Designing Lottery Games To Enhance State Revenues

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I. INTRODUCTION

In recent years state-sponsored lotteries have become popular as sources of public revenues. Although prohibited across the U.S. from 1893 until 1964, today lotteries are operated by two-thirds of all states and the District of Columbia and are under consideration in several more states. Those who oppose the widespread adoption of lotteries question whether government promotion and taxation of gambling activities is sound public policy.[1] However, state fiscal pressures and voter support for lotteries make it unlikely that states will exit the lottery business anytime soon; thus the focus of debate has increasingly shifted from whether to operate lotteries to how existing lotteries should be managed.

As a monopolist,[2] each state's lottery agency controls many variables affecting lottery sales and revenues, including the types of lottery games sold and the features of each game. In designing a portfolio of game offerings, lottery managers generally seek to maximize net revenues or lottery "profits" (Clotfelter and Cook 1990b). In some states, including California, this objective is mandated by law.[3] To achieve revenue goals, lottery managers may modify existing games or introduce new ones. Yet despite the substantial sums of money involved (U.S. lottery sales exceeded $19 billion in 1989), the impacts of game modifications and new product introductions on lottery sales are not well-understood.[4] According to Clotfelter and Cook (1989, p. 113), "...designing prize structures that will maximize public appeal remains more a matter of trial and error than science."

This study examines the effects of game design and product mix on sales of four California lottery games from October 1985 through February 1991. Demand functions are estimated for each game and potential for net revenue enhancement is discussed. In the case of Lotto, game payoffs are not deterministic, but instead arise from the interaction of game design parameters and random events (i.e., the outcomes of Lotto draws). Therefore simulations based on regression estimates are used to evaluate the impact of game structure on Lotto sales. The findings have implications for two lottery-related controversies that have received considerable attention in California.

II. BACKGROUND AND ISSUES

Since lottery tickets first became available in late 1985, California has led the nation in lottery sales, amassing gross revenues of nearly $11 billion in its first five years of operation. Of each dollar wagered on the lottery, approximately half is returned to winning players as prizes, a minimum of 34 percent is allocated to educational institutions, and the remainder covers administrative costs and retailer commissions. Lottery funds now comprise over three percent of public education expenditures in California. Though small as a share of total education spending, these revenues are nevertheless significant at a time when the state faces both a record budget shortfall and unanticipated rapid growth in the population of school-age children.[5]

Of particular interest in this study are the effects of several major changes that have been made in California's portfolio of lottery games. These are described below and summarized in Table I. Note that the most recent of these games ("Little Lotto") is omitted from the subsequent econometric analysis due to a lack of sufficient observations in the sample.

[TABLE 1]

Instant-win games introduced. Instant-win ("scratch-off") games began in October 1985 and were the lottery's sole product during its first year of operation. To play, the consumer scratches off a ticket's opaque covering to reveal symbols indicating its payoff. Each game lasts an average of 54 days and features a particular theme, such as "Baseball," "Wild Card," or "Hidden Treasure." Prize amounts (other than for top prizes) and odds are fixed for the duration of each game, but may vary from game to game. In some cases, "free replay" tickets are among the possible prizes. Additionally, a few

players (less than one per million ticketholders) win an appearance as a contestant on the "Big Spin" television program and a chance to win much larger prizes by spinning a spoked wheel. Top prizes may exceed $1 million, and roll over from game to game until won.

Lotto introduced. After several months of brisk sales and rapid market penetration (Maritz 1987), demand for instant-win tickets waned. Lottery sales declined from May 1986 until the first on-line game, Lotto, was added to the product lineup in October 1986. Lotto proved very popular, and has since been the lottery's best-selling product.

To play Lotto, consumers choose six numbers from a larger field, either manually or by activating an automatic-draw feature on an on-line terminal. Lottery officials draw six winning numbers plus a "bonus number" from the field. Players who succeed in matching all six numbers share the top prize pool. Those who match five of the six numbers plus the bonus number split the second prize pool. Other prize pools are divided among those matching five, four, or three of the six numbers. If no player wins a given prize pool, that amount rolls over to augment the top prize pool for the following draw. A series of such rollovers can lead to enormous jackpots, which in turn generate extremely heavy Lotto sales.

