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94-03

UCD Department of Agricultural Economics

WORKING PAPER SERIES

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LOTTO AND MONEY ILLUSION

by
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Working Paper No. 94-03

LOTTO AND MONEY ILLUSION

I. Background

Early in this century Irving Fisher argued that there exists among the public a pervasive "money illusion", which he defined as a "... failure to perceive that the dollar, or any other unit of money, expands or shrinks in value" (1928, p.4).[1] According to Fisher, people are predisposed to view their national unit of currency as a standard measure of value, just as they consider meters or yards to be standard measures of length. Due to this widespread misperception, decisions to produce, consume, save and invest are influenced by purely nominal changes in economic variables, with negative implications for economic stability and welfare. The damages Fisher attributes to money illusion are twofold. First, by fostering the use of long-term nominal contracts, money illusion leads to unanticipated welfare transfers (i.e., between debtors and creditors, or stockholders and bondholders) during periods of inflation or deflation. Second, money illusion is a major contributor to business cycle fluctuations. Producers, unable to fully distinguish between nominal and real output price changes, adjust output and investment levels procyclically in response to currency fluctuations. Likewise, households alter their level of real savings in response to changing nominal interest rates, accommodating business expansion during inflationary periods and stifling business activity during periods of deflation. Fisher concludes that in the presence of money illusion, "...the effect of the unstable dollar is to expand business unduly during inflation and to contract it unduly during deflation" (1928, pp.91-2).

Although decades have ensued since Fisher advanced this hypothesis, the notion that money illusion is an important determinant of real economic activity continues to be viewed with ambivalence by many economists. On the one hand, both the theoretical and practical implications of money illusion are unappealing. A general inability or unwillingness to account for inflation seems to suggest a lack of rationality on the part of consumers and producers; or at least a puzzling failure to utilize available information, such as published consumer price indexes. Furthermore, to admit the existence of money illusion is problematic for empirical research. For example, it implies that supply and demand functions may be improperly specified unless they include both nominal and real variables as arguments. Yet on the other hand, economists are loathe to dismiss the possibility of money illusion in the face of considerable evidence that it is important. A theoretical argument in defense of money illusion was offered by Patinkin (1949), who showed that in its absence the equilibrium level of nominal prices is indeterminate. Empirical studies also tend to support the money illusion hypothesis (Branson and Klevorick 1969; Kahneman, Knetsch and Thaler, 1986), as does the sheer prevalence of nominalism in pricing, wage-setting, lending and taxation. If only real values matter, as suggested by neoclassical theory, then why are they not more widely used in business transactions?

Much of the debate over money illusion has centered on labor markets, and in particular on the phenomenon of sticky nominal wages as specified in Keynes' *General Theory* (1936). While Keynes himself attributed nominal wage stickiness to a coordination failure associated with union bargaining, Leontief (1936) and Barro (1977) have argued that to specify nominal wages as rigid is tantamount to assuming money illusion on the part of labor. As the relative importance of unions in wage-setting has declined, New-Keynesians have advanced alternative explanations for sticky wages, including menu costs of wage adjustment, efficiency wage-setting, insider-outsider models and implicit contracting (Gordon 1990; Mitchell 1993). However, Mitchell argues that while this literature succeeds in explaining why **real** wages may be less than flexible, it fails to adequately address the underlying cause of **nominal** wage stickiness. He concludes that the "seemingly undue wage nominalism" observed in labor markets is best attributed to workers' perception of nominal currency as a standard of value; that is, to money illusion in the Fisherian sense. His argument is supported by survey data on perceptions of wage fairness, which indicate that real wage reductions are viewed differently depending on whether they originate with nominal wage cuts or general price increases (Kahneman, Knetsch, and Thaler 1986; Tversky and Kahneman 1986). For instance, this line of research indicates that a two percent nominal wage increase during a period of five percent inflation is far more likely to be viewed as "fair" by survey respondents than is a three percent nominal pay cut during a period of zero inflation, even though both actions affect the real wage identically.

