The Economics of Lotto: Design, Income, and Problem Gambling in the UK

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Triple act

1. How much do we love Lotto? (Rhys)
   - We are agnostic on why people play
   - Call it “fun”. Lots of it - £1b pa (£5b sales)

2. But lotto is highly “taxed” (Rob)
   - And its highly regressive
   - More than most “sin” taxes
   - Tax spoils a quarter of the fun (£⅓b pa)

3. Problem gambling? (Me)
   - We attempt to place a value on this
   - £5.5b pa “upper bound” for DSM PG
   - £1.2b pa “upper bound” for PGSI PG
Outline of Act 1

• Provide a simple analytical model of lotto
  – Estimate this on 200+ draws of UK lotto
• Focus on estimating **causal effect** of “price”
  – And overall *shape* of prize distribution
• Find backward looking behaviour
  – Strong “habituation” => LR effect > SR effect
    • Addiction?
• Infer “fun” from estimated “price elasticity”
  – Calculate lost fun due to lotto takeout
Lotto background

• UK context
  – GGY is about $20b ≈ $400 pppa
    • Lotteries most prevalent form of gambling
    • NL accounts for about $5b of GGY in UK

• Lotto is a distinctive form of lottery
  – Pari-mutuel

• Pick your own numbers
  – Allows for “conscious selection”

• “Rollovers” occur
  – More so because of conscious selection
  – Generates spikes in sales
General structure of lotto games

• Each player chooses (or Lucky Dips) $n$ from $N$
• Prize pools shared by all players who match, $n$ balls (jackpot), $n-1$, etc.
  – If no $n$-ball winner at $t-1$ then $J_{t-1}$ added to $J_t$
  – Multiple rollovers possible
• Game design - $n$, $N$, takeout rate, prize pools
  – Design (given $S$) determines $\text{Prob}(R>0)$
• Game design implies $P$, $R$ and $S$ related
  – $P(R,S)$: focus here on $P$, rather than $R$ directly
• *Peculiar* economies of scale (Clotfelter and Cook *AER* 1993)
  – Higher $S$, lowers rollover prob
    • Raises current value of ticket (so reduces $P$)
  – asymptotes to take-out rate ($\approx \frac{1}{2}$) from below
  – So $P$ asymptotes to $\frac{1}{2}$ from above

• Rollover draws (Walker *Econ Policy* 1999)
  – $J_t$ includes $J_{t-1}$ - like adding a “raffle” prize in $t$
    • Raffle prizes are fixed (don’t depend on $S_t$)
  – But if $R_t>0$, then $J_{t-1}$ *worth* less the higher is $S_t$
    • Because higher $S_t$ lowers chance of winning $J_{t-1}$
P(R,S) relationship for 6/49

- P(0,S) tends to ½ from above
- But rollovers shifts P down — P(8,S) and P(4,S) — tend to ½ from below
- Rollover changes P, at any given S — Price elasticity
• Sticker price £1, 35k outlets, twice weekly
  – $n = 6$, $N = 49$, $\tau \approx \frac{1}{2}$
  • Tax (12%) + “good causes” (28%) + costs (10%)
  – Winnings tax free! Paid as lump sum!
  – Prob matching 6 is $\frac{n!}{N!(N-n)!} \approx 1/14m$
• UK game also has 5+B, 5, 4 ball prize pools
  – 3-ball fixed prize, not a pool - £10 (Prob $\approx 2\%$)
• Jackpot
  – $\approx \frac{1}{2} (S/2 + \text{rollover} – 10.w_3)$
• Wed rolls over into next Sat and vice versa
• Existing research estimates simple models
  \[ S_t = a + b \cdot P_t + \text{otherstuff}_t \]
  • Estimate for Weds and Sats separately
  • Expect \( b < 0 \)
  • Otherstuff\(_t\) includes \( S_{t-1} \)
• Take-out from draw \( t \) depends on
  • Take-out rate, \( \tau \) - fixed
  • Rollover size, \( R_t \) – depends on \( S_{t-1} \)
• Use other determinants of \( R_t \)
  • As source of \textit{exogenous} variation in \( P_t \)
    • Unexpected variation in number of 3 ball winners
    • Small and medium numbers in winning n
Lotto is lots of “fun”

