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

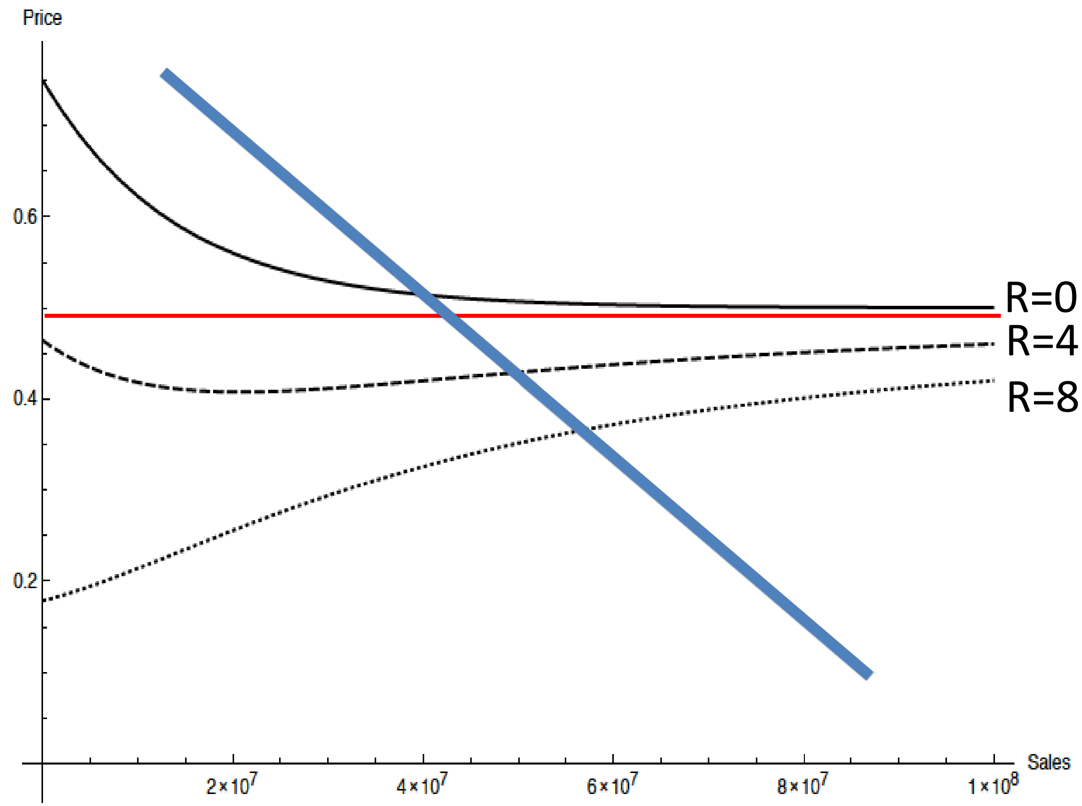
- Each player chooses (or Lucky Dips) *n* from *N*
- Prize pools shared by all players who match, *n* balls (jackpot), *n-1*, etc.
  - If no *n*-ball winner at t-1 then J_{t-1} added to J_t
  - Multiple rollovers possible
- Game design - *n, N, takeout rate, prize pools*
  - Design (given S) determines 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)

