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

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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 (£½b 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
P, S and R

• *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 (≈½) from below
  – So P asymptotes to ½ 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
UK Lotto (pre 2014)

• 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 \( \frac{n!}{N!(N-n)!} \approx \frac{1}{14m} \)
  
• 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
Statistical method

• 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 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” \( P = \frac{1}{2} \)
- \( S \approx 40 \text{m} \ (20 \text{m}) \) per draw
  - £3b pa
- MC = 0.1
- \( \text{Slope}_{LR} \approx -0.02 \ (-0.015) \)
- Fun = CS = £16m (3m)
  - £1b pa
- Tax \( \approx £16m \ (8m) \)
- Lost fun = DWL \( \approx £4m \ (2\frac{1}{2}m) \)
  - Tax spoils £\( \frac{1}{3} \)b 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)
Engle curves

- Standard parametric specification
  \[ \text{Lottoshare}_h = c + d \cdot \text{Log (Totexp}_h) + \text{other stuff}_h \]
  - Nice: \( \eta = (d/\text{Lottoshare})^{-1} \)
  - 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 $\eta = 1 + (-0.0027/0.006) \approx 0.6 < 1$
  - suggests lottery tax is regressive
- Suits (AER 1973) regressivity index
  - $SI = L/T$
- 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
PG money metric

• 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
  - \( f = -1.38, \quad g = 2.65 \Rightarrow f/g = -0.52 \)
  - \( PG_{dsm} = 1 \Rightarrow \text{Loss in } W \text{ (pa)} \approx -£ 9 \text{ k} \)
- For PGSI
  - \( f = -0.40, \quad g = 2.62 \Rightarrow f/g = -0.15 \)
  - \( PG_{pgsi} = 1 \Rightarrow \text{Loss in } W \text{ (pa)} \approx -£ 2.5 \text{ k} \)
- Aggregate
  - \( \Delta W_{pgsi} = -£ 0.75 \text{ b} \)
  - \( \Delta W_{dsm} = -£ 3.5 \text{ b} \)
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
    $-\Delta W_{pgsi} = -£1.2$ $b$ or $\Delta W_{dsm} = -£5.5$ $b$

• 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