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ABSTRACT

The best-selling lottery game in the United States is lotto, a parimutuel game of long odds and large jackpots. Unlike in the other popular lottery games (numbers and instant), there is a strong tendency for per-capita lotto sales to increase with the size of the population base. The fact that the jackpot also tends to increase with population size is not a complete explanation, since the probability of winning tends to be inversely proportional to state population. Our explanation for why the games are more successful in large states is that players tend to judge the likelihood of winning based on the frequency with which someone wins; then a larger state can offer a game at longer odds but the same perceived probability of winning as a smaller state.

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The Peculiar Scale Economies of Lotto

Philip J. Cook and Charles T. Clotfelter*

Lotto is a parimutuel gambling game of long odds and large jackpots. It is currently offered by 29 of 33 state lotteries, accounting for 40 percent of lottery sales in 1989. Unlike for the other popular lottery games (numbers and instant) there is a strong tendency for per capita lotto sales to increase with the size of the population base. As a result, smaller states have found it advantageous to form consortia for the purpose of offering a multi-state lotto game. Two such consortia are currently in operation.¹

What is the source of this scale effect in lotto? With a larger population base comes larger jackpots, but the probability of winning a share of that jackpot is correspondingly lower; the larger lotto games offer riskier prospects with the same expected value as the smaller games. We suggest that the allure of the larger games may be understood by considering the sort of data that is readily available to bettors. The size of the jackpot is widely advertised, as is the outcome of each drawing with respect to the number of winners. If players tend to judge the likelihood of winning based on the frequency with which someone wins, then a larger state can offer a game at longer odds but the same perceived probability of winning as a smaller state. The larger population base in effect conceals the smaller probability of winning the jackpot, while the larger jackpot is highly visible. This interpretation is congruent with prospect theory.

The scale effect evident in lotto presents an interesting contrast to the scale effect in insurance markets. In insurance markets, a wider pool lowers costs by reducing risk premiums to investors. While the widespread aversion to risk in investment instruments produces economies of scale in an insurance pool, the widespread preference for risk in gambling instruments produces economies of scale in lotto.²

Our analysis of lotto begins with a brief description of the game, and a theoretical account of the economics of scale. The premise is that the size of the jackpot matters to lotto players more than the probability of winning. If true, then per capita lotto sales will increase with the size of the state population. Subsequent sections report empirical results which demonstrate the validity of this implication. These results provide a basis for predicting sales of a multistate lotto consortium. We also report an analysis of time series data for Massachusetts, with an estimate of the "jackpot elasticity of demand" in that context. In Section IV the implications for lotto design are briefly developed.

I. Background

Lotto was not introduced as a state lottery game until 1980, although it has long been popular in Europe.³ During the 1980s it has been adopted by most all of the state lotteries. Lotto sales in states offering this game have grown rapidly to an

average of \$47 per capita in 1989, out of total sales of \$115 per capita in those states.

The rules of lotto can be illustrated with those of the Maryland Lotto. A single play consists of choosing six of the numbers between 1 and 49. The minimum bet is one dollar, for which bettors receive two plays. Each play is recorded via an on-line computer link to headquarters. Once a week there is a drawing at which the winning combination of 6 numbers is selected at random. There are 13,983,816 possible combinations, and the probability of choosing the winning combination is 1:6,991,908 for each dollar bet.⁴ Winners (if any) share the grand prize jackpot, which is normally paid out in 20 installments. Lesser prizes are awarded at every drawing to players who correctly choose 4 or 5 of the numbers in the winning combination of 6. Prizes (including the jackpot) depend on the total volume of play: 50 per cent of the "handle" (total amount bet) goes to the prize pool, and 78.4 percent of that goes to the jackpot. If there are no jackpot winners in a drawing, then the amount of the jackpot is added to the new jackpot for the subsequent drawing. Table I summarizes the rules of lotto games in other states.

Among the important characteristics of every state's lotto game are these: 1. The probability of winning the jackpot on a single dollar bet is infinitesimal, ranging from 1 in 974,000 (Delaware) to 1 in 23 million (California); 2. The size of the jackpot depends on the handle; 3. The jackpots are several hundred thousand dollars or more; and 4. The size of the lotto

jackpot and stories of jackpot winners are prominent news items in lottery states.

