sample, where all accounts are taxable, lottery jackpots affect the trading of individual stocks and options but not the trading of bonds and mutual funds. German brokerage trading activity that can be deemed speculative because it involves a quick succession of buying and selling individual stocks and options appears to be particularly sensitive to German jackpots; in contrast, jackpots have no effect on pure selling activity or trading in automatic savings plans (in which clients save in stocks and mutual funds at regular intervals). Moreover, in a subset of the German broker sample consisting of clients who complete a survey that elicits detailed demographic and socioeconomic attributes as well as investing attitudes, the trading behavior of male and less educated investors is more sensitive to jackpots; Albers and Hübl (1997) report that gender and education are the primary personal attributes driving participation in the national German lottery.

A comparison of the economic magnitude of the jackpot effects across the different samples appears reasonable as well. The smallest effect is observed for the aggregate U.S. sample. The effect is larger in the discount brokerage samples, which is consistent with discount brokerage clients being more likely motivated by gambling than the average investor. The effect is largest in the subsample of German discount brokerage clients who select into the survey, which compensates respondents with the equivalent of a lottery ticket for a \$3,000 cash prize.

In a related paper, Gao and Lin (2012) apply a similar research design, first suggested by Dorn et al. (2007), to detect a negative relation between retail stock trading and lottery jackpots in Taiwan, where retail investors account for the lion's share of aggregate trading activity. Consistent with a substitution across gambling venues, Barber et al. (2009b) report that turnover on the Taiwan Stock Exchange was lower after the introduction of the government-sponsored lottery in 2002, controlling for past turnover and contemporaneous trading activity on the Hong Kong and Singapore stock exchanges. Compared with these two papers, our paper develops sharper tests of the substitution hypothesis by using individual- and trade-level attributes to ex ante classify different types of trades and traders as more or less susceptible to substitution. These tests help address concerns that the documented negative relation between lottery jackpots and trading activity is spurious or due to an omitted variable that affects both lotteries and trading.

Two other related papers are those by Kumar (2009) and Dorn and Sengmueller (2009). Kumar (2009) reports that clients in the same U.S. discount broker sample examined in this paper invest disproportionately in "lottery-type" stocks—that is, stocks with lower prices and stocks whose returns exhibit high idiosyncratic volatility and skewness. He also reports that investor characteristics that are associated with greater lottery participation are associated with greater investment in lottery-type stocks. Kumar focuses on portfolio holdings and their determinants, whereas this paper examines the role of gambling motives in trading. We adopt Kumar's definition of lottery-type stocks and document that U.S. small trade participation in such stocks appears to be particularly sensitive to variation in U.S. lottery jackpots. We fail to detect a statistically significant relation between California jackpots and the lottery stock trading of California-based clients in the U.S. broker sample. This failure, however, is likely due to a lack of statistical power since there are very few California-based lottery stock traders on any given day in the sample.

Using the same German discount broker sample examined in this paper, Dorn and Sengmueller (2009) examine the relative importance of different motives for trading. Based on a combination of survey and trading data, they find that entertainment and gambling motives can explain substantial variation in trading activity across individuals. Our paper complements theirs in that we use an objective variable—lottery jackpots—coupled with the substitution hypothesis to infer gambling-motivated trading.

2. Hypothesis Development

This paper's central hypothesis is that at least some individuals substitute between gambling inside and outside the stock market, specifically between playing the lottery and gambling in the stock market.

The payoffs available from playing the lottery and the stock market are clearly quite different, as is the capital required to participate. Despite these differences between lotteries and the stock market, both playing the lottery and trading stocks or options can generate similar thrills or dreams of imagining what a handsome payoff will buy. In fact, the advertisements of brokerage firms such as this one quoted by Barber and Odean (2002) suggest that brokers are betting their advertising dollars on this similarity: "And then there is Discover Brokerage's online trading tow-truck driver. He picks up a snobbish executive who spots a postcard on the dashboard and asks 'Vacation?' 'That's my home,' says the driver. 'Looks more like an island,' says the executive. 'Technically, it's a country,' replies the driver" (p. 455).

Although gambling in the stock market requires much more up-front capital than playing the lottery, stock market investors may be able to sell existing positions or use cash in their brokerage accounts to fund their bets. Hence, trading commissions may be the relevant cost to gambling in the stock market. Trading commissions at discount brokers are of the same order of magnitude as the cost of buying a few lottery tickets.

Adopting Zuckerman's 1994 definition of sensation seeking as a quest for "novel, intense, and varied experiences" associated with "physical, social, and financial risks," Grinblatt and Keloharju (2009, p. 550) argue that trading is an instance of sensation seeking in the financial domain and that sensation-seeking tendencies are stable across different domains. Frequently changing the makeup of one's financial portfolio provides the desired novelty and variety of experiences. The desires for novelty and variety are important ingredients in explaining trading, since one might think that gambling motivated investors could also be content with just buying risky positions and holding out for a big win. Consistent with their conjecture, Grinblatt and Keloharju report that an investor's number of speeding tickets—a proxy for sensation seeking in a nonfinancial domain—is positively correlated with the investor's propensity to trade in a large sample of Finnish individual investors.

This paper argues that lottery playing and stock market trading offer similar thrills for sensation seekers. Moreover, they both offer excuses to dream about handsome payoffs. This paper goes one step further and conjectures that at least some individuals will substitute between gambling across the two venues—that is, decide where to get their thrills or material for their dreams as a function of lottery jackpots.

There are several explanations for such a substitution. First, occasional substitution between playing the stock market and playing the lottery may satisfy the sensation seeker's quest for novelty and variety. Stand-alone bets may offer a more intense experience as opposed to diversifying contemporaneous bets across gambling venues, which may have the effect of diluting the experience. Grinblatt and Keloharju (2009) point out that sensation seekers appear to be particularly drawn to sequentially placing a series of smaller and distinct bets.

Moreover, large jackpots likely capture the attention of gamblers not only because of their magnitude but also because they receive widespread media coverage and are aggressively advertised (see, e.g., Clotfelter and Cook 1989). Large jackpots thus offer both a particularly intense experience to the sensation seeker and an especially salient and attractive excuse to dream about being wealthy. Conversely, one can also imagine scenarios in which stock market gambles appear relatively more attractive. For example, it is no coincidence that Discover Brokerage's tow-truck driver first took the stage during the dot-com era and its stock market millionaire stories of the late 1990s.

The perceived benefits of gambles clearly need not be proportional to their number or size. For example, even the purchase of one lottery ticket entitles its holder to a dream about being wealthy, however remote the possibility. Both playing the lottery and playing the stock market are costly, however, and the costs add up as a function of the number and size of the gambles. Since households have a limited budget in terms of both attention and dollars, we might expect them to allocate their resources as a function of the perceived attractiveness of the gambling venues.

Focusing on the lottery as a form of gambling outside the stock market, and lottery jackpots in particular, has a number of advantages. Contrary to other forms of gambling, lotteries are widely available and frequently played. Shiller (2005) points out the similarity between participation in a lottery and participation in the stock market: "one deals with a computer, one receives a certificate (the lottery ticket), and, in case of the so-called mega-lottos, one participates in a much-talked-about national phenomenon" (p. 54). There is no reason to think ex ante that jackpots are correlated with known determinants of trading activity, such as past returns. Lottery *sales* may reflect seasonal and other patterns in lotto playing that may be spuriously related to stock market trading. But lottery *jackpots* are generated randomly; every period that the lottery goes unwon, the pot is rolled over into the pot of the following week. Particularly large jackpots arise by chance when there is a particularly long string of unwon lotteries. Indeed, if there were strong economic factors underlying large jackpots, one would expect, say, Mega Millions and Powerball jackpots to be highly correlated with one another; in fact, their correlation is only 0.05.

Any relation between trading in financial markets and lottery jackpots might still be due to spurious correlation or a factor that affects both variables. A straightforward example for a positive correlation between lottery sales and trading activity would be the correlated receipt of paychecks at the beginning of the new month; this could explain why some people trade and other people, possibly including some of those who trade, gamble at the beginning of a month. Because of secular growth trends in lotteries and trading activity, one might suspect a spurious positive relation between jackpots and trading activity. It is difficult, however, to come up with a plausible story that explains away a negative high-frequency correlation between jackpot size and trading activity.

Fortunately, the substitution hypothesis can be refined in ways that offer additional robustness checks.

2.1. The Substitution Effect Should Be Observed in Different Samples

If the negative relation between individual trading activity and lottery jackpots were merely spurious, one would not expect to find it in different markets or across different samples. This paper considers three such samples: (1) the relation between aggregate small trade participation in U.S.-listed stocks, derived from the TAQ database, and lottery jackpots in the U.S. multistate lotteries Powerball and Mega Millions; (2) the relation between trading activity in a sample of California-based discount brokerage clients (a subset of the data set introduced by Barber and Odean 2000) and jackpots in the California lottery; and (3) the relation between trading activity in a sample of German discount brokerage clients (the data set used by Dorn and Sengmueller 2009) and jackpots in the German national lottery. The retail participation proxy derived from the TAQ database captures the broad market but relies on the assumption that variation in small trades is driven by retail investors as opposed to institutions breaking up their orders. In the other two samples, trading activity can be unambiguously classified as coming from retail investors.