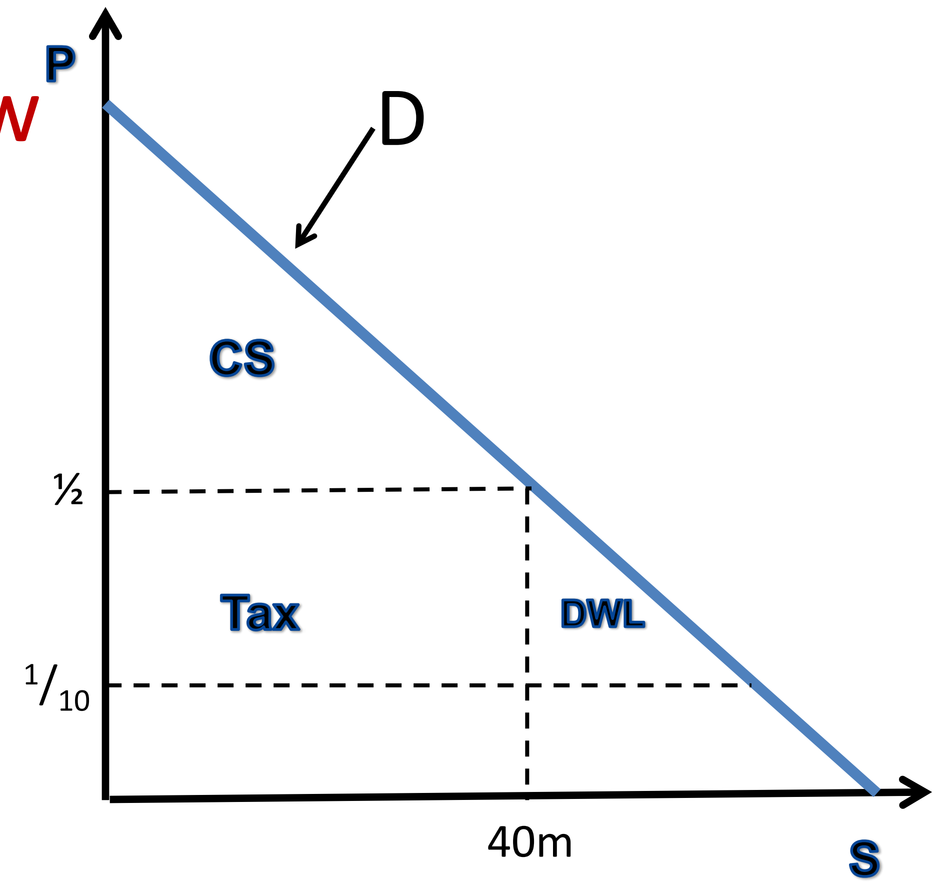
- Sticker price £1, 35k outlets, twice weekly
  - n = 6, N = 49, $\tau \approx$ ½
    - Tax (12%) + "good causes" (28%) + costs (10%)
  - Winnings tax free! Paid as lump sum!
  - Prob matching 6 is $n!/N!(N-n)! \approx 1/14$m
- UK game also has 5+B, 5, 4 ball prize pools
  - 3-ball fixed prize, not a pool - £10 (Prob ≈ 2%)
- Jackpot
  - ≈ ½ (S/2 + rollover – 10.w_3)
- Wed rolls over into next Sat and vice versa

Statistical method

- Existing research estimates simple models
  - $S_t = a + \mathbf{b}.P_t + \text{otherstuff}_t$
    - 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, τ - 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 = 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 $\varepsilon_{Sat} \approx$ -⅔ (0.05) , **$\varepsilon_{Wed} \approx$ -1½** (0.13)

- Set τ to ensure that ε = -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

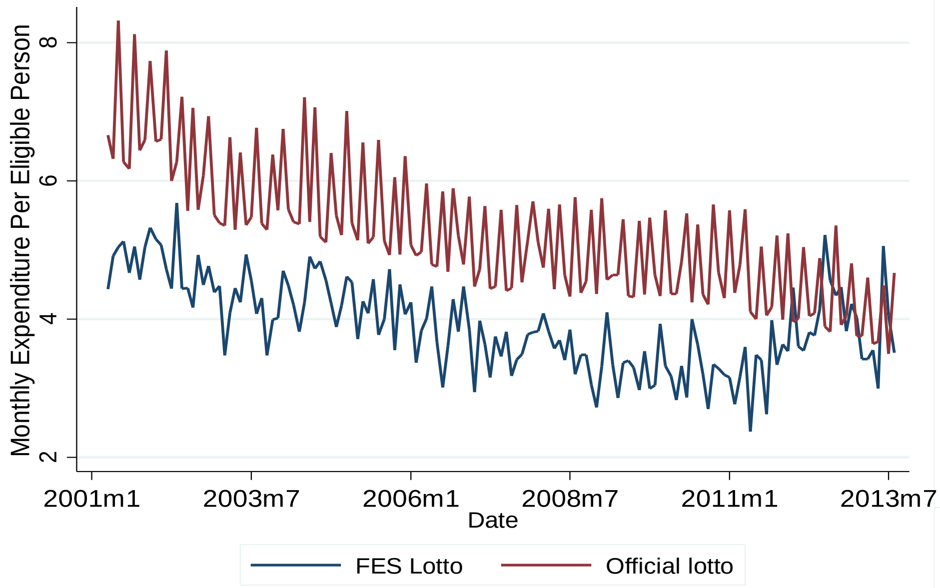
- Taxes on “sin” popular with governments
  - Moral high ground
- Taxing a “necessity” is regressive
  - So poor bear a larger tax burden than rich
  - Determined by “income elasticity” of D, η
    - “Impact of a 1% rise in income on demand
    - Estimate this using data on purchases and income
- Estimate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