Frequency of Lotto draws doubled. In 1987, Lotto drawings were increased from weekly (Saturday) to twice a week (Wednesday and Saturday). In response, weekly revenues virtually doubled. It has been suggested that more frequent draws improve Lotto's play value by reducing the week-long wait between game results.

Decco introduced. A second on-line game ("Decco") was added to the product line in March, 1990. In this game players attempt to match one card of each suit drawn from a standard 52-card deck.

Decco features much smaller prizes than Lotto (e.g., a top prize of $5,000) but better odds of winning. Drawings are held daily except Sunday.

Lotto field size and prize structure modified; Topper introduced. One effect of rising Lotto sales is to reduce the probability that prizes will roll over, thereby inhibiting the buildup of large jackpots. DeBoer (1990) concluded that this phenomenon caused New York lottery sales to stagnate after several years. In California, the percentage of Lotto draws resulting in a rollover declined from 58 percent in 1987 to 44 percent in 1989. To counteract this trend the Lotto game was substantially modified in June 1990. First, the original field size of 49 was increased to 53, significantly decreasing the per-ticket probability of winning each prize.[7] Also, the share of prize money allocated to the top prize pool was increased from 40 percent to 50 percent (i.e., from 20 to 25 cents per wagered dollar) while funds for lower-tier prizes were correspondingly reduced.

In conjunction with the modified Lotto prize structure, a new "linked" on-line game ("Topper") was introduced. Topper can be purchased only as a supplement to a Lotto purchase. The game consists of matching the names of three California cities (automatically picked by an on-line terminal) with three winning names. Topper features higher probabilities of winning than Lotto but a much smaller top prize of $25,000. By adding Topper to a Lotto purchase, a player can improve the odds of winning a prize.

Two controversies. During its short existence, the California lottery has been the subject of several controversies. Most recently, it has been charged that lottery managers have failed to maximize net revenues as required by law.

First, although introduction of the modified (6/53) Lotto game (including Topper) was expected to stimulate public interest in Lotto, the opposite occurred. Sales fell sharply amid media

criticism of the new game structure. Lottery officials countered that this criticism was premature. Because the new game structure's demand-enhancing attributes (larger jackpots) require time to develop, while its drawbacks (e.g., a reduced chance of winning) are immediate, it is possible that the game restructuring could depress sales in the short run and yet perform well in the longer run. Also, the economic downturn of late 1990 may be partially responsible for the observed sales decline. To isolate the long-run effects attributable to the new game structure, this study simulates Lotto sales over a two-year period under the original and modified game rules while holding other variables constant at their June 1990 levels.

A second lottery-related issue arose during California's 1990 gubernatorial campaign. One candidate proposed that the percent of lottery dollars devoted to education be increased from the current legal minimum of 34 percent to 50 percent to raise additional funds for schools. Her opponent countered that this would reduce, rather than enhance, education revenues; i.e., that lottery demand is elastic with respect to the takeout rate.[8] More recently, lottery officials have suggested instead that the takeout rate be reduced to stimulate sales and increase revenues. Unfortunately direct estimation of this key elasticity is possible only for instant-win games; California's takeout rate for on-line games has remained constant at 50 percent. Here an indication of demand elasticity is obtained by simulating the effect of various takeout rates on the size of Lotto rollovers, and assuming that the public's response to the resulting jackpots follows the historical pattern estimated from the data. Such a counterfactual simulation offers some evidence regarding which viewpoint is best supported by past sales patterns.

III. ECONOMETRIC ANALYSIS

A. General Data Considerations

First, it should be noted that on-line data are less aggregated than instant-win data. On-line sales are recorded automatically at the time of purchase. By contrast, instant-win tickets are sold in quantity to retailers, who resell the tickets over a period of weeks and return unsold tickets for refunds following each game's conclusion. For this reason, instant-win data are recorded only by game and are considered separately here.

Observations of some standard demand shifters such as consumer income were not available over the entire sample period. Because important changes in lottery game offerings occurred in mid-1990, restricting the analysis to earlier periods for which data were available was an unattractive option. Therefore only population and the California unemployment rate are included as demographic shifters. Linear interpolation is used where necessary to match data points with lottery observations. Data are from the California Lottery Board, the California Department of Finance (population), and the California Department of Labor (unemployment).[9]

B. Instant-win games

Data and specification. Data on instant-win games consist of 38 observations, each representing a single game played over a period of from 32 to 112 days. The corresponding calendar dates are October 3, 1985 through February 22, 1991.[10]

The logarithm of daily sales per capita (SALES) is hypothesized to depend on four own-game characteristics: the expected value or payout per $1 ticket (EV); the expected amount of the top prize (TOPPRIZE);[11] the per-ticket probability of winning any prize (PWIN); and the duration of the game in days (DAYS). The latter is intended to measure the effect of game novelty on daily

sales. Additionally, California's unemployment rate (UNEMPL) is included as a proxy for fluctuations in the general economy. A trend term (TREND) allows for other time-dependent effects such as inflation, consumer learning or habit formation over time.