2.2. The Substitution Effect Should Be Observed for Different Lotteries

The existence of two large multistate lotteries in the United States offers a natural robustness check. As of the end of 1996, Powerball was available in 21 U.S. states with an aggregate population of 61.4 million; by 2004, the Powerball population had grown to 91 million. Mega Millions was started in 1996 by six U.S. states with an aggregate population of 51 million; by 2004, the Mega Millions population had grown to 119 million. During the baseline sample period from 1998 onward, Powerball and Mega Millions are governed by similar rules, cover populations of roughly similar size, and generate jackpots of similar average size that are essentially uncorrelated with each other. One would thus expect similar trading effects from the two games separately. Coming up with a plausible story that explains away a negative correlation between jackpot size and trading activity is even more difficult when the story must explain why Mega Millions and Powerball jackpots should separately be correlated with trading activity but not with each other.

2.3. The Substitution Effect Should Be Observed Primarily in Small Trades

One would expect lottery jackpots to affect trading activity differentially across trade sizes in TAQ. Jackpots should have a greater influence on small trades than on large trades because small trades are more likely to be submitted by gambling-driven retail investors.

We define small trades in TAQ as those for $5,000. Earlier empirical studies in market microstructure typically assume that orders below $10,000 or below 500 shares are made by individuals (e.g., Lee 1992, Battalio and Mendenhall 2005). This convention is examined by Lee and Radhakrishna (2000), who study a data set of trades in New York Stock Exchange (NYSE) firms in 1990–1991 for which both trade size and trader type (individual versus institutional) were available. The authors report that classifications based on dollar cutoffs perform better than number of share cutoffs. According to their study, only 10% of the orders below $5,000 are from institutions; this fraction doubles for orders below $10,000. In our individual-level trade data set from a German retail broker, the median and mean sizes of a discount trade are roughly $2,500 and $5,000, respectively. Based on transaction records of clients at a U.S. discount broker between 1991 and 1996 and of clients at a U.S. retail broker between 1997 and 1999, Barber et al. (2009a) report that the median (mean) size of a discount trade is $5,000 ($11,000) and that of a retail brokerage trade is $7,000 ($15,000).

We choose a dollar cutoff of $5,000, which in 1991 dollars is lower than the lowest dollar cutoff of $5,000 analyzed in Lee and Radhakrishna (2000) as well as the median and average value of retail trades in the samples studied by Barber et al. (2009a). Because the minimum trade size reported in TAQ is 100 shares, choosing a cutoff smaller than $5,000 would reduce the sample of stocks substantially. Reductions in trading costs over time have led institutions to submit increasingly smaller orders (see Choe and Hansch 2005); we use monthly time dummies in the regressions to control for this issue. Chordia et al. (2011) report that trades of less than $10,000 accounted for approximately 5% of the aggregate trading volume between 1993 and 2001. That percentage increased to and hovered around 10% until the end of 2004. Between 2005 and 2008, the percentage of trading volume due to trades of less than $10,000 jumped to over 60%. Because of these volume patterns as well as TAQ data availability, we examine the 1998–2004 and 2005–2008 periods separately.

2.4. The Substitution Effect Should Be Stronger in the Trading of Individuals Who Are More Likely to Play the Lottery

A simple check of this conjecture can be based on the investor's location. In the German data set, for example, we can distinguish between domestic and foreign investors. Since the German lottery cannot be played abroad or online, one would expect the trading activity of foreign-based investors to be unaffected by German lottery jackpots. Similarly, in the sample of U.S. discount brokerage clients, we can distinguish between California-based clients and clients located elsewhere. California lottery jackpots should primarily affect the trading of clients with California addresses.

Another check can be based on investor characteristics associated with lottery participation. Although a substantial fraction of the population regularly plays the lottery (one-third of the German adult population according to the German national lottery), clearly not all individual investors do. Only investors who gamble outside the stock market are susceptible to trading off bets inside and outside the stock market. For a subsample of clients who responded to a survey, we observe investor attributes that have been linked to lottery participation in the aggregate population—e.g., gender, age, income, and education (see Scott and Garen 1994, Albers and Hübl 1997, Farrell and Walker 1999). To encourage survey participation, the broker essentially compensated respondents with a lottery ticket by enrolling them in a raffle for a $3,000 cash prize. One might thus expect survey participation to be more appealing to lottery players and the trading of the survey subsample to be particularly sensitive to jackpots.

2.5. The Substitution Effect Should Be Stronger in Trading Activity Unrelated to Savings or Liquidity Needs

People are presumably less likely to gamble with money that has been earmarked for retirement. The U.S. discount brokerage data allows us to distinguish between trades in taxable accounts and trades in retirement accounts. Although all German brokerage accounts in the sample are taxable accounts, the records indicate whether trades are made as part of an automated investment plan. One would not expect such trading activity to be affected by lottery jackpots, both because it is unlikely motivated by gambling and because the corresponding trades are executed at preset dates every month.

In contrast, one might expect speculative trading, that is, exchanging one risky asset for another, to be particularly sensitive to jackpots. Given the different payoff patterns of lottery tickets and financial investments, it is unlikely that investors substitute dollar for dollar between buying lottery tickets and, say, buying a stock or option. Rather, they might choose between placing a new bet in the stock market using existing capital (by selling another stock, for example) or playing the lottery. Presumably, sensation seekers who desire novelty and variety in their financial bets are more prone to such trading as well as to participating in gambles outside financial markets. Moreover, speculative bets can be timed in response to the substantial short-term variation of jackpots, unlike bets that rely on new capital, which may require a multiday transfer from another account or may only become available as a function of, e.g., paycheck receipts.

2.6. The Substitution Effect Should Be Stronger in More Lottery-like Securities

One would expect lottery jackpots to affect trading activity differentially across securities to the extent that some securities are more lottery-like and might thus attract the attention of gambling-motivated individuals.

To refine our basic hypothesis that small trade participation decreases in lottery jackpots, we follow Kumar (2009), who classifies stocks into lottery stocks and nonlottery stocks using three stock price/return characteristics: idiosyncratic volatility, idiosyncratic skewness, and price. Presumably, trading in stocks with highly volatile and positively skewed returns and low prices should be particularly sensitive to outside gambling opportunities.

The U.S. and German brokerage data offer additional refinements since one can observe trading in securities other than individual stocks—e.g., mutual funds and options. Of these securities, options resemble lotteries most closely, and one might thus expect retail trading of options to be particularly sensitive to jackpots. In contrast, mutual fund trading presumably fails to produce the experience sought by gambling-motivated investors. Another brokerage commercial cited by Barber and Odean (2002) vividly illustrates this failing: "In Ameritrade's 'Momma's Gotta Trade,' two suburban moms return from jogging. Straight to her computer, a few clicks and a sale later, one declares, 'I think I just made about $1,700!' Her kids cheer while her friend laments, 'I have mutual funds' " (p. 455).

The popularity of certain investments bundled with lottery features, such as lottery-linked deposit accounts (Guillen and Tschloegl 2002) and lottery bonds (see, e.g., Green and Rydqvist 1997), also supports the conjecture that safe investments and lottery tickets are unlikely to be substitutes. If anything, the potential of the lottery ticket may *complement* the security offered by the safe asset for investors who desire both downside protection and a chance to get rich.

3. Data

Table 1 presents summary statistics on the main trading and lottery variables for the aggregate U.S. sample, the U.S. discount broker sample, and the German discount broker sample. For the aggregate U.S. sample, retail trading activity is proxied by the fraction of trading volume contributed by trades valued at $5,000 or less in a given stock on a given day, averaged across all sample stocks for a given day. The data are drawn from the TAQ database, which contains intraday trades for all securities listed on the NYSE, American Stock Exchange, and NASDAQ National Market System. Sample stocks are all stocks in TAQ that have a match in the Center for Research in Security Prices (CRSP) database based on the ticker–date combination and at least one month of daily CRSP return data. The sample period is January 1998 to December 2004; the period January 2005 to December 2008 is considered separately because small trade participation jumps during this period, as noted in the previous section. Small trade participation averages 35% of total dollar trading volume across the sample period; the cross-sectional average increases from about 20% in January 1998 to 40% in December 2004 and 66% in December 2008.