- D shows “willingness to pay”
- Actually “pay” P = ½
- S ≈ 40m (20m) per draw
  - £3b pa
- MC = 0.1
- Slope_{LR} ≈ -0.02 (-0.015)
- Fun = CS = £16m (3m)
  - £1b pa
- Tax ≈ £16m (8m)
- Lost fun = DWL ≈ £4m (2½m)
  - Tax spoils £⅓b pa of the fun
Act 1 Conclusion

• Bigger estimated P effects Weds than Sat

Long run $\varepsilon_{\text{Sat}} \approx -\frac{2}{3} \, (0.05)$, $\varepsilon_{\text{Wed}} \approx -1\frac{1}{2} \, (0.13)$

• Set $\tau$ to ensure that $\varepsilon = -1$ to max revenue
  – So “money left on the table”
    • So raise Wed’s prizes at expense of Sat’s

• Exactly what UK operator did (2013/15)
  – Added large raffle prizes to both draws
  – But these are worth more on Weds than Sats

• Not yet enough data to see if this has worked

• QUESTIONS?
Outline of Act 2

• Taxes on “sin” popular with governments
  – Moral high ground
• Taxing a “necessity” is regressive
  – So poor bear a larger tax burden than rich
  – Determined by “income elasticity” of D, \( \eta \)
    • “Impact of a 1% rise in income on demand
    • Estimate this using data on purchases and income
• Estimate how demand varies with income
  – “Luxury” good, \( \eta > 1 \)
    • Budget share rises with income (entertainment)
  – “Necessity”, \( 0 < \eta \leq 1 \)
    • Budget share falls with income (food, fuel)
Background

• “Incidence” of “tax” on lotto
  – Is tax regressive?
  – Estimate relationship between D and income

• We have 13 years of UK FES data (2001-13)
  – Huge and detailed survey - 69k hh in our data
  – Important feature of data is lots of zeroes

• “Parametric” model
  – $\text{Lottoshare}_h = c + d \cdot \log (\text{Totexp}_h) + \text{other stuff}_h$
  – Simple way of incorporating zeroes (Tobit)
FES vs NL data

- FES lotto spending tracks NL series OK – 30% under reporting
- But OK – Methodology robust to ME in demand
Spending patterns in FES data (weekly)

- Mean Household Lotto Spend
  - 18-24
  - 25-29
  - 30-39
  - 40-49
  - 50-59
  - 60-69
  - 70-79
  - 80+

- Age of Household head
  - 0
  - 1-4
  - 5-9
  - 10+

- No. Lottery Tickets Bought
  - 0
  - 1-4
  - 5-9
  - 10+

- Mean Weekly Income
  - 0
  - 200
  - 400
  - 600

- Percent
  - 0
  - 5
  - 10
  - 15

- Household Lottery Tickets per Week

- Mean Household Lotto Spend
  - Number of "Lotto Eligible" Household Members
  - 1
  - 2
  - 3
  - 4
  - 5
  - 6
  - 7
  - 8
  - 9
Engle curves

• Standard parametric specification
  – \( \text{Lottoshare}_h = c + d \cdot \log(\text{Totexp}_h) + \text{other stuff}_h \)
  • Nice: \( \eta = \frac{d}{\text{Lottoshare}}-1 \)
  • Easy: linear regression

• Many households have zero lotto share
  – “Tobit” and extensions rather than regression

• Results
  – Tobit \(-0.0027 (0.0001)\)

• Semi-parametric analysis
  – Implement a SP version of Tobit?
Act 2 Conclusion

• So \( \eta = 1 + \left(-\frac{0.0027}{0.006}\right) \approx 0.6 < 1 \)
  – suggests lottery tax is regressive

• Suits (AER 1973) regressivity index
  – \( \text{SI} = \frac{L}{T} \)

• Lotto 0.36
• Gambling 0.32
• Alcohol 0.13
• Tobacco 0.42

QUESTIONS?
Outline of Act 3

• “Problem” gambling usually defined by aggregating responses to a questionnaire
  – PG = 1 if score exceeds critical value
  – DSM and PGSI

• Allows us to count the number of PGs
  – But what does PG “cost” to someone with PG?