Another avenue of research on money illusion regards the homogeneity of aggregate demand functions with respect to nominal prices, income, and wealth. Patinkin (1949, 1965) has shown that in a static world with perfect information, a proportional increase in nominal income, nominal wealth and nominal prices leaves purchasing power unaltered, and therefore should not affect a rational agent's demand for goods. An empirical test of this proposition by Branson and Klevorick (1969) rejected the hypothesis that aggregate U.S. consumption is homogeneous of degree zero, thus confirming the presence of money illusion.

Despite the long history of this discussion, the existence of money illusion and its potential impact on real economic activities remain unsettled issues to date. As noted above, previous empirical studies of this phenomenon have focused largely on labor markets, where analysis is hindered by various institutional complexities (e.g., unionization, unemployment insurance, and minimum nominal wages); or have been based on highly aggregated consumption data, in which case problems of aggregation bias and informational lags may affect the results. In order to gain a fresh perspective on this issue, this study tests for evidence of money illusion among players of lotto, a lottery game operated by many state governments as a source of tax revenues. The empirical approach taken here rests on a peculiar institutional feature of lotto games; namely, the practice of systematically overstating the value of grand prizes by an annuity multiplier, a factor that varies positively with the nominal discount rate for long-term annuities. This practice, which by its very existence is suggestive of money illusion, permits a direct test of the impact of money illusion on the demand for lotto tickets. If players are free of money illusion, they should distinguish between changes in the cash (present) value of the jackpot, and changes in its announced value that arise solely from fluctuations in the nominal discount rate. If instead they suffer from money illusion, the amount by which this biased perception affects lotto sales can be estimated.

II. Modelling lottery demand

Lotto is a gambling game that features remote odds of winning large prizes. From the players' perspective, the object of the game is to match a set of k numbers drawn randomly by lottery officials from a larger field of n integers. For example, a typical "49 pick

6" game format requires players to select 6 integers from the field {1,...,49}, without replacement. The grand prize pool is shared equally among ticketholders who correctly match all 6 integers. Lesser prize pools are split among those matching 5, 4, or 3 numbers.[2] Grand prizes are generally paid in the form of annuities, while smaller prizes are paid in cash. The per-ticket probability of matching all k numbers is designed to be very low relative to the population of potential gamblers, thus ensuring that for many draws there is no grand prize winner. In this case unclaimed prize pools "roll over" into the grand prize pool for the next draw. Occasionally a series of several consecutive rollovers results in a huge prize pool, causing ticket sales to escalate. As ticket sales increase, the probability that there will be no winner declines; thus eventually the jackpot is awarded and the game reverts to its original state.

In contrast to lotto, which is characterized by a dynamic and stochastic payoff structure, much of the theoretical and experimental literature on risky choices is concerned with agents' preferences over static lotteries; i.e., lotteries for which the set of possible payoffs and their probabilities are constants that are known to prospective players. Before analyzing the more complex case of lotto, it is useful to begin by examining lottery demand in the static case.

Demand for static lotteries. Before turning to the case of lotto, first consider the demand for a static lottery game $\mathcal{L}$, which is characterized by a set of positive per-ticket payoffs $\mathbf{z} = (z_1,...,z_j)$ with corresponding probabilities $\mathbf{p} = (p_1,...p_j)$. Let prizes be ranked in descending order, with z_1 being the grand or first prize. Assume that $\mathbf{p}$ and $\mathbf{z}$ are parameters that are announced to prospective bettors prior to each draw. Upon paying a nominal entry fee, a player receives a lottery ticket entitling him or her to one draw from this prize distribution. A representative consumer's demand for $\mathcal{L}$ is:

$$q = f(\mathbf{z}, \mathbf{p}, c, \mathbf{w}) \tag{1}$$

where q is the quantity of lottery draws purchased; **z** and **p** are the game's payoffs and odds, respectively; c is the entry fee per draw; and **w** is a vector of demand shifters such as income and prices of other goods. *Ceteris paribus,* demand is expected to be increasing with respect to p_j and z_j and decreasing with respect to c;[3] other properties of q remain to be established empirically.