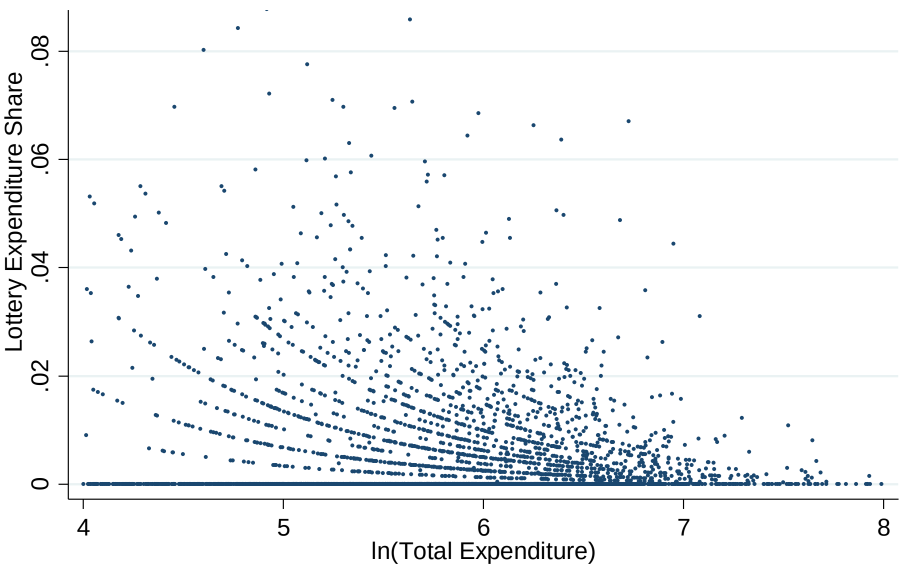
Background

- "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
  - $\text{Lottoshare}_h = c + \mathbf{d}.\ \text{Log}(\text{Totexp}_h) + \text{other stuff}_h$
  - Simple way of incorporating zeroes (Tobit)