The U.S. discount broker sample is the well-known sample introduced by Barber and Odean (2000). For reasons outlined in §5 below, this paper focuses on a subset of this sample—namely, the trading activity of California-based clients. The main trading variable is the number of California-based individual clients (as opposed to trust or corporate clients) who trade individual stocks or options in a taxable account on a given day, divided by the total number of California-based individuals. The shorter sample period (July 1992–November 1996) reflects the availability of California lottery data. The frequency with which clients trade individual stocks and options averages about 2% per day; it increases over time, especially toward the end of the sample period.

The German discount broker sample is based on the same data set examined by Dorn and Sengmueller (2009) and described there in detail; the sample period is January 1995 to May 2000. The main trading variable is the number of clients who trade individual stocks or options during a given week, divided by the total

Table 1 Trading Activity and Lottery Jackpots—Summary Statistics

Panel A: Main trading variables	U.S. aggregate	U.S. discount broker	German discount broker
Mean (%)	35	2	12
Median (%)	37	2	12
Std. dev. (%)	8	1	4
Regression on own lags			
Constant	0.00*	0.00***	0.01**
y_{t-1}	0.46***	0.53***	0.71***
y_{t-2}	0.15***	0.09***	0.00
y_{t-3}	0.12***	0.05	0.04
y_{t-4}	0.07***	0.06*	0.08
y_{t-5}	0.16***	0.06	0.06
y_{t-6}	−0.07**	0.07**	−0.10
y_{t-7}	−0.02	−0.04	0.03
y_{t-8}	0.00	0.09**	0.16**
y_{t-9}	0.03	0.01	0.03
y_{t-10}	0.09***	0.05*	−0.10
No. of obs.	1,750	1,120	272
R^2 (%)	98	78	73

Panel B: Main lottery variables	U.S. multistate	California	Germany
Mean [USD and DEM million]	41	10	7
Median [USD and DEM million]	28	8	5
Std. dev.	39	9	5
Regression on own lags (logs)			
Constant	0.54***	0.81***	5.53***
y_{t-1}	0.92***	0.80***	0.39***
y_{t-2}	−0.04	−0.18***	0.01
y_{t-3}	−0.01	−0.04	0.02
y_{t-4}	0.01	0.11***	0.10
y_{t-5}	−0.03	−0.18***	0.08
y_{t-6}	0.04	0.12***	−0.07
y_{t-7}	−0.03	−0.03	0.10
y_{t-8}	0.00	0.00	0.11
y_{t-9}	0.01	0.03	−0.04
y_{t-10}	−0.01	−0.03	−0.05
No. of obs.	1,750	1,110	272
R^2 (%)	77	48	24

Notes. Panel A presents summary statistics as well as autoregression OLS estimates for the main trading activity variables used in this paper. The main trading variable in the U.S. aggregate sample is the fraction of trading volume contributed by trades valued at $5,000 or less in a given stock on a given day, averaged across all sample stocks for a given day. Sample stocks are all stocks in the TAQ database that have a CRSP match based on the ticker–date combination and at least one month of daily CRSP return data; the sample period is January 1998 to December 2004. The main trading variable in the U.S. discount broker sample (a subset of the sample introduced by Barber and Odean 2000) is the number of California-based clients who trade individual stocks or options in a taxable account on a given day, divided by the total number of California-based clients; the sample period is July 1992 to November 1996. The main trading variable in the German discount broker sample (the same data set used in Dorn and Sengmueller 2009) is the number of clients who trade individual stocks or options during a given week, divided by the total number of clients that week; the sample period is January 1995 to May 2000. Panel B presents summary statistics as well as autoregression OLS estimates for the main lottery variables used in this paper and for the same sample periods as the corresponding trading variables. The main lottery variable for the U.S. aggregate sample is the (log of the) sum of advertised Powerball and Mega Millions jackpots on a given day. The main lottery variable for the U.S. discount broker sample is the (log) jackpot of the California Super Lotto. The main lottery variable for the German discount broker sample is the (log) jackpot associated with the main drawing of the national German lottery.

*Significantly different from zero at the 10% level; **significantly different from zero at the 5% level; ***significantly different from zero at the 1% level.

number of clients that week. The cross-sectional average of weekly participation in individual stocks and options averages 12% over time.

Panel A of Table 1 shows that trading activity is serially correlated in all three samples, with autoregression coefficients generally significant up to lags of about one week; aggregate U.S. small trade participation appears to be especially persistent.

This paper's main explanatory variables of interest are lottery jackpots—combined Powerball and Mega Millions jackpots for the aggregate U.S. sample, California Super Lotto jackpots for the U.S. discount broker sample, and German national lottery jackpots for the German discount broker sample.

We obtained a daily history of jackpots from the Powerball game, the larger of the two multistate lottery consortia during most of the sample period from January 1998 to December 2004, and complement this time series with data on advertised jackpots used in Oster (2004). We also obtained a time series of daily advertised jackpots in the Mega Millions game, the second largest multistate lottery. Note that the news media, including newspapers, report the current jackpot the morning following the draw; people can, in principle, condition their trading decision on day t on the advertised jackpot size on day t. On average, jackpots in the Powerball game are slightly larger than those in Mega Millions, but the largest jackpot during the 1998–2004 sample period, $350 million, was a Mega Millions jackpot. Importantly, the time series of Powerball and Mega Millions jackpots are essentially uncorrelated. We obtained advertised jackpots for the California Super Lotto game from July 1992 to November 1996 through a public records act request. California Super Lotto has drawings on Wednesdays and Saturdays. During the sample period, the jackpots range between $3 million and $60 million. Similarly, jackpot data were obtained for the German government-run lottery, the so-called lotto pool, a lottery consortium formed by the 16 German states (see Albers and Hübl 1997). The drawing is televised every Saturday night on public television during prime time. The top prize, awarded to the participant or the participants who guess all six numbers correctly, represents 3% of the total wager for the week (up from 2% before October 4, 1997). If nobody guesses all the numbers correctly, the money allotted to the top prize increases the top prize for the following week. In the parlance of the German lottery, a jackpot only exists if the top prize was not won the previous week. During the sample period January 1995 to May 2000, German lottery prizes average about $4 million per week, which is substantially lower than those in the two multistate U.S. lotteries. Nonetheless, German lottery sales are responsive to the existence of a jackpot; during jackpot weeks, the amount wagered is 5% higher, on average, than during nonjackpot weeks.

Lottery jackpots are also autocorrelated, as the autoregression estimates in panel B of Table 1 show. In part, the serial correlation is mechanical since the regressions are estimated with daily data, but Powerball, Mega Millions, and California lottery jackpots do not change every day. German jackpots are less persistent since the jackpot drawing frequency coincides with the weekly observation interval.

4. Lottery Jackpots and Small Trade Participation in the United States

4.1. Baseline Results

The basic idea is to regress a daily measure of small trade participation on the combined size of the Powerball and Mega Millions jackpots and a kitchen sink of control variables for the period 1998–2004. There are four weekly drawings—Wednesdays and Saturdays for Powerball, and Tuesdays and Fridays for Mega Millions—which means that the available combined lottery jackpot changes every trading day except on a Tuesday, when it is the same as the preceding Monday. We compute an aggregate measure of small trade participation as follows. For each stock-day, we take the aggregate number of shares traded in orders of less than $5,000 as a fraction of the total number of shares traded that stock-day. The average such fraction across all stocks on a given day is a measure of small trade participation that day.

We divide the trading volume due to small trades by the total trading volume to control for volume effects unrelated to our hypotheses—e.g., differences in volume as a result of earnings announcements, analyst recommendations, or other news variation. Of course, it is still possible that news releases have differential effects on individual and institutional investors; however, it is unclear why such residual effects should be systematically related to lottery jackpots. Theoretically, it is also possible that a negative relation between small trade participation and lottery jackpots is driven by large trades; i.e., for some reason, larger trade activity is positively correlated with jackpots—an economic explanation for such a correlation is hard to come by, however.

As control variables, we consider monthly time dummies, before- and after-holiday dummies, the one-day lagged median relative stock price range, lagged equally weighted CRSP market returns, day-of-the-week dummies (omitting Monday), and the fraction of stocks with nominal prices above $50.

Regulatory actions during our sample period—e.g., the introduction of order-handling rules on NASDAQ and the reduction in minimum tick sizes—have made it less costly for large investors to submit smaller orders, which induces a strong upward time trend in small trader participation (see, e.g., Choe and Hansch 2005). To capture this possibly nonlinear trend, we include monthly time dummies. This is a conservative specification because the time dummies absorb all intermonth variation in small trade participation.

The inclusion of the before- and after-holiday as well as the day-of-the-week dummies reflects that, in principle, trading is a time-consuming activity. Although orders are only one phone call or click away from submission, it may take time to identify stocks to buy and, perhaps to a lesser degree, to sell (see Barber and Odean 2008). Presumably, individual investors find more time during a holiday or weekend to research their trading decisions. One would thus expect more small trade participation immediately before market holidays (because some individual investors take off early) or after holidays. Similarly, one would expect higher small trade participation immediately before and after the weekend.