For a population of n agents, aggregate lottery demand is

$$Q = nq \tag{2}$$

To provide funds for prize payments, lottery managers establish j prize pools, $\mathbf{Z} = Z_1,...,Z_j$, one for each category of prize. Each prize pool is funded by a fixed percentage of total sales:

$$Z_i(Q) = \theta_i cQ \tag{3}$$

where Qc is gross sales revenue and θ_i is the revenue share devoted to prize pool i.

Let $\mathbf{P} = P_1,...,P_j$ be the probabilities associated with the payout of prize pools **Z.** Under the current definition of a static game, each prize pool is certain to be awarded at the end of each draw, and so

$$P_i = 1 \quad \forall i \tag{4}$$

In order for the game to be actuarially sound, expected payouts from prize pool i ($E\{Z_i P_i\}$) must equal expected claims of winners against prize pool i ($E\{z_i Q p_i\}$). This condition will be met if the following relationship holds between the lottery's parameters:

$$z_i(Q) = \frac{Z_i(Q)\,P_i}{Qp_i} = \frac{\theta_i c}{p_i} \tag{5}$$

Note that in the static game the per-ticket prize z_i depends only on game parameters and is independent of Q; lottery managers can choose any three of the four parameters (z_i, p_i, c, θ_i), with the fourth being determined by (5). As will be shown in the next section, this is not the case for lotto, where z_i is endogenous and stochastic.

Lastly, combining (1) and (6) yields the per-capita demand function in term of the game's parameters:

$$q = f\left(\frac{\theta_1 c}{p_1},\ldots,\frac{\theta_j c}{p_j};\ p_1,\ldots,p_j;\ c,\ w\right) = g(\theta,p,c,w) \tag{6}$$

In this reduced form p_i is seen to have an ambiguous net effect on demand, increasing the likelihood of winning prize i but reducing the amount of the prize. Thus an element of optimal lottery design consists of choosing the combination of prizes and odds that are most preferred by consumers.

Demand for lotto. From the player's perspective, lotto is distinguished from a static lottery by per-ticket payoffs (**z**) that vary from draw to draw and are stochastic. Lacking knowledge of **z**, lotto players form subjective beliefs about **z** that are likely to vary with the state of the game. The variability of these projections arises from several sources. First, rollovers from previous draws can augment the grand prize pool of the current draw, so that the relationship of the grand prize pool (Z_1) to sales revenues (Qc) is not constant as in a static game. Second, both the probabilities that top prize pools will be awarded (P_1 and P_2) and the expected number of winners in each prize category are endogenous functions of total sales (Q); thus forecasting the game's per-ticket outcome involves predicting the behavior of other players. And third, lottery officials do not disclose the estimated cash value of the grand prize pool Z_1; rather, they announce the undiscounted sum of payments from an annuity they expect to purchase with Z_1. On average, this practice inflates the apparent cash value of the prize pool by a factor of two. However, the degree of distortion varies, being a function of prevailing annuity discount rates. If money illusion exists, these changes in the annuity multiplier are potential sources of demand variability. For instance, a prize pool containing \$5,000,000 in cash may have an announced value of \$9,000,000 or \$11,000,000, depending on the current multiplier.

To develop a model of lotto demand, begin by modifying equation (1) to reflect agents' uncertainty about the amounts of possible prize awards:

$$q = f(\hat{z}, p, c, w) \tag{1'}$$

Here $\hat{z}_i$ indicates the bettor's subjective beliefs about the game's per-ticket prizes, with other variables defined as in the static game. As in (1), it is expected that the direct effects of $\hat{z}$ and p_i on demand are positive, while the direct effect of c is negative.