Three versions of the basic model were specified. Equation 1 includes only the explanatory variables listed above. Equation 2 incorporates dummy variables indicating the existence of Lotto (LOTTO) and Decco (DECCO) respectively. An advantage of this specification is that Lotto and DECCO are not determined contemporaneously with scratch-off sales. However, these variables fail to reflect variations in Lotto game characteristics over time.[12] In Equation 3, the average value of the Lotto carryin rollover (in thousands) during the course of each instant-win game (AVGROLL) replaces Lotto. AVGROLL indicates changes in the relative attractiveness of Lotto wagers, since Lotto's expected value and jackpot amounts are enhanced by large rollovers.

Regression results and revenue implications . Equations 1-3 were estimated by generalized least squares using the iterative Cochrane-Orcutt method to correct for first-order autocorrelation. Results are shown in Table 2. Given the semilog functional form, coefficients represent the estimated proportional change in sales arising from a level change in each dependent variable.

[TABLE 2]

Of the four own-game characteristics considered, the effects of TOPPRIZE and DAYS differ significantly from zero at the 99 percent confidence level. A $1,000 increase in the average Big Spin prize is found to increase instant-win sales by between .81 and .87 percent. This implies that larger top prizes could enhance net instant-win revenues. For example, in late 1990 a hypothetical scratch-off game might feature one Big Spin winner per 1,400,000 tickets sold; an average Big Spin prize of $83,500; and total sales of $62,000,000. To increase the expected top prize by $1000 would cost

approximately $44,000, provided money was not diverted from other game prizes. The resulting increase in sales is estimated to be about $520,000. Assuming revenues to education are 35% of sales, a net gain of $138,000 per instant-win game ($182,000 - $44,000) would result from this prize enhancement. However, analysis of on-line data (discussed in the following section and reported in Table III) suggests that Lotto sales would fall by 0.6 percent in response to higher instant-win prizes. Based on typical Lotto sales of $12 million per draw and 15 Lotto draws per instant-win game, Lotto sales would decline by $1,080,000, more than offsetting instant-win gains. Smaller losses from Decco and Topper are also indicated, though the effects are not statistically significant. These findings imply that reductions in top instant-win prizes are optimal. Based on data from early 1991, it appears that lottery managers have already taken steps to lessen competition between Lotto and instant-win games by reducing the average size of "Big Spin" prizes.

Each one-day increase in game duration (DAYS) is found to reduce daily sales by slightly over 1 percent. This may reflect not only consumers' desire for novelty but also a response to the fresh advertising campaign that introduces each new game. Whether net revenues would rise in response to shorter games depends on the increased costs of game development, ticket printing and advertising that would be incurred.

Expected value (EV) and the per-ticket probability of winning (PWIN) are found to be positively related to daily sales; however, their estimated coefficients have relatively large standard errors. For equations 1 through 3, elasticity estimates with respect to EV range between .84 and .93 evaluated at data means, while for PWIN elasticities are between 0.12 and 0.13. While keeping in mind that these estimates have large standard errors, it appears that augmenting either the payout rate or the probability of winning would reduce net revenues. Consider adding one additional $1.00 prize per 100 tickets sold. This would increase PWIN to 15 (from a mean of 14 percent) and EV to $.51 (from a mean of $.50), and would raise prize costs by 1 percent of sales. From equation 1, the

estimated effect of this prize enhancement is to increase sales by (1.6618*(.01) + .0094*(1)) = 2.6 percent. Given that revenues for education equal about 35 percent of sales, this yields a gross revenue gain of .91 percent of sales, insufficient to cover the associated 1 percent cost increase. Conversely, a small reduction in the prize pool (as from a 1 percent increase in the takeout rate) would enhance net revenues slightly.