II. The Theoretical Importance of Scale

A. Expected Value of a Lotto Bet

Since the prize pool is typically only half of the handle, most lotto bets are far short of fair. A calculation of the expected value of a bet reveals a surprising feature of the game: the expected value of a \$1 bet depends not only on the fraction of the handle going to the prize pool, but also on the total amount bet by other players. There is an interesting externality created by the rules of the game: when player A bets a dollar, she has increased the jackpot available to player B (a positive externality) and simultaneously increased the chance that if B does win the jackpot, he will have to split it with someone else (a negative externality). In terms of the effect on the expected value, the former is larger than the latter; adding another player to the pool increases the expected value of a bet.⁵

To demonstrate this point, we begin by adopting the simplifying assumption that players choose the numbers they play at random. (Later we discuss the implications of relaxing that assumption.) Then the expected value of the jackpot from betting B different combinations (at \$1 each) is

$EV = (\text{probability of win}) \times (\text{jackpot}) \times (\text{expected share of jackpot if win})$, which can be closely approximated by the expression⁶

(1)

$$(pB) [R+k (B + N)] \left[\sum_{x=0}^N \frac{1}{1+x} e^{-pN} \frac{(pN)^x}{x!} \right]$$

$$\approx \frac{B}{N} [R+k(B+N)] (1-e^{-pN})$$

where

- k = fraction of handle going into the jackpot
- N = amount bet by other players
- R = rollover from previous drawings
- p = probability of winning in a single play

If there is no rollover ($R = 0$) and the bet is just one dollar ($B = 1$), then this expression is a monotonically increasing function of N , asymptotic to k . For most state lotto games, pN is about 1 (as shown in Table 1), so when there is no rollover the EV of a single play is less than the payout rate k . For example, suppose that 25% of the handle is placed in the jackpot, and 25% is awarded in smaller prizes (all of which is awarded at each drawing). If the chance of there being a jackpot winner is 60%, then the EV of a \$1 bet is only \$.40 (\$.25 from smaller prizes, and \$.15 from the jackpot) despite the fact that 50 percent of the handle is going into the prize pool. Of course, if there is no winner in the first drawing, then the jackpot (and the EV) will be larger in the next drawing.

The assumption that lotto players pick their combinations at random requires some discussion. Almost every lotto agency does

offer players the option of having a computer pick numbers at random to bet for them (Leonard A. Paster, 1987, 22). But many players choose their numbers through some other process. In the aggregate, one result of players making conscious choices is that there is greater concentration of play on certain numbers and combinations than would result from random selection.⁷ For example, we found that on one lotto drawing in Maryland, over 3200 players had selected the combination 1,2,3,4,5,6. If that combination had won, the jackpot winners would have received a measly \$193.50 each (Charles T. Clotfelter and Philip J. Cook, 1989, p. 86).

A related effect of conscious selection is that there is less "coverage" than would result from random play; that is, for a given handle, the number of combinations that have been bet at least once will be less with conscious selection.⁸ However, as long as some players bet randomly, coverage will increase with the size of the handle, and the complementary probability of a rollover will fall as the handle increases, just as would be predicted from the assumption of random play. However, we need to qualify the conclusion that the expected value of a bet increases with the handle; this conclusion is true if players make selections randomly, but is not well defined if they do not. One approach to providing definition for the expected value concept when selection is conscious is to assume that from the perspective of any one player, choices made by others are probabilistic, with probabilities that differ among the

combinations. Then it is true that the EV of a bet on any one combination will increase monotonically with the size of the handle. In that sense, the assumption of random play is not essential to demonstrating the nature of the externalities involved in the game.

This section has discussed the externalities inherent in the parimutuel lotto game. The addition of a new player to the pool creates a positive externality (larger jackpot) and a negative externality (smaller expected share of the jackpot to a winner). In practice, state lottery agencies have adjusted the format of their games so that the expected jackpot share is about the same in large states as small states. In the theoretical section above, it was demonstrated that the expected jackpot share (and the probability that there will be at least one winner) is determined by the product of the probability and the number of bets. As shown in Table 1, most all of the 14 lotto games have selected formats so that the product of their probability and their state population is close to one. (All but Pennsylvania lie in the interval 0.6 to 1.5.) This choice of formats is presumably a reflection of bettor preferences with respect to such matters as the likelihood of having no winner in a drawing, and the likelihood of having multiple winners in a drawing. Relevant considerations with respect to choice of lotto format are further developed in the next section.