As in the static case, aggregate demand is

$$Q = nq \tag{2'}$$

Equation (3), describing cash prize pool amounts, is modified to reflect the possibility that the grand prize will be augmented by a rollover (R) from the prior draw:

$$Z_i(Q) = \begin{cases} \theta_1 Qc + R, & i = 1 \\ \theta_i Qc, & i = 2,\ldots,j. \end{cases} \tag{3'a}$$

Information regarding the actual or anticipated level of the various prize pools are not disseminated to prospective lotto players. Instead, lottery officials calculate and announce the aggregate sum of undiscounted annuity payments that are expected to be purchased with Z_1. Let Z_1^A denote this announced value or so-called "expected jackpot". Conditional on Q, its value equals Z_1 times an annuity multiplier, M. The value of M is market-determined and exogenous, and depends solely on the number of annual payments (t) and the current discount rate (k) for annuities due of length t.[4]

$$Z_1{}^A(Q) = Z_1(Q)\left[\frac{kt}{[1-(1+k)^{-t}](1+t)}\right] = Z_1(Q)M \qquad \textbf{(3'b)}$$

As we are interested in determining whether players distinguish between variations in the cash value of the jackpot (Z_i) and changes in the annuity multiplier (M), let players' subjective beliefs about the grand prize pool be given by:

$$\hat{Z}_1 = Z_1(Q)h(M) \qquad \textbf{(3'c)}$$

where h(M) is a measure of the degree of money illusion. If agents are illusion-free, then h is a constant; while if agents are entirely unable to differentiate between changes in Z_i and M, then h(M) = M.

Next, recall that a key difference between lotto and static lotteries is that top prize pools sometimes roll over rather than being paid out to current bettors. Under the assumption that lotto players choose their numbers randomly, probabilities of payout conditional on Q are

$$P_i(Q) = (1 - (1-p_i)^Q) \leq 1 \qquad \textbf{(4')}$$

More generally, if certain lotto numbers are more popular than others, then $P_i = P_i\ (Q,\ p_i)$, an amount less than that given by (4'). In either case, the probability that prize pools will be awarded approaches certainty as Q grows large. This phenomenon limits the consecutive number of rollovers observed.

Given ticket sales Q, the representative consumer's subjective expectations regarding the per-ticket prize vector **z** are given by

$$\hat{z}_i|Q = \frac{\hat{Z}_i(Q)P_i(Q)}{Qp_i} = \begin{cases} (\frac{\theta_1 c}{p_1} + \frac{R}{Qp_1})[1-(1-p_i)^Q]h(M), & i=1; \\ (\frac{\theta_i c}{p_i})[1-(1-p_i)^Q], & i=2,...,j. \end{cases} \tag{5'}$$

This expression will be independent of M so long as individuals are illusion-free. Inserting (5') and (2') into (1') yields an expression for individual lottery demand, conditional on aggregate ticket sales:

$$q|Q = f(\hat{z}(\theta,p,c,w,R,M,nq);p;c;w) \tag{6'a}$$

Assuming no sunspot equilibria, equation (6'a) implicitly defines expected per capita wagering:

$$\hat{q} = g(\theta,p,c,w,R,M,n) \tag{6'b}$$

Then given representative agents, per capita lotto demand is

$$q = g(\theta,p,c,w,R,M,n) \tag{6'c}$$

Of greatest interest here is the presence of M, the annuity multiplier, in the demand function. In the next section, this equation is estimated in order to test whether M is significant in explaining draw-by-draw demand for California lotto tickets.

III. An empirical application: California lotto

Data and variables. To test whether lotto players evince money illusion, this section develops empirical estimates of lotto demand, based on equation (6'c) and draw-by-draw data on California lotto sales. In the lotto game's first year of operation, draws were held weekly (each Saturday). Beginning in October 1987, a Wednesday draw was added. The period of analysis is from October 18, 1986, when the first draw was held, through March 6, 1991, when a competing game (misnamed "little lotto") was introduced in direct competition with lotto. Thus the length of the sample is 409 observations..[5]

For each draw, primary lotto data obtained from the California lottery includes ticket sales (Q), announced jackpots, and the number of winners by prize category. In conjunction with information on game parameters θ_i and **p**, these data were used to calculate the dollar amount of the rollover (R) and the annuity multiplier (M) by draw.[6] Game parameters θ_i and **p** remained constant from October 1986 to June 1990, during which time the game had a "49 pick 6" format. In June 1990 the game was modified in an effort to generate larger jackpots, and it was hoped, higher sales. Two changes were made simultaneously. First, a "53 pick 6" format was adopted, substantially reducing the values of p_i (e.g., p_1 fell from about one in 14 million, to 1 in 22 million.) Also, the share of revenues going to the grand prize pool (θ_1) was increased at the expense of lesser prizes. Since the individual effects of these changes cannot be distinguished in the data, their joint effect is captured here by a dummy variable, **NEWGAME**. Another dummy variable, **WED**, indicates Wednesday draws. Wednesday sales have historically been lower than Saturday sales. Lastly, during the entire sample period, the nominal entry fee per draw (c) remained constant at $1.00.