In equations 2 and 3, the estimated impacts of LOTTO and AVGROLL are positive, while that of DECCO is large and negative. It is possible that Decco and instant-win games are viewed as substitutes by consumers as they are the only lottery games that can be played daily. However, the degree to which on-line games affect instant-win games is unclear, since the estimated coefficients for LOTTO, DECCO and AVGROLL do not differ significantly from zero.

The effect of unemployment on instant-win sales is positive but not significant at the usual levels. Lastly, the effect of the time trend variable is negative and significant at the 99 percent level. The implied annual rate of decay in (nominal) per capita instant-win sales is between 22 and 26 percent. Assuming 2.6 percent population growth and 5 percent inflation, this indicates an underlying annual decline in total real sales of approximately 26 percent.

In conclusion, it appears that net revenues from instant-win games would rise slightly (relative to their downward trend) if the takeout rate were increased, barring extensive negative publicity. Larger top prizes are found to enhance instant-win sales and revenues, but by making these games a better substitute for Lotto, reduce total lottery revenues.

C. On-line games

Data and estimation. Three on-line games are considered here: Lotto, Decco and Topper. Lotto data consist of 409 observations, one for each Lotto draw from October 18, 1986 through March 6, 1991. Topper data, also by draw, consist of 73 observations (June 27, 1990 through March 6,

1991).[13] Decco observations by draw (daily except Sunday from March 5, 1990 through March 6, 1991) were aggregated by three-day intervals to correspond to Lotto and Topper observations, resulting in 105 semiweekly observations.

Specification--Lotto. As with instant-win games, various aspects of Lotto's prize structure could be important determinants of Lotto spending patterns, including the expected value or payout per ticket; the amount of the largest possible prize; the probability of winning any prize, or a prize above a certain size; the expected mean prize; and so on. However, unlike instant-win games, Lotto prizes and expected value are endogenous functions of current sales, influenced primarily by the size of the rollover (if any) from the previous draw, the share of prize money devoted to each prize pool, and the field size.[14] The latter determines the per-ticket odds of winning each category of prize.

The logarithm of per capita Lotto sales is hypothesized to depend on several own-game characteristics. These are: prizes rolled over from the previous draw (ROLLOVER), measured in million dollars; the number of draws offered per week (NDRAWS); and the day of the week on which a draw occurs (Wednesday (WED) as opposed to Saturday). Also, recall that three major changes affecting Lotto were made simultaneously in June 1990: (i) an increase in the field size from 49 to 53; (ii) a rise in the percentage of the prize pool devoted to the top prize; and (iii) introduction of the "add-on" game, Topper. The dummy variable NEWGAME represents the joint effects of these changes other than on rollover size.

Variables designed to capture competition or substitution between games are: a dummy variable indicating the presence of DECCO and a variable indicating the amount of the average top prize concurrently available in an alternative lottery game (ALTPRIZE). ALTPRIZE is measured in thousands; its effect will be negative if larger "Big Spin" prizes cause instant-win games to substitute more closely for Lotto. Also, TREND (measured in weeks) and UNEMPL are included as before.

Specification--Decco and Topper. Decco and Topper are specified as functions of the same variables as Lotto, excluding those dummy variables that are constant over their shorter sample periods. Decco and Topper sales do not depend on any own-game characteristics, since each game's design has been constant to date.

Regression results. Table 3 reports the results of three regressions. The dependent variables in Equations 1, 2 and 3 are the logarithms of Lotto, Decco, and Topper sales per capita, respectively.

[TABLE 3]

Lotto. Equation 1 indicates that the rollover is a key determinant of Lotto sales. A $1 million increase in the rollover is found to raise Lotto sales by nearly 7 percent; the corresponding elasticity is .165 evaluated at data means.

Bettors' enthusiastic response to the introduction of a second weekly draw is evident in the positive and insignificant coefficient for NDRAWS. Wednesday sales appear to consist of new money rather than dollars diverted from the Saturday draw. On average, Wednesday draws generate 13 percent fewer sales than do Saturday draws.[15]

NEWGAME measures the effects of the new (6/53) game design other than on rollovers. Its estimated coefficient is negative and significant, implying a downward shift in Lotto demand of over 35 percent in response to the new game regime and the introduction of Topper. However, the total impact of the new game design on sales is not immediately apparent, since this negative intercept shift excludes the rollover-enhancing effect that motivated the game restructuring. Because rollovers evolve stochastically, a simulation model based on Equation 1 is employed in the next section to investigate the net sales gain or loss resulting from the new game structure.