B. Scale and Lotto Design

Suppose two states offer identical lotto games and experience the same average sales per week. Further suppose that the lottery directors are considering merging these two games in the hope of increasing per capita sales in both states. If the rules of the merged game are the same as for the old games, then the new game would have a larger jackpot (which is of course attractive to players) and an outward shift in the probability distribution of the number of winners on any one drawing (which is unattractive). But one option for the directors is to change the rules: in particular, they could cut in half the probability of winning on a single play. Since the probability distribution of the number of winners depends only on pN , the new game will have the same distribution of the number of winners as the old one ($p^* = p/2$; $N^* = 2N$; $p^*N^* = pN$). From the players' perspective, then, the new game will offer a larger jackpot at a reduced probability, with all else unchanged. Will the new game generate higher sales per capita? We believe it will, primarily because bettors' evaluation of a lotto bet tends to be more sensitive to the size of the jackpot than to the objective probability of winning:⁹

*The probability of winning is not advertised and will not be "known" in any sense to most bettors. On the other hand, the jackpot size is common knowledge (although the advertised size distorts its true value).

*People tend to classify small probability events rather crudely as either possible or impossible (Daniel Kahneman and Amos Tversky, 1984, 345). As long as someone wins the jackpot at almost every drawing, then it seems likely that most players will continue to view the new lotto game as offering a real possibility of winning.¹⁰

*Many players do not accept the scientific view of chance, but rather believe that the probability of choosing a winning combination in a lottery game can be improved through the application of skill and effort (Ellen J. Langer, 1975; Langer and Jane Roth, 1975). This belief is evidenced by the active market in advice for choosing lottery numbers, offering everything from numerology texts to news articles that explain what system the latest winner was using.

These arguments support the conclusion that has already been reached by the lottery industry -- that bigger is better for the game of lotto. Three New England states have merged to offer the TriState lotto game, while LottoAmerica was launched in 1988 with five states and the District of Columbia. (Several additional states have joined since then.) The empirical evidence in support of these mergers is quite clear, as shown in the next section.

III. Findings

A. Cross Section

Table 2 presents the results of regressions run on cross section data for the 17 states that offered lotto games

throughout FY 1986. The dependent variable in each case is lotto sales divided by the state population. All seven specifications were estimated in log linear form, and all include population¹¹ and state per capita income. The results for the population variable confirm that the scale of the game has a positive effect on sales per capita. The estimates of the elasticity of sales with respect to population range from .41 to .52, and all of these estimates are significantly different than zero at the 1% level. These regressions also show that sales are highly sensitive to per capita income. Of the other variables, the effect of the percentage of the state population that is black is small and statistically insignificant throughout, whereas the payout rate and the relative size of the urban population both have significant positive effects when entered together.

It should be noted that those cross section results are for lotto games that differ with respect to the game format. In particular, the larger states tend to offer lotto games with a smaller p (for reasons suggested in the theoretical discussion). If all state lottery agencies choose the optimum game format given the state population and other characteristics, then the coefficient on population can be interpreted as an unbiased estimate of the "envelope" of possible sales across states. If some states have chosen a suboptimal format, then the coefficient estimate may be biased.

In contrast to lotto, there is no obvious reason why per capita sales of the numbers game will be influenced by the scale

of the game. We replicated the regressions reported in Table 2, replacing lotto sales with sales of the numbers game as the dependent variable. In these regressions population size has little or no effect on numbers sales. (Indeed, the only variable in these regressions that is statistically different from zero in a statistical sense is the proportion of the population that is black.) In a sense, these regression results for the numbers game strengthen our conclusion concerning the causal importance of population in lotto sales; the population coefficient estimates for lotto sales are not an artifact of some omitted "gambling preference" variable that happens to be correlated with population across these states.

The lotto results can be used to predict the sales of the new LottoAmerica consortium. Based on Equation 1 of Table 2, we predict that per capita sales in each of the six jurisdictions in this consortium will increase by a factor ranging from 1.8 (Iowa and Oregon), up to a factor of 3.6 (District of Columbia), as a result of creating a pooled population base of nearly 12 million.

B. Time Series

The cross section results on lotto sales demonstrate that sales increase with the scale of operation, presumably because sales are sensitive to the size of the jackpot. We also analyzed time-series data for a single state to estimate the effect of the jackpot on lotto sales in that context.