Non-lottery variables to be specified include population (n) and other demand shifters (**w**). Theory suggests that possible elements of **w** include income, wealth, and prices of other goods. Here population is measured by California Department of Finance estimates, interpolated by draw. Likewise, prices of other goods are represented by a monthly California CPI index, interpolated by draw. Obtaining suitable data on income and/or wealth proved more difficult. Because published income estimates are quarterly while lotto is observed weekly or twice-weekly, inclusion of an income variable would necessitate extensive interpolation. Nor is a suitable measure of wealth available. Therefore, as a proxy for these indicators of the state of the economy, monthly data on the unemployment rate is included, interpolated by draw (**UNEMP**).

Specification. Inspection of equations (1'-6') suggests that lotto demand may be highly non-linear in its arguments. Previous Box-Cox analysis of California lotto data suggests that demand is well-approximated by an exponential formulation (Whitney 1992). Thus estimated equations are of the semi-log form.

Nominal versus real? The issue of nominal versus real assumes particular importance here, since the object is to determine whether sales are affected by money illusion. The basic equation to be estimated is:

$$q = g(R, M, c, n, CPI, UNEMP, NEWGAME, WED) \tag{7}$$

Note that because the nominal entry fee per draw has remained constant at c = \$1.00, the variable q may be interpreted as either the number of lotto tickets sold, or nominal sales revenues. The former interpretation is intended here, on the assumption that playing 100 \$1.00 tickets is qualitatively different than betting \$100 on single draw. Furthermore, it is the aggregate number of draws (not their value) that determines the game's probabilities of payout. Therefore two versions of (7) were initially specified with q as the dependent variable:

$$q = g(R_{nom}, M, n, CPI, UNEMP, NEWGAME, WED) \quad \textbf{(8a)}$$

$$q = g(R_{real}, M, c_{real}, n,, UNEMP, NEWGAME, WED) \quad \textbf{(8b)}$$

In (8a), all monetary variables are nominal, and c does not appear as it is constant. CPI is included as a proxy for nominal prices of other goods. In (8b), all monetary variables on the RHS are deflated by CPI; therefore c_{real} appears and CPI does not.

Although the primary interest here is in the quantity of tickets demanded, it is standard in the applied gambling literature to specify real sales revenues as the dependent variable. Also, the "price" of a gamble is generally considered to be the "takeout rate"; that is, the difference between the entry cost (c) and the expected value of the lottery (p'z), expressed as the percentage of the entry fee (i.e. 1 - p'z/c). In the context of this discussion, where distinctions between nominal and real values are important, it is interesting to note that this "price" is invariant whether expressed in nominal or real terms. This suggests a third specification having the real value of ticket sales (denoted by s) as the dependent variable:

$$s = g(R_{real}, M, n,, UNEMP, NEWGAME, WED) \qquad \textbf{(8c)}$$

However, inspection of the data revealed that all of the following variables were highly correlated (with absolute degrees of correlation in excess of .99): CPI; population (n); and (negatively) c_{real}, which is the inverse of CPI. Indeed, all three of these variables were almost perfectly correlated with a weekly time trend. This reflects the relatively stable growth of CPI and population during the sample period, plus the use of interpolation between data points. Therefore the separate effects of these variables cannot be discerned in this data set. However, the inclusion of a trend variable should capture the joint effects of these variables. Making this substitution yields the final set of estimable equations:

$$q = g(R_{nom}, M, TIME, UNEMP, NEWGAME, WED) \qquad \textbf{(9a)}$$

$$q = g(R_{real}, M, TIME, UNEMP, NEWGAME, WED) \qquad \textbf{(9b)}$$

$$s = g(R_{real}, M, TIME, UNEMP, NEWGAME, WED) \qquad \textbf{(9c)}$$

Results. Equations (9a,b,c) were estimated by ordinary least squares, using a modified Cochrane-Orcutt procedure to correct for autocorrelation (White, 1987). Table 1 defines and describes the variables used; Table 2 reports the regression results.