It is interesting that unemployment is found to have a negative effect on Lotto sales, but a positive effect on sales of Decco, Topper and instant-win games. This is consistent with findings by Clotfelter and Cook (1987), who reported that lower-stakes games had a more regressive tax incidence than did high-jackpot lotto games in Massachusetts and Maryland. However, none of the coefficients are significant at the usual levels.

The trend coefficient indicates that nominal per capita Lotto sales have been increasing at 9.8 percent per annum, other factors held constant. Assuming annual population growth of 2.6 percent and 5 percent inflation, the implied trend in total real sales is +7.4 percent. Lastly, there is evidence that both instant-win games and Decco compete with Lotto for the consumer's wagering dollar. In particular, Decco is found to have had a substantial negative effect on Lotto sales.

Decco and Topper. As with Lotto, Decco and Topper sales respond positively to the size of the rollover, and are lower during the Monday--Wednesday period than during Thursday--Saturday. Consumers appear to buy Decco tickets and Topper tickets in conjuction with Lotto purchases (a necessity in the case of Topper.) The negative effect of NEWGAME on Decco may reflect the unpopularity of the new Lotto structure, competition from Topper, or both.

Annual trends in nominal Decco and Topper sales per capita are estimated to be -67 percent for both games. In real terms and adjusted for 2.6 percent population growth, this implies declines of almost 70 percent annually. This sharp decline in demand may indicate players' desire for game novelty, as was found for instant-win games. As noted earlier, the coefficient on unemployment is positive (but not significantly so) for both games.

IV. SIMULATING LOTTO SALES UNDER ALTERNATIVE POLICIES

To compare long-run Lotto sales under the original (6/49) versus the modified (6/53) game structure, while controlling for other factors, regression estimates from Table 3 were used to simulate Lotto sales over a two-year period under each regime. Initial values used for exogenous variables are the actual levels observed in June 1990, just prior to introduction of the new game structure.[16]

Each two-year simulation was repeated 20 times per policy regime. Table 3, part A reports mean, maximum and minimum estimates of the average sales per draw under 6/49 and 6/53 game structures, for actual 50 percent takeout rates.

[TABLE 4]

A comparison of simulation results under the old (6/49) and new (6/53) game formats and the actual 50 percent takeout rate indicates that the new game structure has reduced Lotto sales $2,411,000 per draw *ceteris paribus*, or $250,744,000 annually. This decline is partially offset by sales of Topper, which averaged $1,718,000 per draw over the sample period.[17] The net sales loss under the new game regime is found to be $693,000 per draw, or $72,072,000 annually. This implies a loss of net education revenues of at least 34 percent of that amount, or $24.5 million dollars annually.

Note that the game modifications clearly have the intended effect of generating larger rollovers and thus more exciting (larger) jackpots. Although the new structure more than doubles the size of the average rollover, the positive sales response to the larger rollover is insufficient to offset the negative demand shift resulting from lower probabilities of winning, Topper competition and/or smaller intermediate prize pools.

A second policy experiment simulates the effects of changing the Lotto takeout rate. This experiment is only suggestive since it is counterfactual; the actual Lotto takeout rate has always been

constant at 50 percent. To implement these simulations, the amount entering the 6 of 6 prize pool per draw was increased (decreased) by 5 percent, for both the 6/49 and 6/53 game structures.

This experiment is likely to underestimate the elasticity of Lotto demand with respect to the takeout rate for two reasons. First, the regression model lacks the detail necessary to model the differential effects of various types of prize enhancements (such as increasing the number of small or medium-sized prizes, or raising the minimum prize from $5.00 to $10.00). Thus the simulation considers only the impact of altering the percentage of sales revenues entering the top (6 of 6) prize pool. It is possible that an alternative form of prize enhancement might be favored by consumers. Secondly, increasing or decreasing the takeout rate not only changes the size of the rollover, but also alters the game's expected value. There is no historical evidence regarding how consumers respond to the latter effect; thus only responses to changes in the rollover (for which data exist) are simulated here. The impact of favorable or adverse publicity arising from a change in the game's expected value is not considered and could well be important.