Table 3 reports regression results for 169 consecutive lotto drawings in Massachusetts. The variables included in Equation 1 to explain total weekly lotto sales are "time," a dummy variable for Saturday drawings (which attract more "action" than Wednesday drawings), and the rollover from the preceding drawing. The rollover is zero if there is a winner the preceding drawing (which occurred in 72 percent of the drawings included in this data set); otherwise rollover is equal to the advertised jackpot for the preceding drawing. Since jackpots are actually paid in 20 annual installments, their present value is about half the advertised amount (assuming an annual discount rate of 9 percent). The coefficient estimate implies that a thousand dollar increase in the advertised jackpot generates \$418 of additional lotto sales; equivalently, a \$500 increase in the present value of the jackpot generates \$418 in additional sales.

Assuming that bettors anticipate that there will be heavier betting when there is a rollover, then they will anticipate a larger jackpot for these drawings than would result simply from the addition of the rollover to a normal jackpot. The second regression in Table 2 shows that the jackpot is increased by \$1,255 for every \$1,000 rolled over from the previous drawing. The "extra" \$255 is the result of the additional betting stimulated by the rollover. If the bettors exhibit rational expectations, then they will decide how much to bet on the basis of the expected jackpot. The third regression is motivated by this assumption. The coefficient on the "predicted jackpot"

variable (derived from equation 2) implies that a \$1,000 increase in the expected jackpot increased sales by \$333. This result can be converted to an elasticity of sales with respect to the jackpot (present value). For drawings when there is no rollover, this elasticity is about 0.2 -- less than half of the cross-section estimate of sales elasticity with respect to population (from Table 2). This difference in elasticities may be explained by the fact that the Massachusetts game format remains constant over time, regardless of the handle; in the cross-state data, game format differs from state to state, and is chosen by lottery authorities to suit the typical handle.

When there is a large jackpot due to a rollover, lotto play increases. Does the extra betting on lotto come at the expense of other lottery games? We explored this possibility using data on numbers sales for the same period as that for the lottery sales data, and found that the amount of rollover in the lotto jackpot has a negligible effect on numbers betting. Thus the increased lotto sales that result from a rollover situation do not come at the cost of reduced numbers sales. The lure of a large jackpot brings new money into the lottery.¹²

IV. Implications

A small state seeking to increase per capita lotto sales has several options. First, it could increase the fraction of the handle going into the jackpot. But the regression estimate of the "jackpot elasticity of demand" in Massachusetts suggests that

the additional betting engendered by this ploy will not cover the cost.¹³ Second, it could seek to mimic the game offered by a larger state by guaranteeing a large minimum jackpot while changing the format to produce a corresponding reduction in the probability of winning. This ploy would surely fail, however, because the game would lose credibility after going many weeks without a winner. Third, it could join with other states to increase the population base for the game, and that is what a number of small states have in fact done.

The scale effect evident in lotto forms an interesting contrast to the scale effect in insurance markets. In insurance, people choose to pay a premium to eliminate the small probability of a large loss; in lotto, people choose to pay a premium to create a small probability of a large gain. In the insurance case, increasing the "scale" by forming a larger pool of independent risks is attractive because it reduces the investment risk. In the case of lotto, increasing scale is profitable because it allows the provision of a more risky instrument (that is not necessarily perceived as such). In both cases, bigger is better.

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Table 1
Lotto Format and State Population, 1990

State	Format	1/p (thousands)	Population (thousands)	Pop x p
AZ	6/42	5,246	3,752	0.7
CA	6/53	22,957	29,126	1.3
CT	6/40	3,838	3,279	0.9
DE	6/36-2	974	666	0.7
IL	6/54-2	12,914	11,612	0.9
MD	6/49-2	6,992	4,729	0.7
MA	6/46	9,367	5,880	0.6
MI	6/47	10,738	9,293	0.9
NJ	6/47	10,738	7,899	0.7
NY	6/54-2	12,914	17,773	1.4
OH	6/44	7,059	10,791	1.5
PA	6/48-2	6,136	11,827	1.9
Tri-State*	6/40	3,838	2,916	0.8
WA	6/44-2	3,530	4,657	1.3

*Maine, New Hampshire, and Vermont.