All three models perform quite well, with no single specification showing a clear advantage over the others. Of primary interest here is the finding of a positive effect of the annuity multiplier M on demand. For every specification, the hypothesis that lotto players are free of money illusion (i.e., that $\beta_m = 0$) is rejected at the 99% confidence level. This indicates that lotto demand depends, not only on the cash value of the grand prize pool, but also on the degree to which the prize's value is overstated by lottery officials. It is interesting to note that at the means, the expected dollar increase in sales arising from a one-percent increase in M (about 1 cent) roughly equals the expected increase associated with a one-percent rise in the rollover (approximately 1.19 cents).

Other findings are consistent with expectations. The rollover is the single most important factor affecting lotto demand. This reflects the fact that higher rollovers unambiguously improve the expected outcome of the current game, albeit at the expense of past bettors. Demand has increased significantly with respect to time; however as we have seen, various interpretations can be attached to this variable. The estimated effect of unemployment on lotto demand is negative and significant. Demand for lotto is about 25 percent lower on Wednesdays than on Saturdays, a pattern similar to that reported in other states. The introduction of the 6/53 game format (indicated by NEWGAME), portrayed in media accounts as a marketing debacle, is clearly seen to have been unpopular, having caused sales to decline sharply.[7]

In many states including California, lottery wagering is a relatively new phenomenon. In light of state governments' deliberate efforts to deceive players into miscalculating lottery prize amounts, it seems reasonable to assume that there may be a learning period during which the public becomes familiar with the game and with the tactics used to market it. If so, perhaps the significance of M may decline over time. To investigate this probability, Model I was re-estimated for the first and last 154 observations (omitting 100 observations in between). Findings indicated that the effect of the multiplier on sales not only failed to decline, but actually increased over the sample period. Thus it does not appear that lotto players are learning to compensate for the distorted jackpot values announced by the state.

Discussion. As alluded to in the introduction, a positive finding of money illusion has sweeping ramifications for both microeconomic and macroeconomic theory, as well as for empirical analysis. Therefore such findings are likely to be resisted, and rightfully deserve considerable scrutiny. In an effort to begin this process, several possible explanations for the current finding of significant money illusion are presented and critiqued.

1. Real returns matter. Recall from (3'b) that variations in the annuity multiplier are the result of changes in the discount rate on annuities, k. Theory suggests that k is comprised of a real rate k*, plus an inflation premium. Knowing that grand prizes are paid in the form of annuities, sophisticated lottery players might respond to fluctuations in the real component of return, while ignoring purely nominal shifts in k. According to this argument, if it is rational for investors to increase annuity purchases when real rates of return are high, then it is also rational for lotto players to increase purchases of tickets having annuities as prizes.

While theoretically possible, this argument lacks plausibility in the present case. First, real changes in k are likely to be dwarfed by nominal changes. Second, the act of gambling on lotteries (which have notoriously low payout rates) is generally seen as antithetical to saving; thus the careful analysis of anticipated real rates of return on potential future annuities seems incongruous with lotto wagering. If anything, higher real rates of return on annuities should induce some rational gamblers to reduce lottery purchases in favor of savings.

2. Tax effects matter. Given the progressiveness of income taxes, it is clearly preferable that large jackpots be paid as annuities rather than as lump-sum cash awards. This suggests that lotto players may consider tax consequences in assessing the appeal of prospective lotto prizes. However, this in itself does not explain why bettors should prefer jackpots having higher nominal payments per unit of present value; in fact, given nominal rigidities in income taxation, the opposite effect seems more likely. At issue is not whether lump sums are better than annuities; rather it is whether one nominal annuity is better than another, given equal present values.