In spite of these reservations, counterfactual simulations provide some useful information. For example, if a lower takeout rate is found to raise net revenues under these restrictive model assumptions it would be strong evidence that the true response would also do so, since the actual response should equal or exceed the simulated one. Also, one could speculate that the simulation results capture the major effects of changing takeout rates, given that consumers who care about the takeout rate per se are not likely to be heavy lottery players. (Other forms of gambling in California have much lower takeout rates than does the lottery. For instance, the takeout rate on racetrack wagers is less than 19 percent, while at casinos in neighboring Nevada rates are even lower.)

Again, 20 simulations were run for each policy regime, each consisting of a sequence of 208 draws (representing two years of twice-weekly Lotto draws). The results suggest that a reduction in the takeout rate to 45 percent will raise sales but reduce net revenues. Likewise increasing the

takeout rate to 55 percent depresses sales but results in a net revenue gain. Since these findings are biased toward finding an inelastic response, the results are inconclusive; nevertheless, it can be seen that a strong demand response to factors other than the rollover would be necessary before a reduced takeout could be revenue-enhancing.

V. CONCLUSIONS

California law requires that the state lottery be operated so as to maximize net revenues for education. In seeking to meet this objective, lottery managers can modify various features of existing lottery games or introduce new games. This study has examined the effects of game design, new game introductions and other factors on lottery sales to determine whether there is potential for further revenue enhancement.

First, after controlling for other explanatory factors including rising unemployment and intergame competition, all games except Lotto exhibit strong negative sales trends over time. Barring radical changes in product line (legalized sports betting, for example), it appears that even with optimal management future lottery revenues will be limited by diminishing game novelty, or product maturity.

Sales of instant-win games are affected more by the size of major prizes than by the overall probability of winning a prize or the expected payout per wagered dollar. Estimates indicate that net instant-win revenues would rise if the average size of top "Big Spin" prizes were increased. However, large instant-win prizes are found to erode on-line sales to the extent that their total effect on lottery revenues is negative. Daily instant-win sales respond positively to an increased frequency of new game introductions. Whether games of shorter duration would generate more net revenues depends on the extra costs of rotating games more often.

Analysis of on-line game data suggests that any additional new games are likely to cannibalize sales from existing games. The 1990 restructuring of the Lotto game with an expanded field size resulted in more frequent rollovers and larger jackpots as intended. However, the public's positive response to larger rollovers was more than offset by the downward shift in demand arising from the new game design. As a result, the estimated effect of the game modification has been to reduce net education revenues by over $24,000,000 per annum, other variables held constant at June 1990 levels. A return to the original field size and prize pool distribution should be revenue-enhancing, although to completely duplicate the original game would require discontinuing the add-on game, Topper.[17]

It has been suggested that revenues for California schools could be enhanced by modifying the state's takeout rate on lottery wagers. Regressions and counterfactual simulations offer some support for this idea. Raising the takeout rate above its current 50 percent level is found to enhance revenues from both instant-win and on-line games. Conversely, recent proposals to lower the takeout rate are found to reduce net revenues. However, any significant increase in the takeout rate is likely to generate adverse publicity, the effects of which are not captured in the empirical model; thus a "safe" policy would be to maintain the current takeout rate.

NOTES

1.A major concern for many is the apparently regressive incidence of lottery taxation (reported in empirical studies by Borg and Mason (1988), Brinner and Clotfelter (1975), Clotfelter (1979), Clotfelter and Cook (1987), Heavey (1978), Spiro (1974) and Suits (1977)). Others feel that state-sponsored gambling sends an inappropriate message to the public, by suggesting that luck rather than effort is the avenue to success (Clotfelter and Cook 1990). Objectionable advertising and marketing practices are noted by Karcher (1989). Lotteries may also promote addictive gambling behavior. Mikesell and Pirog-Good (1990) report that state lotteries are associated with higher crime rates.

2.Although each lottery has a monopoly on the sale of tickets within its state's borders, it may face direct competition from lotteries in neighboring states (Mikesell, 1987) as well as indirect competition from other legal and illegal gaming activities. Martin and Yandle (1990) have characterized state lotteries as duopolies between state governments and illegal gambling interests.

3.The California Lottery Act states that "...the Lottery shall be initiated and operated as to produce the maximum amount of net revenues to benefit the public purpose described in this Chapter"; namely, "providing additional moneys to benefit education." (California Lottery Act: Section 2, Section 5.)