Definitions: "Format" describes the choice that a bettor makes in playing the game. In every state, a single play consists of choosing 6 of the numbers between 1 and n, where n differs from state to state. In some states, bettors make 2 plays for a dollar, which doubles the probability of winning the jackpot (p).

Note: The states that have joined Lotto America are excluded from the above list.

Source: Format information gathered by telephone. The Population data are from Statistical Abstract of the United States, 1990, p. 24.

TABLE 2
 FY'86 LOTTO SALES REGRESSIONS: Log Linear Specification

(t-statistics in parentheses)

REGRESSION NUMBER

INDEPENDENT VARIABLE	(1)	(2)	(3)	(4)	(5)	(6)	(7)
1. Intercept	-21.43*	-16.49*	-17.13*	-21.78	-19.04*	-12.35	-18.06
	(2.8)	(2.5)	(2.9)	(3.0)	(2.4)	(1.9)	(2.9)
2. Population ^a	0.44**	0.41**	0.47**	0.45**	0.48**	0.47**	0.52**
	(4.9)	(5.0)	(5.5)	(5.4)	(5.2)	(5.8)	(6.8)
3. P.C. Income ^b	2.56*	1.90*	2.21**	2.28*	2.42*	1.53	1.94*
	(3.1)	(2.4)	(3.7)	(2.9)	(3.0)	(2.1)	(2.8)
4. Black ^c	-0.04	---	---	-0.12	-0.03	---	-.14
	(0.5)			(1.4)	(0.4)		(2.0)
5. Urban ^c	---	0.31	---	0.72	---	0.53	1.04*
		(0.86)		(1.6)		(1.5)	(2.6)
6. Payout Rate ^d	---	---	1.63	---	1.57	2.26	2.55*
			(1.3)		(1.2)	(1.8)	(2.3)
R ²	0.79	0.80	0.81	0.83	0.82	0.85	0.89
Root MSE	0.29	0.29	0.27	0.27	0.28	0.26	0.23

* p<.05

** p<.01

Note: All variables are in natural log form.

Mean for dependent variable (per capita numbers sales) was 3.44.

Regressions based on the 16 states which had numbers games throughout FY '86.

Sources:

a. Estimates of 1985 population from Bureau of Census, Current Population Reports Series, p-25, No. 998, Dec. 1986.

b. Per capita income from Government Finances (GF 85-No.3)

c. Percent black and percent urban for 1980 from Statistical Abstract of the United States, 1986.

d. Payout rates obtained by telephone from state lottery commissions.

e. Per capita sales computed using FY '86 data from Gaming and Wagering Business, May 1987, and provisional population estimates (note a).

TABLE 3

Massachusetts Lotto Sales 7/21/84 to 3/1/86 (\$1,000's)

(Standard errors in parentheses)

Ind. Var/Dep. Var	(1) Total Wager	(2) Actual Jackpot	(3) Total Wager
Intercept	2,935 (102)	2,512 (172)	2,098 (114)
Rollover (\$1,000's)	0.418 (0.019)	1.255 (0.031)	---
Saturday	559 (89)	360 (150)	439 (89)
Time	7.066 (0.923)	1.548 (1.548)	6.550 (0.926)
Predicted Jackpot (\$1,000's)	---	---	0.333 (0.015)
R ²	0.80	0.91	0.80
D.W.	2.022	1.977	2.022

Lotto drawings occur on Wednesdays and Saturdays.

The "Actual Jackpot" is the sum of 20 annual payments.

"Predicted Jackpot" is calculated from equation 2.

"Rollover" is equal to zero if there is a winner in the preceding drawing; if no winner, then it is equal to the jackpot for the preceding drawing.

"Time" is a counting variable, running from 1 the first period to 170 the last.

(ALTERNATE) TABLE 3

Massachusetts Lotto Sales 7/21/84 to 3/1/86 (\$1,000's)

(Standard errors in parentheses)

Ind.Var/Dep.Var	(1) Total Wager	(2) Actual Expected Value	(3) Total Wager
Intercept	2,935 (102)	0.529 (0.161)	623 (302)
Rollover (\$1,000's)	0.418 (0.019)	1.160×10^{-4} (0.062×10^{-4})	---
Rollover (\$1,000's) - Squared	---	-5.491×10^{-9} (0.653×10^{-9})	---
Saturday	559 (89)	.0022 (0.140)	461 (147)
Time	7.066 (0.923)	-4.162×10^{-4} (1.444×10^{-4})	10.039 (1.510)
Predicted E.V.	---	---	4,391 (413)
R ²	0.80	.80	.50
D.W.	2.022	1.85	1.89

Lotto drawings occur on Wednesdays and Saturdays.