3. **Asymmetric information exists.** Unlike arguments 1 and 2, this explanation for the significance of M to lotto demand is clearly plausible. The representative agent assumption used in developing the lotto demand equations implies that agents can readily forecast

aggregate demand based on knowledge of their own demand response. In this formulation, lottery operators hold no inherent informational advantage. In a world of varied preferences, lotto managers are privy to information on aggregate demand that is not directly available to others. They use this information to update forecasts of the upcoming cash prize pool Z_1, then multiply the resulting estimate by M to arrive at the "expected jackpot" Z_1^A. While players recognize that the announced jackpot is contaminated by noise from M, it nevertheless contains information on the true value of the grand prize pool, and thus affects real sales.

This explanation gains additional credibility when one considers the difficulties not only of forecasting Q, but of learning the value of other relevant variables, such as lagged values of Q needed to calculate R. While information on these variables is available upon request from the lottery board, it requires time to obtain and is not readily accesible by those who might plan to play lotto. Perhaps this shortage of information encourages players to adopt simple rule-of-thumb methods for estimating the cash value of the jackpot, such as dividing the announced jackpot by two.

4. Lotto players are irrational, but unrepresentative of the general public. The widely held belief that at least some lotto players are irrational can be supported by noting the commercial popularity of lotto number-picking "systems" and the like. However, this explanation for a finding of money illusion should inflame rather than allay rationalists' concerns, unless it can be determined that the relative numbers of such irrational people in society is low. But this appears not to be the case with lotto. Marketing surveys indicate a majority of adults in lotto states play lottery games at least occasionally. In California alone, gross lottery revenues in fiscal year 1990 exceeded $2 billion, or about $67.00 per man, woman and child. One could add that the nighty reporting of biased jackpot estimates by reputedly well-informed news anchors smacks of irrationality in unexpected places.

As an alternative to irrationality, one could argue that individuals engage in lottery gambling (and the associated number-picking activities) for non-pecuniary entertainment values, just as rational people may read horoscopes for enjoyment without believing in the accuracy of the predictions. But this does not provide a clear explanation of why M has positive effects on sales.

Conclusion. Based on the arguments presented above, it appears likely that the cause of the money illusion observed among California lotto players is imperfect information, augmented by some degree of irrational or wishful thinking.[8] Whether a similar degree of money illusion extends beyond the market for lotto tickets is not clear, given the unusual and highly asymmetric information that exists in the lotto market. It is well-known that asymmetric information can cause temporary money illusion among rational agents, due to the time required to learn about real prices. This has led to the notion of money illusion as a short-term phenomenon. The results of this study suggest that an ongoing stream of asymmetric information can lead to a more permanent level of money illusion among the public.

IV. Summary

It is the practice of many state governments to overstate the value of lotto prizes by an annuity multiplier that varies with the nominal discount rate on annuities. I have shown here that this institututional peculiarity permits testing for the presence of money illusion in a well-defined market, that for lotto tickets. An empirical analysis of California lotto demand finds that ticket sales are positively related to the annuity multiplier, as would be expected if consumers suffer from money illusion. These results suggest that real economic decisions are influenced by nominal variables, as hypothesized by Irving Fisher in the 1920's.

TABLE 1. DATA SUMMARY STATISTICS

VARIABLE	definition	units	mean	min	max
q	lottery tickets per capita per draw (also equals nominal sales revenue per capita per draw)	# of tickets x 100 (= cents)	51.4	17.78	286.14
s	real sales revenue per draw (1982-4 = 100)	cents	40.69	15.1	215.96
M	illusion factor (annuity multiplier)	--	1.96	1.75	2.14
R_{nom}	nominal rollover	$ million	2.39	0.00	17.24
R_{real}	real rollover (1982-4 = 100)	$ million	1.87	0.00	13.82
unemp	unemployment rate	percent	5.51	4.30	7.80
time	trend variable	--	126.3	2.00	409
newgame	6/53 game format indicator variable	--	0.18	0.00	1.00
wed	wednesday draw indicator variable	--	0.44	0.00	1.00