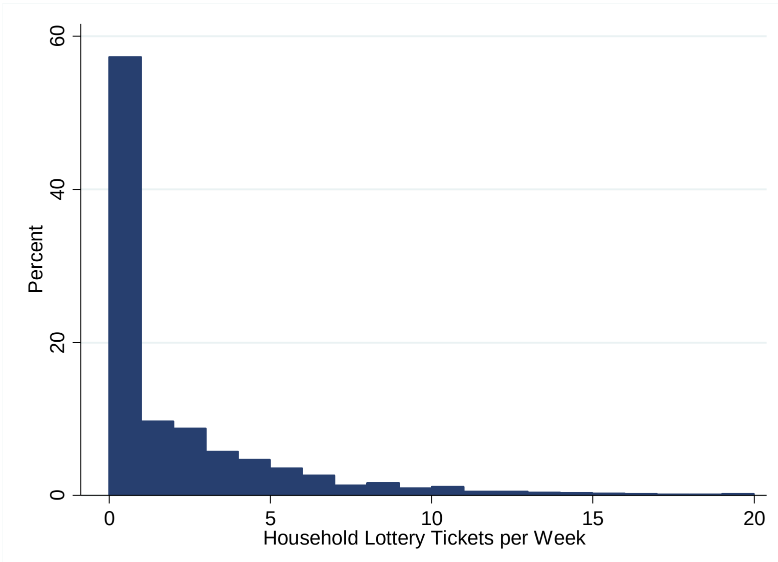
FES vs NL data

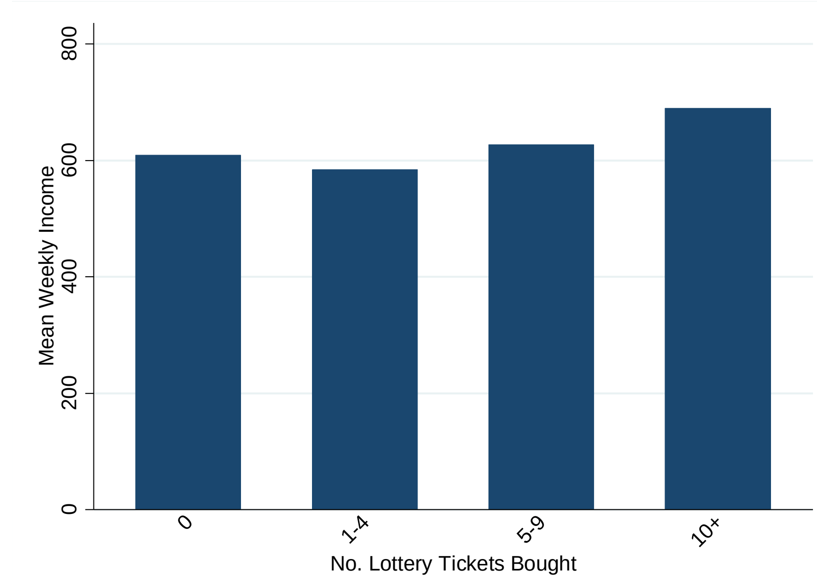
- FES lotto spending tracks NL series OK
  – 30% under reporting
- But OK
  – Methodology robust to ME in demand