4.Studies by DeBoer (1986, 1990); Mikesell (1987); Mikesell and Zorn (1987); Vasché (1985); and Vrooman (1976) have examined how one or more aspects of game design or product mix affect lottery sales. Of these, Vrooman's analysis of New York lottery sales is most similar in spirit to this study, although it considers only a single type of lottery game.

5.An issue not examined in this study is the extent to which lottery funds may replace rather than augment existing education revenues. In response to charges that lottery money was supplanting education revenues from traditional sources, California voters approved Proposition 98 in November, 1988. This proposition guarantees that California public schools receive at least 40 percent of total state revenues, not including lottery dollars.

6.For example, the odds of matching all six numbers fell from 1/13,983,816 to 1/22,957,480.

7.The takeout rate is that percentage of total wagers not paid back to winners as prizes.

8.One issue is whether variables should be measured in real or nominal terms. Here nominal data on lottery sales and prizes are used, for two reasons. First, the quantity of tickets sold determines the probability of lotto rollovers; thus projections of nominal sales are needed in order to simulate the lotto game. Also, there is some question as to the appropriate deflator to use in deriving real sales. Given the rapid escalation in property values in California during the late 1980's, a cost-of-living index including homeowner's costs might seriously overstate inflation, while an index excluding housing costs could be biased in the opposite direction. Additionally, interpolation would be required to match cost-of-living measures with lottery observations. Rather than risk introducing measurement error into lottery data through deflation, a time trend is included in each regression to allow for inflation-driven trends in nominal sales. Since lottery sales and payoffs are measured in the same units, failure to deflate may have less impact than is true for other goods.

9.Game 31 was an "overlay", played concurrently with other games. An alternative regression included a variable indicating the percentage of each game's play period that coincided with sales of another instant-win game. Its coefficient was negative but insignificant.

10.As mentioned previously, top prizes are awarded to contestants who win an appearance on the "Big Spin" television game. Prizes are determined by the spin of a wheel, and build up until won. For each game, the variable TOPPRIZE is calculated as the dollar value of the Big Spin prize pool per contestant, in thousands.

11.Decco's game characteristics have been constant to date.

12.The first Topper draw was held on June 23, 1990. As its sales were nearly ten times higher than for subsequent draws, it was omitted from the sample as an extreme outlier. Apparently many lotto players tried Topper once but did not become steady customers for the new game.

13.Over time, California's average lotto payout rate has remained fixed at 50 percent. However, on a draw-by-draw basis the game's expected value varies substantially. A draw with no carryin rollover has an expected payout well below .5, since 50 cents per dollar enters the prize pool and there is a significant probability that a portion of the prize pool will roll over rather than being paid out. Any sums rolled over from a prior draw augment the current draw's prize pool at no cost to current players, increasing the expected payout and the prize amounts that can be won. Additionally, unusually large rollover pools attract media coverage, generating free advertising exposure. The amount of the rollover is preferred to jackpot size as an explanatory variable because it is predetermined at the time a lotto ticket is purchased rather than being affected by current sales.

14.For readers who play Lotto this suggests that, all else equal, one's wagers should be placed on Wednesdays rather than Saturdays.

15.For each game structure (6/49 or 6/53), an estimate of first-period lotto sales was generated based on initial values. To this estimate was added a shock of mean zero and variance equal to that of the regression error, drawn from a random normal distribution. After transforming the resulting sales projection to a total sales basis assuming a population growth rate of 2% per year, the probabilities of each possible rollover event were calculated. Based on these probabilities, a random draw from a uniform (0,1) distribution was used to indicate the rollover outcome. The above steps were repeated using the new simulated rollover value, until a two-year period (208 draws) was reached.

It is assumed here that Lotto players choose their numbers at random, as when using the "Quick Pick" option to make their number selection automatically. However, it is well-known that certain numbers are more frequently chosen by the public than would occur based on random chance. For instance, "lucky" numbers such as 7 and 21, and numbers corresponding to birthdates may receive heavier play than do others. For this reason, the actual probability that a prize pool will roll over is likely to exceed the probability if play were strictly random.

Note also that actual sales under the 6/53 game structure have been less than those predicted by the simulation model, most likely as a result of the sharp downturn in California's economy that began shortly after the new game structure took effect. To test the model's ability to replicate actual sales, another set of 20 simulations was performed using the actual mean unemployment rate rather than the lower June 1990 rate. This experiment yielded a simulated mean (in millions) of $12.558 with a range of $11.803--13.492 in average sales per draw. By comparison, actual mean sales per draw from June 1990 through February 1991 were $12.032 million.