Given reports that institutional investors react more strongly than individual investors when absolute returns are large on a given day (see Dennis and Strickland 2002), we include the one-day lagged median price spread, where a stock's price spread is the difference between the maximum and the minimum price divided by the price midpoint, as a regressor. One would expect small trade participation to decrease in the spread. Finally, we include lagged equally weighted CRSP market returns and the fraction of stocks with a nominal price above $50 on a given day as control variables. Since the definitions of small trades are dollar based, and since the smallest observed trade size is 100 shares, small trade participation in a given stock mechanically drops to zero as the price of that stock moves above $50.

Column (1) of Table 2 reports the results of an ordinary least squares (OLS) regression of small trade participation, defined as the mean fraction of total trading volume from trades of less than or equal to $5,000, on the logarithm of the sum of the jackpots in the Powerball and Mega Millions games as well as the control variables. Other things equal, a one-standard-deviation increase in log jackpot size, roughly corresponding to a doubling of the jackpot, is associated with a statistically significant 0.6% drop in small trade participation relative to its average level (the absolute drop is about 0.2%). Most of the other coefficients have the expected signs. Consistent with Dennis and Strickland (2002), the price range is significantly negatively related to small trade participation (coefficient not reported). Small trade participation is higher immediately before and after holidays or weekends. Not surprisingly, the holiday and day-of-the-week effects are substantial; e.g., other things equal, small trade participation increases roughly 3% on the first trading day following a holiday.

The excellent fit of the model is mostly due to the inclusion of time effects. The monthly time dummies alone account for about 98% of the variation in small trade participation. Other time trend specifications, such as a linear trend (which explains 77% of variation in small trade participation), or a combination of annual time dummies with linear intrayear trends (which explains 95% of variation in small trade participation), or higher-order polynomials in time, do not materially affect the association between trading activity and jackpots and are thus not reported. It is useful to put the magnitude of the jackpot effects in the context of these time effects. Across the entire sample period, the standard deviation of small trade participation is more than 8%; the average standard deviation within a month, however, is only 1%. The 0.2-percentage-point absolute decrease in small trade participation associated with a one-standard-deviation increase in jackpots thus appears meaningful.

The Durbin–Watson statistic for the regression is 1.6, suggesting that the residuals are serially correlated. To address this issue, we estimate Newey–West standard errors, allowing for serial correlation of up to five lags; the number of lags chosen reflects the autocorrelation structure of small trade participation as depicted in Table 1. Column (2) of Table 2 presents the results of this specification. The jackpot coefficient's standard error increases slightly, but the coefficient remains highly significant. In unreported robustness checks, we consider Newey–West standard errors allowing for serial correlation of up to 22 lags (the number of trading days in a month) and find that our inference does not depend on a particular choice of lags.[1]

To examine whether the negative association between small trade participation and jackpots is somehow an artifact of the growing popularity of multistate lotteries, we detrend the log jackpot series as follows. We estimate linear regressions of the logarithm of the combined Powerball and Mega Millions jackpots on a constant and a linear time trend separately during four time periods that reflect substantial game changes such as entry of large states and an increase in the

[1] In unreported results, we also consider a Prais–Winsten specification and a specification with lagged dependent variables. The jackpot coefficient is negative and significant in both cases. When including lagged dependent variables, however, the magnitude of the jackpot effect is reduced. This reduction can be explained by the joint presence of serial correlation and a highly correlated regressor (the correlation between the jackpot and its one-day-lagged value is close to 90%). Achen (2001) shows that such a combination can lead to underestimating the effect of the regressor. Consistent with this interpretation, we find that including lagged dependent variables in the German sample, where the jackpot time-series correlation is much lower, does not materially affect the results.

Table 2 Linear Regressions of U.S. Small Trade Participation on U.S. Multistate Lottery Jackpots

	Small trade participation								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Stocks:	All	All	All	All	Lotto	No lotto	All	All	All
Small trade:	USD 5k	USD 5k	USD 5k	USD 5k	USD 5k	USD 5k	USD 5k	500 shares	USD 5k
Estimation:	OLS	NW	NW	NW	NW	NW	NW	NW	NW
Constant	25.54***	25.54***	3.70	24.90***	53.61***	2.63***	25.44***	26.43***	39.28***
	(0.36)	(0.41)	(10.16)	(0.37)	(1.22)	(0.31)	(0.40)	(0.44)	(2.50)
ln(*JP*)	−0.19***	−0.19***			−0.57***	−0.13**		−0.11	0.12
	(0.05)	(0.06)			(0.18)	(0.05)		(0.07)	(0.13)
ln(*JP*) *detrend*			−0.19***						
			(0.06)						
ln(*JP*) *trend*			5.78**						
			(2.79)						
JP q2				0.04					
				(0.08)					
JP q3				−0.18*					
				(0.10)					
JP q4				−0.23**					
				(0.12)					
Top 5% JP				−0.15					
				(0.15)					
ln(*PB JP*)							−0.13**		
							(0.05)		
ln(*MM JP*)							−0.08*		
							(0.04)		
Before holiday	0.60***	0.60***	0.60***	0.60***	1.11**	0.44***	0.59***	0.77***	0.13
	(0.14)	(0.14)	(0.14)	(0.14)	(0.53)	(0.11)	(0.14)	(0.17)	(0.48)
After holiday	1.07***	1.07***	1.07***	1.07***	1.68***	0.48***	1.07***	1.43***	0.69**
	(0.17)	(0.17)	(0.17)	(0.17)	(0.49)	(0.11)	(0.17)	(0.21)	(0.32)
Tuesday	−0.76***	−0.76***	−0.76***	−0.76***	−1.12***	−0.28***	−0.76***	−1.08***	−0.41***
	(0.07)	(0.06)	(0.06)	(0.06)	(0.22)	(0.05)	(0.06)	(0.06)	(0.10)
Wednesday	−0.80***	−0.80***	−0.80***	−0.80***	−1.29***	−0.45***	−0.80***	−1.08***	−0.48***
	(0.07)	(0.07)	(0.07)	(0.07)	(0.25)	(0.05)	(0.07)	(0.07)	(0.10)
Thursday	−0.73***	−0.73***	−0.73***	−0.73***	−1.28***	−0.40***	−0.72***	−1.07***	−0.39***
	(0.07)	(0.06)	(0.06)	(0.07)	(0.24)	(0.06)	(0.06)	(0.07)	(0.12)
Friday	−0.64***	−0.64***	−0.64***	−0.64***	−0.98***	−0.32***	−0.63***	−0.96***	−1.20***
	(0.08)	(0.08)	(0.08)	(0.08)	(0.26)	(0.06)	(0.08)	(0.09)	(0.21)
	Ancillary statistics								
Unreported	Monthly time dummies, 5 lags of market returns, price range, fraction of stocks priced ≥ 50								
No. of obs.	1,755	1,755	1,755	1,755	1,755	1,755	1,755	1,755	1,002
R^2 (%)	99	99	99	99	96	98	99	99	95

Notes. The dependent variable is the mean fraction of dollar trading volume contributed by trades valued at less than or equal to $5,000 (or 500 shares in column (8)). In columns (1)–(4) and (7)–(9), this fraction is calculated across all stocks. In column (5), the fraction is only calculated across lottery stocks as defined by Kumar (2009). Column (6) reports the corresponding estimates for nonlottery stocks. The sample period is January 1998 to December 2004, except in column (9), where it is January 2005 to December 2008. The estimation method is OLS with White standard errors for column (1) and Newey–West (NW) standard errors with five lags for the remaining columns. All coefficient estimates and standard errors are in percentages. *JP* is the sum of the advertised Powerball (*PB*) and Mega Millions (*MM*) jackpots. Detrended jackpots and jackpot trends are obtained as described in the text. The second (q2), third (q3), and fourth quartile (q4) jackpots as well as the top 5% jackpots are based on a size ranking of jackpots during the entire sample period. *Before holiday* is a dummy that is 1 if the day following the current trading day is a market holiday; the *after holiday* dummy is 1 if the day preceding the current trading day is a market holiday. The day-of-the-week dummies are 1 for the corresponding day and 0 otherwise; Monday dummies are omitted. Coefficients for monthly time dummies, five lags of market returns, price range, and the fraction of stocks priced at ≥ 50 are not reported. The price range is the difference between maximum and minimum prices for a given stock and day, divided by the midpoint of these prices, averaged across all stocks that day. Market return is the equally weighted return across all sample stocks in CRSP.

*Significantly different from zero at the 10% level; **significantly different from zero at the 5% level; ***significantly different from zero at the 1% level.

minimum jackpot.[2] When the detrended jackpot variable and the jackpot trend are included as regressors instead of raw jackpots, the coefficient of the detrended variable is basically the same as its raw counterpart, and the coefficient on the trend variable is positive and significant, as reported in column (3) of Table 2.