The "Actual Expected Value" is given by $\frac{J(1 - e^{-pN})}{N} + .1744$;

the constant is the E.V. of prizes awarded for choosing 4 or 5 of the 6 numbers correctly. In Massachusetts, $p = 5.13 \times 10^{-7}$

"Rollover" is equal to zero if there is a winner in the preceding drawing; if no winner, then it is equal to the jackpot in the preceding drawing.

"Time" is a counting variable, running from 1 the first period to 169 in the last.

ENDNOTES

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1. In Canada, five provincial lotteries offer a lotto game under the umbrella of the Interprovincial Lottery Corporation. The other provinces each offer their own lotto game.

2. One referee suggested that since the advantage of scale in lotto has to do with externalities in consumption, rather than with the costs of provision (the usual source of scale economies), the term "economies of scale" is not apt. However, others have used this term as we do here. For example, Michael L. Katz and Carl Shapiro's (1985) discussion of network externalities includes this statement: "...consumption externalities give rise to demand-side economies of scale,...(p. 425)."

3. Lotto is currently offered in Canada, Mexico, Brazil, the USSR, Hong Kong, Australia, New Zealand, and a number of European countries.

4. This is twice the probability that a random drawing of 6 numbers from 49 (without replacement) will match 6 predetermined numbers. That probability is given by the expression $49!/6!43!$

5. The possible exception to this rule occurs when the jackpot includes a rollover that is large relative to the amount that is bet on any one round.

6. The third term in this expression makes use of the Poisson approximation to the binomial distribution for the probability that there will be x winners in N independent random trials each with a probability p of success.

7. William T. Ziemba (1986, 46-55) discusses the strategy of playing "against the crowd" in lotto. He notes that it is possible to identify certain numbers which are consistently unpopular; playing combinations of such numbers in lotto reduces the probability that a winner will have to share his or her jackpot with others. Playing this strategy increases the expected value of a bet over a strategy of choosing numbers at random, but no strategy will yield a favorable bet (when there is no rollover) unless the total amount bet exceeds twice the reciprocal of the probability of winning the jackpot, since the prize pool is 50 percent or less of the total amount bet. Data presented below indicate that in most states the amount bet is approximately equal to the reciprocal of the probability of winning.

8. We studied this effect using data from from 38 drawings in Illinois (September 3, 1986 to January 10, 1987). The coverage for these data is consistently about eight percentage points less in fact than would result from completely random play. The correlation between actual coverage and predicted (random) coverage is very close to one.

9. As a technical point, it should be noted that this will be true for utility-maximizing players who are risk lovers. However, people who are consistent risk lovers (over the full range of wealth) are presumably rare, since most of them would very soon be bankrupt. Nevertheless, there is no reason to assume that lottery bettors are necessarily irrational. As Milton Friedman and L.J. Savage (1948) suggested, it is quite reasonable for normally risk-averse people to be willing to pay a premium (over expected value) for a chance of winning an improvement in their standard of living large enough to cause a qualitative change in their social standing. The Friedman-Savage explanation is discussed by Shapira and Venezia (1990), who offer experimental evidence on the attractiveness of different lotto prize structures.

10. Another reason why people may overestimate the probability of winning is wishful thinking. The desirability of the outcome of a prospect has been shown to influence subjective probability assessments. "People may overestimate the chances of winning a lottery because of the excitement of winning and underestimate the chances of having their houses destroyed by an earthquake because of its horror (Colin F. Camerer and Howard Kunreuther, 1989, p. 571)." Notably, the "excitement of winning" may increase with the size of the jackpot and the quantum of fame that comes with winning, both reasons why a game with lower probability and higher jackpot will be more attractive.

11. For the three states in the TriState consortium, Vermont, New

Hampshire, and Maine, the population figure used in the regression is the sum of the populations of these three states.

12. Other data, reported in Clotfelter and Cook (1987, p. 538) suggest that large jackpots are particularly appealing to relatively high income players. The income distribution of lotto players is higher when the jackpot is above \$5 million than otherwise.

13. Some states do guarantee a minimum jackpot, regardless of the handle.