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 (£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
Lottery 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 $\frac{n!}{N!(N-n)!} \approx \frac{1}{14m}$
  • UK game also has 5+5, 5, 4 ball prize pools
    – 3-ball fixed prize, not a pool - £10 (Prob $\approx 2\%$)
• Jackpot
  – $\approx \frac{1}{2} \left( S/2 + \text{rollover} - 10.w_3 \right)$
• 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 \textbf{other} determinants of \( R_t \)
  - As source of \textbf{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}$
- $S \approx 40m (20m) \per draw$
  - £3b pa
- $MC = 0.1$
- $Slope_{LR} \approx -0.02 (-0.015)$
- 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
  
  \[ \varepsilon_{\text{Sat}} \approx -\frac{2}{3} (0.05), \quad \varepsilon_{\text{Wed}} \approx -1\frac{1}{2} (0.13) \]

- 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, η
    • “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, η > 1
    • Budget share rises with income (entertainment)
  – “Necessity”, 0 < η ≤ 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
  – \( \text{Lottoshare}_h = c + d \cdot \text{Log} \left( \text{Totexp}_h \right) + \text{other stuff}_h \)
  • Nice: \( \eta = \left( \frac{d}{\text{Lottoshare}} \right) - 1 \)
  • 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
  – $SI = \frac{L}{T}$

• 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
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 \( f/g \equiv % \Delta \text{income that makes } W_{PG=1} = W_{PG=0} \)
PG money metric

- \( f/g \equiv \% \Delta \text{ income that makes } W_{PG=1} = W_{PG=0} \)
- For DSM
  - \( f = -1.38, \quad g = 2.65 \Rightarrow f/g = -0.52 \)
  - \( PG_{dsm} = 1 \Rightarrow \text{Loss in } W \text{ (pa)} \approx -£9k \)
- For PGSI
  - \( f = -0.40, \quad g = 2.62 \Rightarrow f/g = -0.15 \)
  - \( PG_{pgsi} = 1 \Rightarrow \text{Loss in } W \text{ (pa)} \approx -£2.5k ! \)
- 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
    \[ \Delta W_{pgsi} = - \£ 1.2 \] or \[ \Delta W_{dsm} = - \£ 5.5 \]

• 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