Column (4) of Table 2 explores an alternative definition of the jackpot variable, allowing for nonlinear jackpot effects by including dummy variables for jackpot quartiles (size relative to the entire sample period) as well as a dummy indicating top 5% jackpots. Consistent with the substitution hypothesis, top quartile jackpots have the largest effect on small trade participation, but the third quartile jackpot dummy is negative and significant as well.[3] Top 5% jackpots are associated with even less trade participation (on top of the top quartile effect), but not significantly so, which may reflect the small number of very large jackpot observations. In a related, unreported, robustness check, we find that excluding the top 5% jackpot observations leaves the jackpot coefficient almost unchanged. This result is noteworthy not just because it indicates robustness to a particular econometric specification. If the results were driven by extremely large jackpots, one might be concerned that the substitution effect is a merely a product of long lines at lottery retailers: extremely large jackpots can create such widespread excitement that merely buying a lottery ticket, which can usually be done quickly, may become a quite time-consuming task. As such, lottery participants might have substantially less time for all other tasks, including trading.

The linear models of small trade participation considered above imply a constant marginal effect of the jackpot variable. Since small trade participation is bounded by 0 and 1, however, marginal effects cannot be constant across the entire range of the independent variables. To examine how sensitive our results are to the assumption of linearity, we estimate a fractional response logit model using quasi-maximum likelihood as suggested by Papke and Wooldridge (1996). In unreported results, we find that the negative association between lottery jackpots and small trade participation is significant in this model as well.

[2] The four periods are January 1998 to mid-May 1999 (when New Jersey entered the Mega Millions game), mid-May 1999 to mid-May 2002 (in May and June 2002, New York and Ohio joined Mega Millions, the minimum Mega Millions jackpot doubled from \$5 million to \$10 million, and Pennsylvania joined Powerball), mid-May 2002 to November 2003 (Texas joined Powerball at the beginning of December 2003), and December 2003 to December 2004 (the end of our sample). As one might expect, the resulting intercepts increase over time, and the linear trend coefficients tend to be positive as well.

[3] In unreported results, we also find a significantly negative association between small trade participation and dollar jackpots.

Since equity trading volume is several orders of magnitude larger than lottery sales, one can ask whether the amounts that flow into lotteries are big enough to explain the estimated coefficients. Any comparison between the increase in lottery sales and the decrease in trading activity associated with a higher jackpot is complicated by the fact that higher jackpots will cause both stock market participants and nonparticipants to play more. However, one can estimate the increase in lottery sales due to substitution as follows. From a participation cost or gambling budget perspective, refraining from trading to play the lottery frees up the trading commissions that would have been spent otherwise. During our sample period, the stock trading volume on a given day aggregated across all stocks is very roughly \$100 billion, on average. Suppose that retail investors account for about one-third of this volume—trades below \$5,000 account for 35% of total dollar volume in a stock, on average (see Table 1), and individual investors held one-third of common stocks in the United States between 1998 and 2004, according to estimates by French (2008)—and that retail investors pay roughly \$300 million in trading commissions on a given day (for a sample of transactions of U.S. discount brokerage clients, Barber and Odean 2000 report that trading commissions average 1.5% of transaction value and that the trade-weighted average commission is 0.7% of transaction value). Our coefficients suggest that a one-standard-deviation increase in the jackpot is associated with a relative decrease in small trade participation in the neighborhood of 1%; this would free up several million dollars in foregone trading commissions for lottery ticket purchases. This appears to be reasonable given actual Powerball sales figures between 1998 and 2000; during that time, ticket sales for a given drawing average \$12 million with a standard deviation of \$17 million (the corresponding numbers for the Mega Millions game should be a bit lower).

4.2. Stronger Results for Lottery Stocks

Although the payoff profiles of lottery tickets differ from those of financial securities, some securities resemble lotteries more than others. In the spirit of Kumar (2009), we conjecture that small trade participation in lottery-type stocks is particularly sensitive to lottery jackpots. For every month t, we classify stocks as lottery-type stocks if they are in the bottom stock price tercile on the last trading day of month $t-1$, in the top idiosyncratic volatility tercile, and in the top idiosyncratic skewness tercile; volatility and skewness are calculated based on daily returns during the previous month. Columns (5) and (6) of Table 2 contrast the sensitivity of small trade participation—defined as the mean fraction of total trading volume from trades of less than \$5,000—to lottery jackpots in lottery-type and non-lottery-type stocks. Consistent with the conjecture, jackpot size appears to have a stronger effect on small trade participation in lottery-type stocks than in non-lottery-type stocks. In unreported results, we verify that the results are robust to the variations of the lottery-stock definition mentioned in Kumar (2009)—for example, computing stock attributes using data for the past three months as opposed to the past one month.[4]

4.3. Small Trades Are Affected by Both Powerball and Mega Millions Jackpots

Given that the time-series correlation of Powerball jackpots and log Mega Millions jackpots is very low (correlation coefficient of 0.05), one can test the robustness of the substitution hypothesis by including the two jackpots as separate regressors. It is hard to imagine that a spurious correlation argument applies separately to the two jackpot series. However, the substitution hypothesis predicts a negative relation between either jackpot series and small trade participation, other things equal. The results reported in column (7) of Table 2 are consistent with this hypothesis. Other things equal, both Powerball and Mega Millions jackpots are significantly negatively correlated with small trade participation.

4.4. Results Are Weaker for Trades Less Likely Due to Retail Investors

To examine the importance of focusing on small trades in dollar terms, we modify the small trade definition to include trades up to 500 shares. Given that nominal share prices typically range between \$25 and \$35, the average size of a small trade will be substantially larger under this alternative definition. Relative to the baseline definition of small trades as those of less than \$5,000, such trades are more likely from institutional investors and less likely motivated by gambling. Hence, one would expect weaker jackpot effects. The corresponding regression results reported in column (8) of Table 2 confirm this conjecture. The association between lottery jackpots and the alternative measures of small trade participation remains negative but loses statistical significance.

Much of the increased use of small trades is concentrated in the 2005–2008 period, as noted by Chordia et al. (2011). Trading volume in trades of less than \$10,000, for example, accounts for roughly 5% of total trading in 1998, hovers around 10% in 2004, and jumps to more than 60% by 2008. Chordia et al. (2011) report that much of the growth in small trade volume has occurred in stocks with the highest institutional ownership and attribute these patterns to order splitting by institutional investors and algorithmic traders. Consistent with this speculation and with institutions being better informed than individuals, O'Hara et al. (2014) report that, by 2008, approximately half of NASDAQ price discovery is accounted for by trades of 100 shares; Choe and Hansch (2005), using a comparable methodology, report that trades of 100 shares account for less than 20% of NASDAQ price discovery between 1996 and 2000. Thus, as individual investors cease to dominate small trades, it appears likely that variation in small trade participation in this later period (even within a month) is increasingly driven by professional investors who are not affected by lottery jackpots. Column (9) of Table 2 shows that there is no longer a significant association between lottery jackpots and small trade participation between 2005 and 2008.

It is interesting to note that the holiday and day-of-the-week dummies lose much of their economic and statistical significance during this more recent period. Lakonishok and Maberly (1990) and others have reported that individual investors are more active at the beginning of the week and around holidays relative to institutional investors. The strong day-of-the-week and holiday effects for small trade participation during the 1998–2004 sample period points to variation in small and large trades being driven by groups of investors with different weekday and holiday trading preferences. The weakening of weekday and holiday effects during 2005–2008 are consistent with institutional investors driving variation not only in large trades (as they have presumably been doing all along) but also in small trades.

5. California Lottery Jackpots and Discount Broker Participation

The documented link between aggregate small trade participation and multistate jackpots is suggestive of retail investors substituting gambles between the lottery and financial markets. Small trades in TAQ cannot be unambiguously classified as retail trades, however.

To address the issue of trade classification and provide additional robustness, this section examines jackpot effects in the discount brokerage data set introduced by Barber and Odean (2000). This data set offers two main advantages over the TAQ data: First, trades can be identified as retail trades. Second, the data set contains trading activity in individual stocks, options, and mutual funds in both retirement and nonretirement accounts. (We exclude accounts that are held on behalf of someone, e.g., trust or corporate accounts. There are relatively few such accounts, and one would not expect trading in them to be motivated by gambling.) This permits sharper tests of the substitution hypothesis: for example, one would expect little, if any, relation between lottery jackpots and retirement account trading or trading in mutual funds. Such trading may be more predominantly motivated by savings or rebalancing

[4] Given the similarities between lotteries and initial public offerings (IPOs)—as noted by Green and Hwang (2012), for example—we prefer a lottery-stock classification based on a short window, which allows recent IPOs to be included in the sample more quickly.