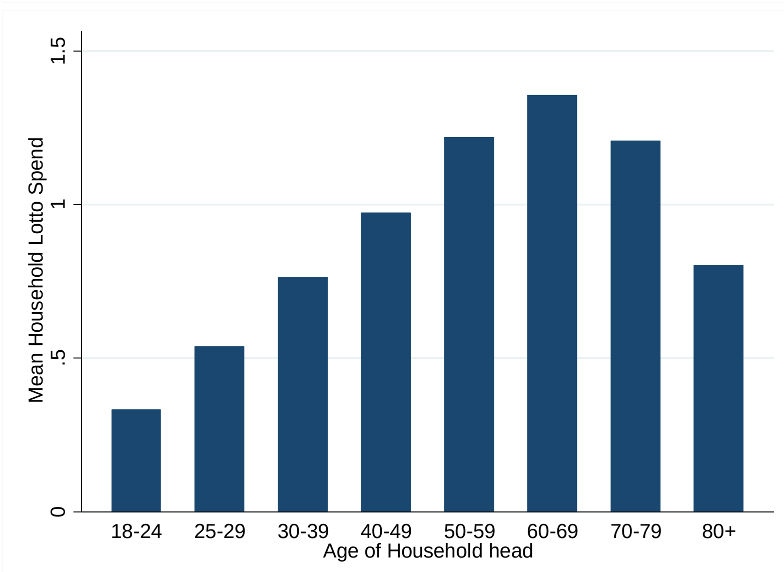


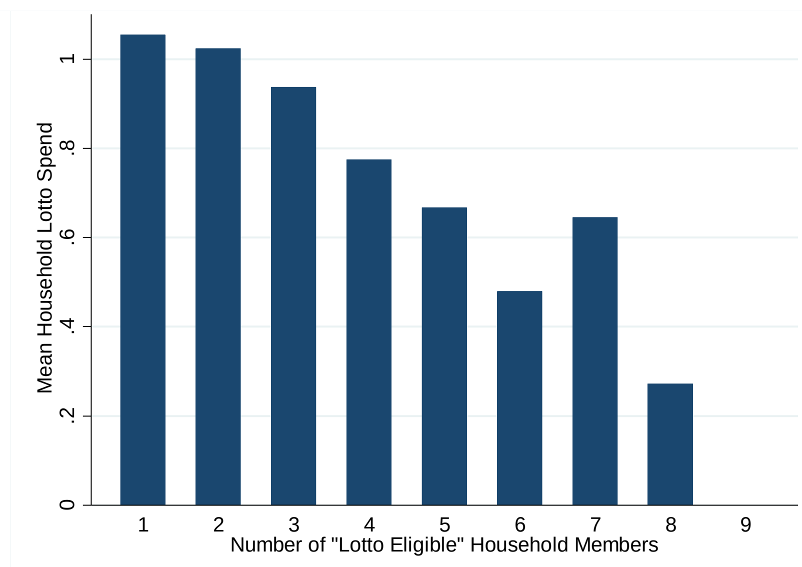


Spending patterns in FES data (weekly)









Engle curves

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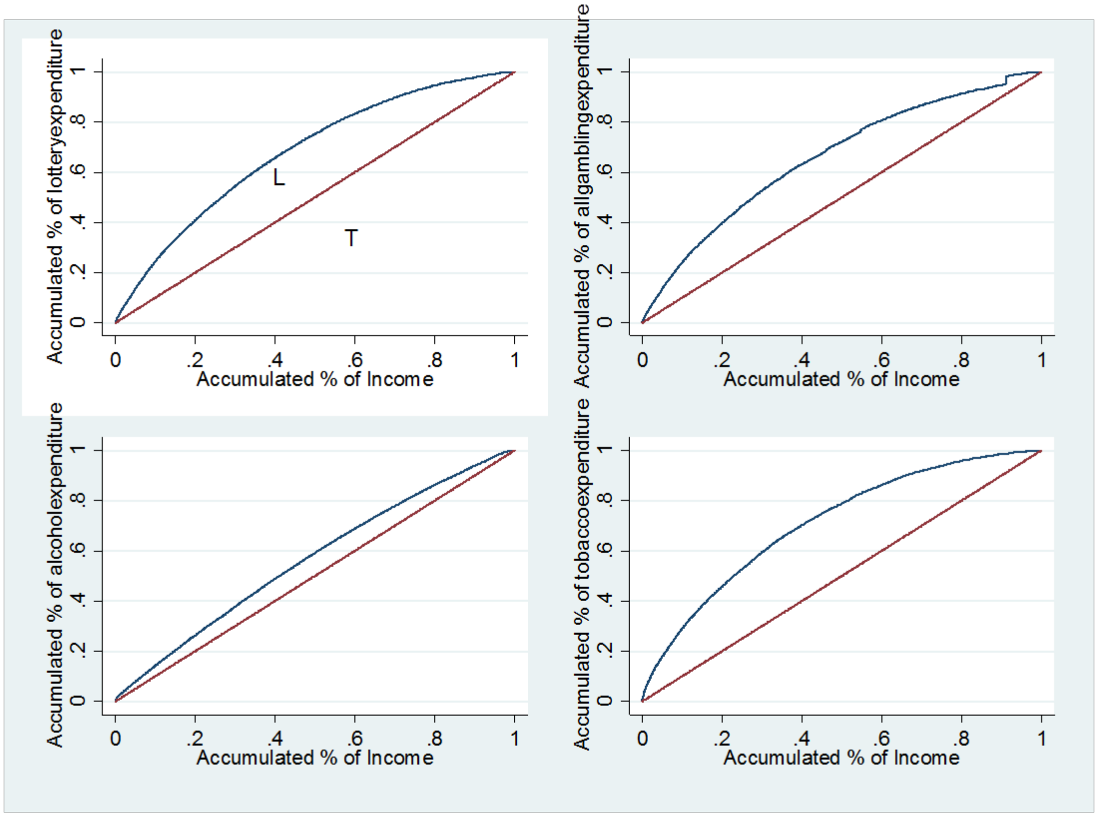
- Standard parametric specification
  - $\text{Lottoshare}_h = c + \mathbf{d}.\ \text{Log}\ (\text{Totexp}_h) + \text{other stuff}_h$
    - Nice: $\eta = (\mathbf{d}/\text{Lottoshare})\text{-}1$
    - Easy: linear regression
- Many households have zero lotto share
  - "Tobit" and extensions rather than 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 ?**