• Can we improve the way that PG is defined?
• Can we improve on our estimates?
Problem Gambling in UK

- PG defined in UK GPS 2010 (and later HSE)
  - PGSI > 7 = 0.63% (of 46 m popn = 290k people)
  - DSM > 2 = 0.83% (of 46 m popn = 380k people)
Well-being in GPS

• UK 2010 GPS records “well-being” (W)
  – “How happy would you say you are these days”
• UK 2010 only GPS to do this
  – W not in HSE
  – Nor in other GPS’s
• W widely used to value life events
  – Divorce
  – Marriage
  – Unemployment
  – And, now, PG
Well-being in GPS

- W falls as PG score rises
  - For both DSM and PGSI
  - But neither have a step down at the critical value
Income in GPS

- GPS records income
  - in £5k “bins”
- Income makes you happier
  - If you don’t have much
- Use log Income
  - Rather than income
• Our methodology increasingly common
  – Estimate $W$ vs Log Income and “event”
    • Event, in this case, is $PG=1$
  – $W_i = e + f \cdot PG_i + g \cdot \text{Log Income}_i + \text{otherstuff}_i$
    • Log income is grouped – replace by a prediction from an integer regression
  – $f (<0)$ tells us how much less $W$ is for $PG=1$ vs $0$
  – $g (>0)$ tells us effect of doubling income on $W$
  – So $f/g \equiv \% \Delta$ income that makes $W_{PG=1} = W_{PG=0}$
PG money metric

- $f/g \equiv \% \Delta \text{income that makes } W_{PG=1} = W_{PG=0}$

- For DSM
  - $f = -1.38, \quad g = 2.65 \implies f/g = -0.52$
  - $\Delta W_{dsm} = -£9k$

- For PGSI
  - $f = -0.40, \quad g = 2.62 \implies f/g = -0.15$
  - $\Delta W_{pgsi} = -£2.5k$

- Aggregate
  - $\Delta W_{pgsi} = -£0.75b$
  - $\Delta W_{dsm} = -£3.5b$
Causal effect

• Our regression estimate of $f$ is likely to be biased because of measurement error in PG
  - Downwards (attenuated towards 0)
  - Exploit the second PG measure. Then, we get
    $-\Delta W_{pgsi} = -£1.2b$ or $\Delta W_{dsm} = -£5.5b$

• But $f$ also biased because of simultaneity
  - Unhappy people gamble more
  - Upwards – so estimates above are “upper bounds”
  - More difficult in this case – working on it
Act 3 Conclusion

• Conventional measures of PG associated with large/huge reductions in well-being

• Conventional definitions probably flawed
  – So who knows what the right answer is?
  – Ours is an upper bound on true answer

• Well-being data offers the possibility of
  – Designing better questions
  – And better, data-driven, aggregation of answers
  – To get a more defensible PG scale
Take away

• Lotto is a £1b of fun pa
  – But taxation reduces the fun by close to 50%

• And the tax is highly regressive

• PG may be a large problem
  – Small % of (a large number of) people
  – Method for “valuing” PG
    • Different values for two popular (similar) measures
      – Either huge (at most £5.5b)
      – or just large (at most £1.2b)
      – But these are “upper bounds”

• QUESTIONS?
Questions?

• Unanswered questions
  – Does lotto cause more/less PG? Working on it!
  – Does lotto good-causes spending do any good?
    • Not yet working on this!
      – Scouts, Opera House, Olympic medals, “Warm glow”
  – Can we improves estimates? Working on it!

• If you want the paper(s), or these slides?
  – Email ian.walker@lancaster.ac.uk

• If you have hard questions?
  – We can talk later ... in the bar?

• And if you have cool data for us
  – Then we’re buying the drinks