Table 3 Linear Regressions of California Discount Brokerage Trading Participation on California Lottery Jackpots

	Trade participation by CA households					Non-CA households
	(1)	(2)	(3)	(4)	(5)	(6)
Asset class/type of account:		Stocks and options in nonretirement accounts only			Retirement assets plus mutual funds	Stocks and options nonretirement
Estimation method:	OLS	NW	NW	NW	NW	NW
Constant	−1.415***	0.856***	0.837***	0.905***	1.546***	0.877***
	(0.209)	(0.157)	(0.155)	(0.164)	(0.263)	(0.174)
ln(*CA jackpot*)	−0.021**	−0.021*			−0.008	−0.008
	(0.010)	(0.013)			(0.017)	(0.011)
CA jackpot			−0.003**			
			(0.001)			
ln(*PB jackpot*)				−0.004		
				(0.011)		
Shorter trading day	−0.041	−0.041	−0.039	−0.064	0.028	0.015
	(0.087)	(0.106)	(0.106)	(0.109)	(0.222)	(0.100)
CA holiday	0.162**	0.162***	0.162***	0.166***	−0.021	0.073**
	(0.065)	(0.052)	(0.052)	(0.052)	(0.059)	(0.034)
Before holiday	0.075	0.075	0.073	0.067	−0.044	0.119**
	(0.065)	(0.058)	(0.058)	(0.058)	(0.073)	(0.053)
After holiday	0.090**	0.090*	0.092*	0.089*	0.364***	0.108***
	(0.044)	(0.050)	(0.050)	(0.049)	(0.090)	(0.039)
Tuesday dummy	−0.148***	−0.148***	−0.148***	−0.145***	−0.330***	−0.210***
	(0.024)	(0.021)	(0.021)	(0.020)	(0.046)	(0.016)
Wednesday dummy	−0.132***	−0.132***	−0.132***	−0.124***	−0.377***	−0.220***
	(0.023)	(0.021)	(0.021)	(0.021)	(0.043)	(0.018)
Thursday dummy	−0.111***	−0.111***	−0.112***	−0.105***	−0.410***	−0.204***
	(0.024)	(0.021)	(0.021)	(0.021)	(0.044)	(0.017)
Friday dummy	−0.024	−0.024	−0.025	−0.018	−0.381***	−0.123***
	(0.024)	(0.019)	(0.019)	(0.019)	(0.042)	(0.018)
			Ancillary statistics			
No. of obs.	1,120	1,120	1,120	1,120	1,120	1,120
Unreported regressors		Monthly time dummies, contemporaneous market return and 5 daily lags, price range				
R^2 (%)	85	85	85	85	70	88

Notes. The table reports linear regressions of California (CA) and non-CA client trade participation, as observed in the data set introduced by Barber and Odean (2000), on California lottery jackpots, Powerball jackpots, and control variables. In column (1), the standard errors reported in parentheses are estimated via OLS, and the other columns report Newey–West (NW) standard errors with five lags. CA trade participation in stocks and options on a given day (the dependent variable in columns (1)–(4)) is the number of Californian client households who trade stocks or options, divided by the total number of Californian clients that day. In column (5), trade participation is calculated in terms of risky asset trading in retirement accounts (in stocks, options, and mutual funds) and mutual fund trading in nonretirement accounts. In column (6), non-CA trade participation in stocks and options is defined analogously as the dependent variable in columns (1)–(4) but for households with addresses outside California. *CA jackpot* is the advertised California Super Lotto jackpot as reported by the California Lottery for the period July 1992-November 1996. *PB jackpot* is the advertised Powerball jackpot for the period April 1992-November 1996. *Shorter trading day* is a dummy that identifies a shorter trading day around a holiday. The *CA holiday* dummy identifies CA public holidays that are not trading holidays. The *before holiday* and *after holiday* dummies identify days before and after public or trading holidays. All regressions include monthly time dummies, contemporaneous and five daily lags of equally weighted CRSP market returns, and the price range. The price range is the difference between maximum and minimum prices for a given stock and day, divided by the midpoint of these prices, averaged across all stocks that day. All coefficient estimates and standard errors are in percentages.

*Significantly different from zero at the 10% level; **significantly different from zero at the 5% level; ***significantly different from zero at the 1% level.

considerations. Also, if only for institutional reasons, retirement holdings tend to be more tilted toward mutual funds. (In principle, people are at liberty to invest in individual stocks and options through their individual retirement accounts, for example, but do less so than through their taxable accounts.)

Although the data set contains investors located all over the United States, this paper focuses on the subset of investors with a California address. California was chosen because it has by far the largest number of client households in the data set and a large state lottery. (New York is a distant second with roughly one-fourth the number of clients.) Sample size is important since, during a given trading day, relatively few households trade, and thus proxies of aggregate participation measures for states other than California tend to be very noisy. Also, because of their geographic location, Californians are likely to play the California lottery, whereas it may be fairly easy for some New Yorkers, for example, to buy Powerball tickets in neighboring Connecticut.

For a given trading day, we compute trading participation as the number of households who trade divided by the number of households with active accounts. A household is classified as active as long as there is either a monthly position or a trade in a risky asset (stock, option, or mutual fund) associated with that household before and after that day. Daily participation, that is, the fraction of clients who trade, is a simple measure of trading activity and representative for the brokerage population as a whole—as opposed to turnover, which overweights large and active clients.

Columns (1)–(3) of Table 3 report the results of regressing California trade participation in stocks and options in nonretirement accounts on California jackpots and a similar set of control variables as in Table 2. The coefficient of the jackpot variable is significantly negative, regardless of whether the standard errors are estimated via OLS (column (1)) or Newey–West with five lags (column (2)), or whether the jackpot variable is in absolute dollars instead of logs (column (3)). A one-standard-deviation increase in log jackpots is associated with a 1% reduction in stock and options trading; the effect is thus of a similar magnitude as in the aggregate sample.

Column (4) of Table 3 reports the results of a placebo test in which trading activity of Californian clients is regressed on Powerball jackpots. Powerball jackpots are essentially uncorrelated with California jackpots, as one would expect, and variation in Powerball jackpots has no effect on the stock and options trading activity of Californians.

The regression reported in column (5) of Table 3 examines the conjecture that variation in lottery jackpots does not affect trading activity that can be classified ex ante as unlikely motivated by gambling, such as retirement account trading and trading in mutual funds. Consistent with the conjecture, there is no significant relation between jackpots and trade participation in retirement accounts and mutual funds.

One concern is that the jackpot time series is spuriously correlated with an omitted variable that affects trading. Column (6) of Table 3 presents the results of a placebo test designed to help address this concern. Trading participation in stocks and options in nonretirement accounts by *non-Californian* clients is highly correlated with the corresponding trading variable calculated for Californian clients; in fact, the time-series correlation exceeds 0.9. This is perhaps not surprising because many determinants of trading are not a function of the trader's physical location. California lottery jackpots are an example for a local trading factor; they should affect the trading of Californian clients, but not the trading of other clients. This is indeed the case, as column (6) of Table 3 shows.

Aside from the main results, households participate more actively on Mondays and around public trading or CA holidays, which is consistent with the day-of-the-week and holiday effects for small trade participation documented in the aggregate U.S. TAQ data between 1998 and 2004.

In unreported results, we fail to detect greater sensitivity of lottery stock trading and speculative trading (that is, a rapid succession of selling and buying) to lottery jackpots. The underlying analysis, however, is hampered by the small size of the corresponding subsamples. On any given day, there are few option traders or traders in lottery stocks; for example, using Kumar's (2009) widest definition of lottery stocks, the median daily number of Californian lottery stock traders is 14. Matching speculative trading to a particular jackpot requires a rapid sequence of buying and selling, which leaves us with similarly few observations. In contrast, the median number of Californian sample clients trading individual stocks or options on a given day is 128—an order of magnitude larger.

6. Lottery Jackpots and Discount Broker Participation in Germany

The German discount brokerage data set resembles the U.S. discount brokerage data set along many dimensions: relative to the general investing population, clients tend to be younger, be better educated, have higher incomes, and trade more actively. Besides offering another robustness test, the German data offer different ways to ex ante classify different trades as more or less likely gambling motivated and, as such, more or less affected by jackpots. The transaction records include an indicator that identifies trades as being part of an automatic savings plan. Through such plans, investors can trade on one of four predetermined dates every month (the 1st, 5th, 15th, and 20th of a month or the next trading day, respectively) at a monthly, bimonthly, quarterly, or semiannual frequency. Savings plan trades account for 12% of all trades in stocks and mutual funds during the sample period. Trading activity in automatic savings plans is unlikely motivated by gambling and occurs at predetermined dates during a given month; thus, it should not expected to be affected by jackpots. Another advantage of the German trading records is that they include demographic information for all clients as well as detailed socioeconomic attributes and self-reported investing attitudes for a subsample of clients. These attributes and attitudes help us assess a client's affinity for gambling and hence the extent to which his trading may be affected by jackpots.