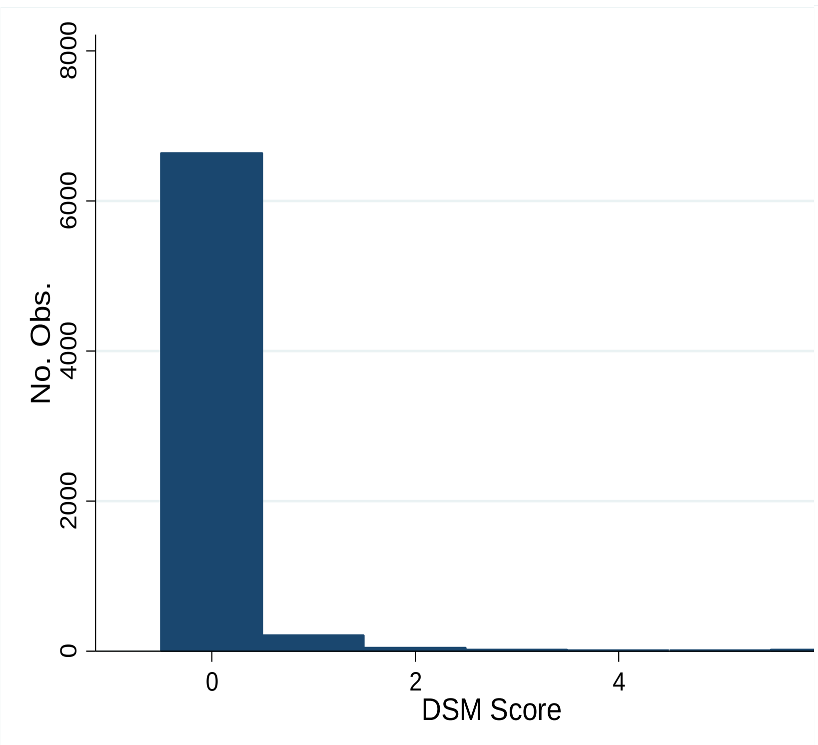


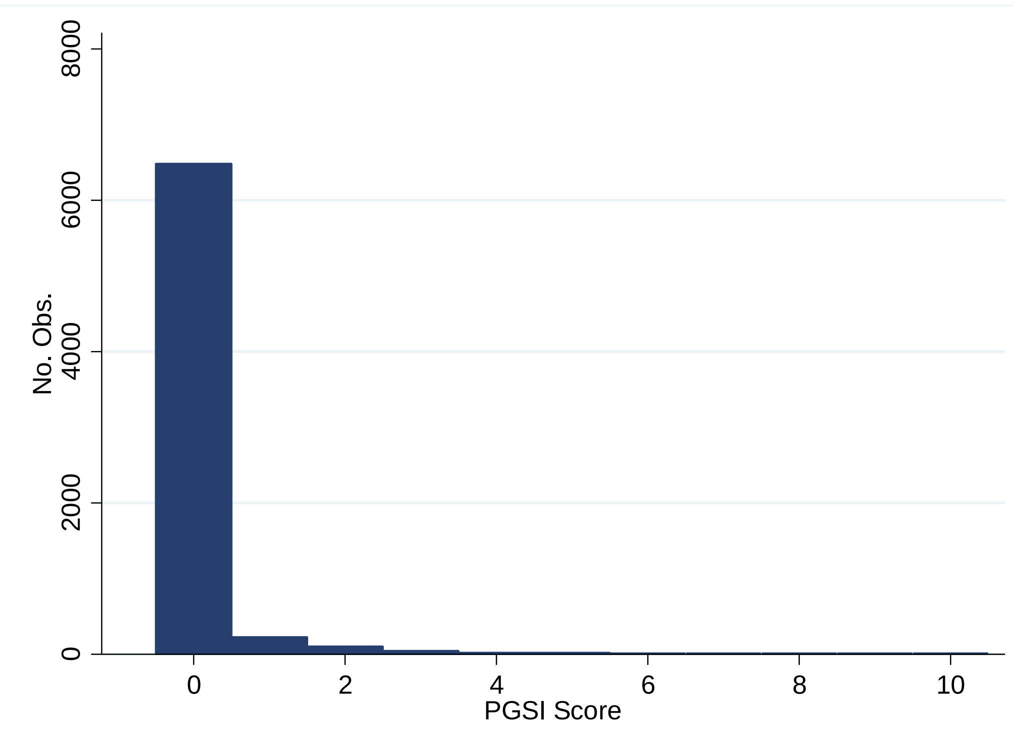
Outline of Act 3

- “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