TABLE 2. ESTIMATED PER-CAPITA DEMAND FOR LOTTERY TICKETS

Model	I	I (elas.)	II	II(elas.)	III	III(elas.)
Variables: Dependent	log(q)		log(q)		log(s)	
Independent						
Rollover (nominal)	.0733 (31.97)	.18	--	--	--	--
Rollover (real)	--	--	.0946 (31.75)	.18	.0945 (31.72)	.18
M (illusion)	.8088 (4.16)	1.59	.8762 (4.48)	1.72	.8726 (4.46)	1.71
Time	.0021 (5.15)	.27	.0023 (5.72)	.29	.0014 (3.38)	.17
Unemp	-.0622 (2.19)	-.34	-.0597 (2.12)	-.33	-.0615 (2.17)	-.34
Wednesday	-.1287 (14.70)		-.1281 (14.49)		-.1281 (14.50)	
Newgame	-.4671 (6.60)		-.4703 (6.72)		-.4730 (6.72)	
Constant	2.327 (5.10)		2.155 (4.70)		2.056 (4.48)	
Adj. R^2	.8329		.8313		.8335	

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Notes

1. Other authors have quite different notions of money illusion; for a detailed discussion, see Patinkin, 1965.

2. The lottery game examined in the empirical portion of this paper differs slightly from the standard format, as follows. Lottery officials draw 6 lotto numbers plus a bonus number. First prize goes to those matching all 6 lotto numbers. Second prize requires matching 5 of the 6 lotto numbers, plus the bonus number. Third prize goes to those matching 5 lotto numbers but not the bonus number. Fourth and fifth prizes are for those matching 4 or 3 lotto numbers, respectively.

3. In empirical studies of gambling demand, the "price" of a lottery is generally considered to be the expected loss per wager, expressed as a share of the entry fee: [1 - (**p'z/c**)]. In the case of a static game, where p_i, z_i and c are constants, this price equals the share of each dollar retained by the house, or "takeout rate." A typical U.S. lottery pays out 50 cents of each dollar as prizes, and so has a takeout rate of .5. By contrast, a fair gamble would have a takeout rate (and price) of zero.

4. The expression for the annuity multiplier M is derived as follows. Let $E\{Z_1\}$ denote the anticipated cash value of next draw's grand prize pool Z_1. Lottery managers anticipate using this sum to purchase from commercial sources an annuity due having t annual payments. The amount of each payment is expected to be:

$$PV = \left[\frac{[1-(1+k)^{-n}](1+k)}{k}\right] PMT$$

where k is the nominal discount rate on annuities in effect at the time the prize is announced.

Rather than announcing the expected cash value of the prize ($E\{Z_i\} = E\{PV\}$), the lottery agency instead claims that the prize value is the undiscounted sum of the n annuity payments to be purchased with Z_i. Therefore the announced value AV is related to the cash value according to:

$$AV = \sum_n PMT = \left[\frac{kn}{[1-(1+k)^{-n}](1+k)}\right] PV = M * PV$$

Dividing AV by PV yields the prize multiplier M. M measures the degree to which the prize is overstated by the lottery agency, and is a function solely of the nominal discount rate and the payout period t. Given that lotteries typically maintain a constant payout period n over time, the multiplier is a transform of the nominal discount rate. During periods of high nominal interest rates, as when inflationary expectations are high, M increases; during periods of anticipated deflation, M is low.

5. Despite its name, this game was static, featuring fixed payoffs and somewhat higher odds of winning than regular lotto.

6. For each draw, the realized value of M equals the official (announced) jackpot, divided by the realized value of the prize pool Z_1. Because this information does not become available until the draw is complete, the realized value of M from the previous draw is used by lottery officials to project Z_1^A, and is the variable included in these regressions.

7. Due to poor sales, this game design has since been replaced with a 6/51 format.

8. Of course, the distinction between these categories is an arbitrary one. For instance, a failure to apply the laws of probability may indicate a lack of education, or misinformation learned from parents, friends or institutions. In fact, lotto players could argue that so-called "rational thinkers" are themselves suffering from imperfect information, being unable to comprehend important human ideas such as predestination, miraculous intervention, and luck.

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