Table 4 reports results of time-series regressions of different measures of retail trading participation derived from the German discount brokerage records on lottery jackpots and additional variables known to affect the aggregate propensity to trade such as lagged market returns, public holidays (which essentially coincide with stock market holidays), and IPO volume. The log of German IPO volume during the current and past week is included because the aggressive marketing

Table 4 Linear Regressions of German Discount Brokerage Trading Participation on German Lottery Jackpots

	Participate					Trade	Buy	Sell
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Clients:	Domestic		Foreign	Domestic	Domestic		Domestic	
Asset class:	Stocks, options		Stocks, options	Funds, bonds	Savings plan		Stocks, options	
Constant	10.83***	5.27***	1.79***	2.84***	0.17	0.66***	3.08***	1.84***
	(2.14)	(0.13)	(0.18)	(0.20)	(0.19)	(0.07)	(0.37)	(0.08)
ln(*Top prize*)	−0.38***							
	(0.14)							
JP dummy		−0.42**	−0.08	0.11	0.30	−0.20**	−0.80	−0.02
		(0.16)	(0.28)	(0.33)	(0.33)	(0.10)	(0.60)	(0.13)
# holidays t	−1.66***	−1.68***	−1.70***	−1.28***	−0.75**	−0.59***	−0.52*	−0.67***
	(0.19)	(0.19)	(0.52)	(0.35)	(0.35)	(0.07)	(0.29)	(0.12)
# holidays t − 1	−0.47**	−0.48**	−0.26	0.31	0.40	−0.23***	−0.56*	−0.05
	(0.19)	(0.20)	(0.38)	(0.29)	(0.29)	(0.08)	(0.29)	(0.11)
ln(*IPO vol t*)	0.16	0.15	0.09	−0.15	−0.24	0.09**	0.17	0.03
	(0.10)	(0.10)	(0.08)	(0.16)	(0.15)	(0.04)	(0.15)	(0.03)
ln(*IPO vol t* − 1)	0.00	−0.01	0.03	0.36*	0.30*	−0.01	−0.12	0.02
	(0.08)	(0.08)	(0.10)	(0.19)	(0.17)	(0.04)	(0.15)	(0.05)
	Ancillary statistics							
Unreported	Monthly time dummies, 5 lags of market returns							
No. of obs.	278	278	278	278	278	278	278	278
R^2 (%)	90	90	78	46	33	92	45	72

Notes. The dependent variable in columns (1)–(4) is the trading participation, defined as the number of clients at a German discount broker who trade certain risky assets during a given week outside of automatic savings plans (i.e., non-plan trades) divided by the number of clients with an open account that week. The dependent variable in column (5) is the fraction of clients with trades in automatic savings plans—that is, orders to buy or sell individual stocks and mutual funds that are automatically executed on preset dates in a given month and recur monthly, bimonthly, quarterly, or semiannually. In column (6), a client is considered to participate ("trade") in week t if he makes non-plan purchases of individual stocks or options during week t and sells any risky assets during week t. In column (7), a client is considered to participate ("buy") in week t if he makes non-plan purchases of individual stocks or options during week t but does not sell any risky assets during that week. In column (8), a client is considered to participate ("sell") in week t if he sells individual stocks or options during week t but does not buy individual stocks or options during that week. The sample period is January 1995 to May 2000. The regression reported in column (3) only considers trading activity by clients with foreign addresses; all other regressions are estimated for domestic (German) clients. The risky assets considered in columns (1)–(3) and (6)–(8) are individual stocks and options; in column (4), the risky assets are mutual funds and individual bonds. Standard errors are Newey–West with four lags. *Top prize* is the potential prize of a lottery participant who correctly guesses all seven numbers of the German national lottery's weekly drawing. *JP dummy* is 1 if nobody claimed the top prize during the previous week (implying a larger top prize during the current week). The variable *# holidays* refers to the number of stock exchange holidays during a given week. *IPO vol t* and *IPO vol t* − 1 refer to the DEM volume of initial public offerings in German marks (valued at the midpoint of the book-building range) on German stock exchanges during the current and prior week, respectively. Unreported regressors include monthly time dummies and five lags of returns of the main German stock index DAX. All coefficient estimates and standard errors are in percentages.

*Significantly different from zero at the 10% level; **significantly different from zero at the 5% level; ***significantly different from zero at the 1% level.

of IPOs during the sample period may have energized retail investors to participate in IPOs and in the stock market more generally. Since retail participation trends up over time, we also include monthly time dummies.

The dependent variable in the baseline specification is trading participation outside of automatic savings plans of domestic, i.e., Germany-based, clients in individual stocks and options. Brokerage clients who live outside of Germany cannot conveniently buy Germany lottery tickets; their trades should thus be unaffected by jackpots. Column (1) of Table 4 reports that non-plan participation of German-based clients in individual stocks and options is significantly negatively related to the logarithm of lottery jackpots, other things equal. The economic magnitude is comparable to the results obtained for U.S. small trade participation: a one-standard-deviation increase in lottery jackpots is associated with a 0.3% lower retail participation, other things equal; this corresponds to a roughly 2% decrease relative to the average weekly participation rate in stock and options trading. As expected, the coefficients on the monthly time dummies are highly significant. Monthly time dummies account once again for the very good fit of the model, but the negative association between jackpots and trading activity is robust to other ways of modeling time trends in trading activity such as a linear trend or higher-order polynomials in time (not reported).

The regression reported in column (2) is similar but uses a jackpot dummy variable instead of a continuous variable. The jackpot dummy is 1 if there is a jackpot in the parlance of the German national lottery—that is, no participant guessed all numbers correctly during the previous week. This specification is not only interesting for examining nonlinear robustness, but also because of jackpot advertising constraints. In contrast to the United States, where jackpot sizes are prominently advertised (on billboards, for example), German lottery advertising is muted. The German lottery can and does advertise the existence of a jackpot, but there has been legal wrangling as to whether the national lottery can aggressively promote particularly high jackpots. For example, German lower courts have issued rulings that automatically disallowed advertising of jackpots greater than EUR 10 million; in 2010, the German Federal Court of Justice overturned these rulings but imposed constraints on advertising large jackpots. One might thus expect that particularly large jackpots do not elicit the same response as under unconstrained advertising and that a categorical jackpot variable such as the jackpot dummy captures the perceived attractiveness of the lottery quite well. The jackpot dummy is indeed statistically significant, and its economic effect is of similar magnitude as that of a one-standard-deviation increase in jackpot dollar value. To conserve space, we only report jackpot dummy variable specifications in the following. The results are generally similar, regardless of whether the logarithm of jackpots or a jackpot dummy is used.

Column (3) of Table 4 verifies that the individual stock and option trading of clients domiciled outside of Germany is indeed unresponsive to variation in lottery prizes. This result is consistent with our hypothesis and especially noteworthy since the time-series correlation between the trading activity of domestic and foreign clients is almost 0.9. It should be interpreted with some caution, however, since there are only about 900 foreign-based clients in the sample, an average of 60 of whom trade in a given week.

As hypothesized, the mutual fund and individual bond trading of Germany-based clients is not affected by variation in lottery prizes. This negative result, reported in column (4) of Table 4, is not merely due to a lack of power: on average, more than 1,000 clients trade mutual funds or bonds during a given week, and the time-series correlation between mutual fund and bond trading on the one hand and individual stock and options trading on the other hand is greater than 50%.

In principle, we would like to consider finer asset categories, for example, just trading activity in options or lottery-type stocks. Such an analysis, however, runs into power issues. For example, even when using Kumar's (2009) widest definition of lottery stocks, there are fewer than 60 such stocks during some weeks, and they are only traded by a handful of clients in a given week; the resulting trading time series thus tend to be very noisy.

6.1. Results Are Stronger for Trades More Likely Motivated by Gambling

With the data at hand, one can examine the jackpot sensitivity of different kinds of trading activity for which one would ex ante expect different responses to jackpots. One might expect sensation seekers with their taste for novel and varied bets to be particularly prone to buying or trading speculatively—that is, selling a position associated with an old bet or moving out of cash to provide the capital to fund a new bet. In contrast, one would not expect straight selling to be particularly motivated by gambling and thus affected by jackpots (even though, in principle, sellers might bet on avoiding a large loss or move their capital into risky investments outside the observed brokerage accounts). This paper separately considers trading activity in savings plans, straight buying of individual stocks or options (that is, buying of these securities without any selling of risky securities), straight selling of individual stocks or options, and speculative trading activity in individual stocks or options (defined as buying *and* selling such securities within the same week).[5]

Column (5) of Table 4 verifies that savings plan activity is unresponsive to lottery prizes. Consistent with our conjecture, speculative trading activity is particularly sensitive to lottery jackpots, as reported in column (6) of Table 4. Straight buying activity also declines in weeks with jackpots, but the effect is not significant at conventional levels (see column (7) of Table 4). Selling of individual stocks and options without any accompanying purchases is unrelated to jackpots (see column (8) of Table 4).