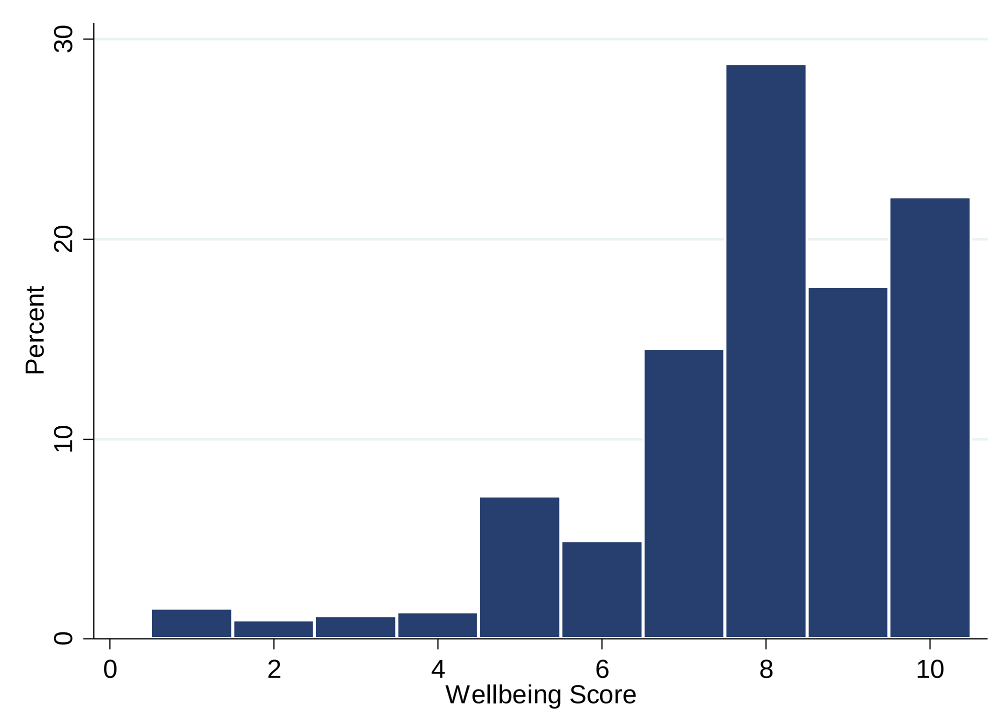
- PG defined in UK GPS 2010 (and later HSE)
  - PGSI > 7 = 0.63% (of 46 m pop^n = 290k people)
  - DSM > 2 = 0.83% (of 46 m pop^n = 380k people)