16. While the new game structure is credited with the gains from Topper sales, note that Topper could have been introduced while maintaining the original 6/49 lotto format.

17.Controversy over declining lottery sales has recently led to the hiring of a new lottery director. A complete line of new games have been introduced or are in the planning stages. Games first offered in the spring of 1992 include Super Lotto, which replaces Lotto 6/53 and features a reduced field size of 51; Fantasy Five, which replaces Little Lotto; and a numbers game. Decco remains available, while Topper has been cancelled. It is anticipated that a keno game will also be offered, although the system necessary to deliver the game to consumers is not in place at present.

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TABLE I

CHRONOLOGY OF CALIFORNIA LOTTERY'S GAME OFFERINGS

Date	Event
October 1985	Instant-win games begin
October 1986	Lotto 6/49 begins; weekly draws
October 1987	Lotto draws increased to two per week
March 1990	Decco begins
June 1990	Lotto 6/53 replaces Lotto 6/49; Topper begins
March 1991	Little Lotto begins

TABLE II

INSTANT-WIN GAMES

Log of average daily sales per capita, by game

Model Specification:	**1**	**2**	**3**
EV	1.6618 (1.35)	1.6879 (1.40)	1.8292 (1.38)
TOPPRIZE	.0087 (5.40)	.0082 (5.06)	.0081 (4.74)
PWIN	.0094 (0.83)	.0084 (0.76)	.0088 (0.75)
DAYS	-.0106 (-5.06)	-.0107 (-5.16)	-.0106 (-4.43)
TREND	-.0417 (-5.13)	-.0400 (-3.43)	-.0352 (-3.72)
UNEMPL	.0255 (0.56)	.0438 (0.91)	.0368 (0.75)
CONSTANT	-3.0400 (-4.47)	-3.1737 (-4.68)	-3.2031 (-4.34)
LOTTO	--	.1401 (0.73)	--
AVGROLL	--	--	.1614 (0.24)
DECCO	--	-.2251 (-1.02)	-.2638 (-1.22)
R^2=	.960	.964	.962

TABLE III

ON-LINE GAMES

Sales per capita, by Lotto draw

Dependent Variable (in logs)	SALES LOTTO	SALES DECCO	SALES TOPPER
	n=409	n=105	n=73
Independent Variable:			
ROLLOVER	.0693 (34.04)	.0015 (1.92)	.0408 (4.62)
NDRAWS	.0429 (0.65)	--	--
WED	-.1277 (-13.91)	-.0388 (-8.57)	-.0432 (-0.76)
DECCO	-.2289 (-3.61)	--	--
ALTPRIZE	-.0060 (-3.61)	-.0021 (-0.78)	-.0104 (-0.76)
UNEMPL	-.0382 (-1.47)	.0255 (1.02)	.1011 (0.65)
TREND	.0018 (3.55)	-.0211 (-4.25)	-.0212 (-1.53)
NEWGAME	-.3554 (-5.29)	-.1314 (-3.32)	--
CONSTANT	-.2425 (-0.92)	-2.3751 (-7.53)	-2.5286 (-1.88)
R^2	.840	.988	.495

TABLE IV

SIMULATED LOTTO SALES UNDER SIX POLICY SCENARIOS

1. ORIGINAL GAME STRUCTURE (6/49)

AVERAGE OUTCOME PER DRAW, in million dollars

Takeout rate	SALES		ROLLOVER		REVENUES
	Mean	RANGE	Mean	RANGE	Mean
45%	16.430	16.082--16.993	1.58	1.27--1.93	7.393
50%	15.983	15.473--16.634	1.30	1.05--1.85	7.992
55%	15.448	15.222--15.768	0.99	0.74--1.28	8.496

2. NEW GAME STRUCTURE (6/53)

AVERAGE OUTCOME PER DRAW, in million dollars

Takeout rate	SALES		ROLLOVER		REVENUES
	Mean	RANGE	Mean	RANGE	Mean
45%	14.051	12.923--16.012	3.63	3.09--4.49	6.323
50%	13.572	12.592--15.420	3.34	2.64--3.96	6.786
55%	12.772	11.875--13.711	2.79	2.26--3.39	7.025