6.2. Results Are Stronger for Clients Who Are More Likely to Play the Lottery

For a subsample of the clients considered in the previous sections, detailed demographic and socioeconomic attributes are available via a survey described in detail by Dorn and Sengmueller (2009). According to the substitution hypothesis, the presence of a jackpot can only have an effect on the trading activity of investors who consider playing the lottery, since only such investors can engage in substitution. Although we do not directly observe whether sample investors participate in lotteries, we observe attributes that have been linked to lottery participation in the broader population.

Gender and educational attainment appear to be reliably correlated with lottery participation across samples of potential lottery players. Male respondents

[5] There are different ways of capturing speculative trading. For example, Odean (1999) examines purchases that follow profitable sales of entire positions within three weeks to rule out tax, rebalancing, and liquidity motivations. Given weekly lottery drawings in our case, it makes sense to relate trading within a given week to the jackpot in effect that week. We do not require that purchases follow sales during the week since it is possible that clients temporarily reduce their cash position (we do not observe their cash position). Also, we include both profitable and unprofitable sales since capital gains were essentially not taxed in Germany during the sample period. Conditioning on observing sales of entire positions yields similar results since the vast majority of sales are of entire positions; these results are not reported.

Table 5 Lottery Jackpots and German Retail Investor Participation—Panel Results

	Investor-week trade indicator			
	(1)	(2)	(3)	(4)
Jackpot indicator (*JP*)	−1.858***	−1.153	−0.762	−1.434
	(0.175)	(0.931)	(0.868)	(0.937)
JP × *Male*		−0.907*	−0.843	−0.940*
		(0.530)	(0.591)	(0.528)
JP × *Age* 29–38		−0.052	−0.376	−0.091
		(0.839)	(0.688)	(0.846)
JP × *Age* 39–48		0.830	−0.226	0.775
		(0.902)	(0.717)	(0.909)
JP × *Age* 49–58		0.053	0.387	−0.012
		(0.963)	(0.765)	(0.969)
JP × *Age* ≥ 58		0.598	−0.374	0.503
		(1.057)	(0.820)	(1.059)
JP × *Blue-collar vocational degree*		−1.540***	−1.561***	−1.558***
		(0.564)	(0.579)	(0.567)
JP × *White-collar vocational degree*		0.055	−0.044	0.066
		(0.499)	(0.475)	(0.498)
JP × *Income* 50k–75k		−1.321	−1.105*	−1.389*
		(0.834)	(0.622)	(0.837)
JP × *Income* 75k–100k		−0.766	−0.649	−0.783
		(0.766)	(0.601)	(0.770)
JP × *Income* 100k–150k		−0.962	−1.295**	−1.003
		(0.745)	(0.620)	(0.747)
JP × *Income* ≥ 150k		−0.589	−0.313	−0.626
		(0.829)	(0.692)	(0.829)
JP × *Experience*		0.092**	0.107**	0.084*
		(0.045)	(0.043)	(0.045)
Male	2.269***	2.801***		2.817***
	(0.617)	(0.622)		(0.629)
Age	−0.029	−0.036		−0.037
	(0.021)	(0.022)		(0.023)
Blue-collar vocational degree	1.053*	1.088*		1.103*
	(0.629)	(0.658)		(0.664)
White-collar vocational degree	0.165	1.017		1.025
	(0.697)	(0.774)		(0.782)
ln(*Income*)	−0.515	−0.372		−0.366
	(0.427)	(0.436)		(0.441)
ln(*Wealth*)	0.383*	0.350*		0.336
	(0.210)	(0.212)		(0.214)
Experience	0.122**	0.074		0.069
	(0.054)	(0.059)		(0.060)
	Ancillary statistics			
Individual fixed effects	No	No	Yes	No
Monthly time dummies	No	No	No	Yes
Observations	165,909	165,909	165,909	165,909
Individuals	1,166	1,166	1,166	1,166
R^2 (%)	20	20	25	21

Notes. Columns (1)–(4) report the results of regressing a trade indicator (1 if customer i trades individual stocks or options in week t) on the jackpot indicator for week t (1 if nobody won the top prize in the national German lottery in week $t-1$ such that the prize money rolls over to week t) and interactions of the jackpot indicator with demographic and socioeconomic characteristics gleaned from survey responses of German retail brokerage clients (a subsample of the investors considered in the previous analysis): gender of the primary accountholder (1 if male), age, two dummy variables for educational attainment (college-level education is omitted), income, wealth, and length of experience in the stock market. Additional controls not reported in the table include four lags of the dependent variable (not included in column (3)), market returns (contemporaneous and four lags), portfolio returns (contemporaneous and four lags), the logarithm of the one-week lagged portfolio value, and the one-week lagged portfolio concentration measured as the equity portfolio's Herfindahl–Hirschman index. The regression reported in column (3) includes individual effects, and the regression in column (4) includes monthly time dummies. Except for column (3), standard errors are corrected for heteroskedasticity and clustering at the individual level. All coefficients and standard errors are in percentages.

*Significantly different from zero at the 10% level; **significantly different from zero at the 5% level; ***significantly different from zero at the 1% level.

in studies of potential lottery players in Germany (Albers and Hübl 1997) and the United Kingdom (Farrell and Walker 1999) are more likely to play the lottery, as are less educated respondents in Germany and the United States (Scott and Garen 1994). In the UK and U.S. samples, participation initially increases both in age and income but later falls in these attributes.

Motivated by these studies, we specify a linear probability model of weekly trading participation in individual stocks and options, regressing participation at the individual investor level on the German lottery jackpot indicator as well as interactions of the jackpot indicator and investor attributes previously linked with the propensity to gamble. Control variables include time-invariant investor attributes such as gender and education as well as a wide range of time-dependent covariates such as portfolio and market returns, portfolio size, and portfolio concentration. To address concerns about unobserved heterogeneity, we include either lagged trading participation or individual fixed effects.

Column (1) of Table 5 reports the coefficient estimates along with standard errors that are corrected for heteroskedasticity and possible clustering at the account level. Across all accounts and periods, the trading probability is 1.9 percentage points lower during a week with a lottery jackpot than during a week without a jackpot, other things equal; in other words, the presence of a jackpot lowers the trading frequency of the sample investors from 20% to about 18%, on average.

This jackpot effect is not only highly significant in statistical terms, it is also substantially larger than that estimated for the larger client sample in the previous section. One explanation is that clients with an affinity for gambling were more likely to respond to the survey because their response guaranteed them a shot at a $3,000 cash prize sponsored by the broker to encourage participation.

As in prior work, male investors are more prone to trading, other things equal. Investors with a blue-collar background also trade significantly more. Not surprisingly, individual trading activity is persistent and positively related to both lagged aggregate trading activity as well as past aggregate and own portfolio returns (these coefficients are not reported).

Column (2) of Table 5 reports the results of the regression with the interaction terms between the jackpot indicator and gambling-related investor attributes as additional explanatory variables. The interaction terms between the jackpot dummy and the gender and education dummies are significantly negative; male investors and investors with a blue-collar vocational degree, in particular, are particularly sensitive to the presence of a jackpot, other things equal. The interaction terms between the jackpot dummies and the age and income categories are not statistically significant. Stock market experience reduces the jackpot sensitivity by about half a point per five years of experience.

Columns (3) and (4) of Table 5 explore different econometric specifications, such as using individual fixed effects instead of specific time-invariant investor attributes (in column (3)) and including monthly time dummies. The results are robust to these variations. The association between the propensity to trade and the logarithm of jackpots is negative but not significant. This unreported result is perhaps due to the constraints on advertising during particularly large jackpot weeks.

Dorn and Sengmueller (2009, p. 596) use survey responses to the statements "Games are only fun when money is involved" and "In gambling, the fascination increases with the size of the bet" to proxy for a respondent's affinity to gambling.[6] One might expect investors who agree with these statements to be more likely to gamble and, as such, substitute between gambling in and outside the stock market. This, however, is not the case. Unreported results fail to show a higher sensitivity of such investors to large lottery prizes.

7. Conclusion

This paper documents a negative correlation between retail trading activity and lottery prizes in three completely unrelated data sets: between aggregate U.S. small trade participation and U.S. multistate lottery jackpots, between California discount broker participation and California lottery jackpots, and between German discount broker participation and German lottery jackpots. This paper also offers a variety of additional tests that suggest that gambling-related trading activity is sensitive to lottery jackpots, whereas, e.g., savings-related trading activity is not. These results are broadly consistent with this paper's substitution hypothesis: some individual investors substitute between the excitement of playing the lottery and that of playing the stock market.

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[6] They also use other statements, but the cited statements come closest to identifying potential gamblers.

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