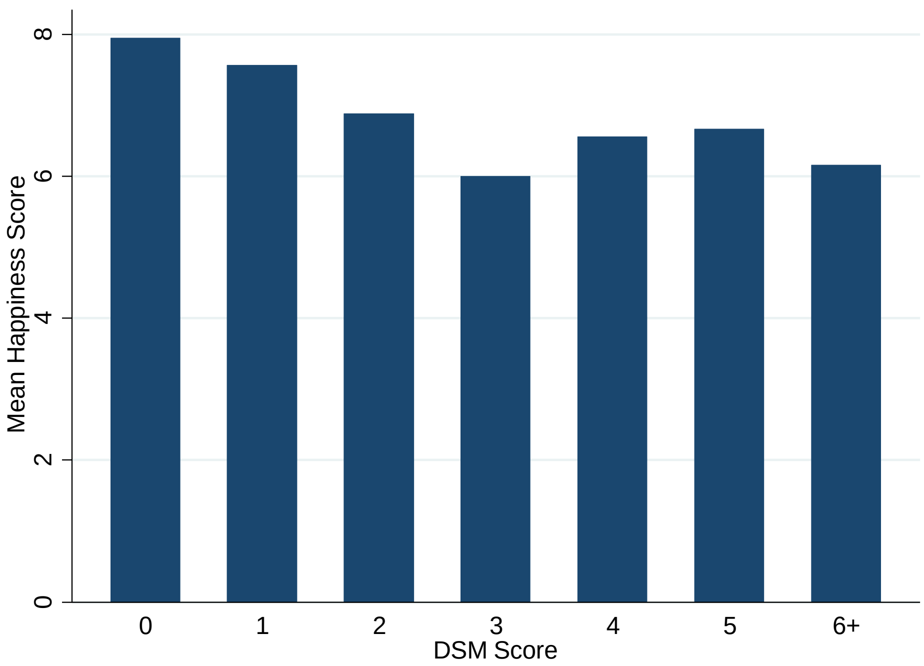
Well-being in GPS

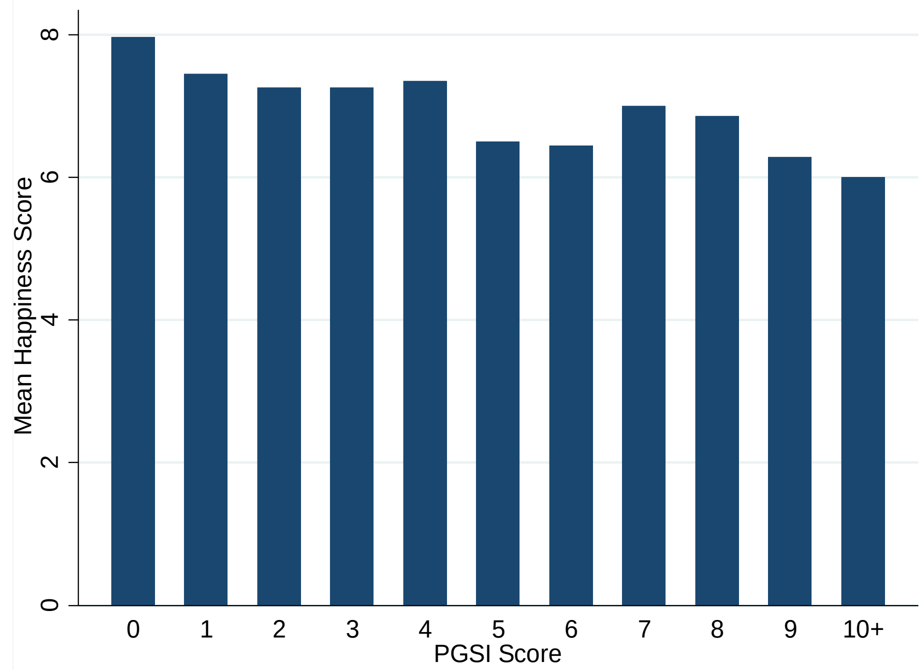
- UK 2010 GPS records “well-being” (W)
  - “How happy would you say you are these days”
- UK 2010 only GPS to do this
  - W not in HSE
  - Nor in other GPS’s
- W widely used to value life events
  - Divorce
  - Marriage
  - Unemployment
  - **And, now, PG**



Well-being in GPS

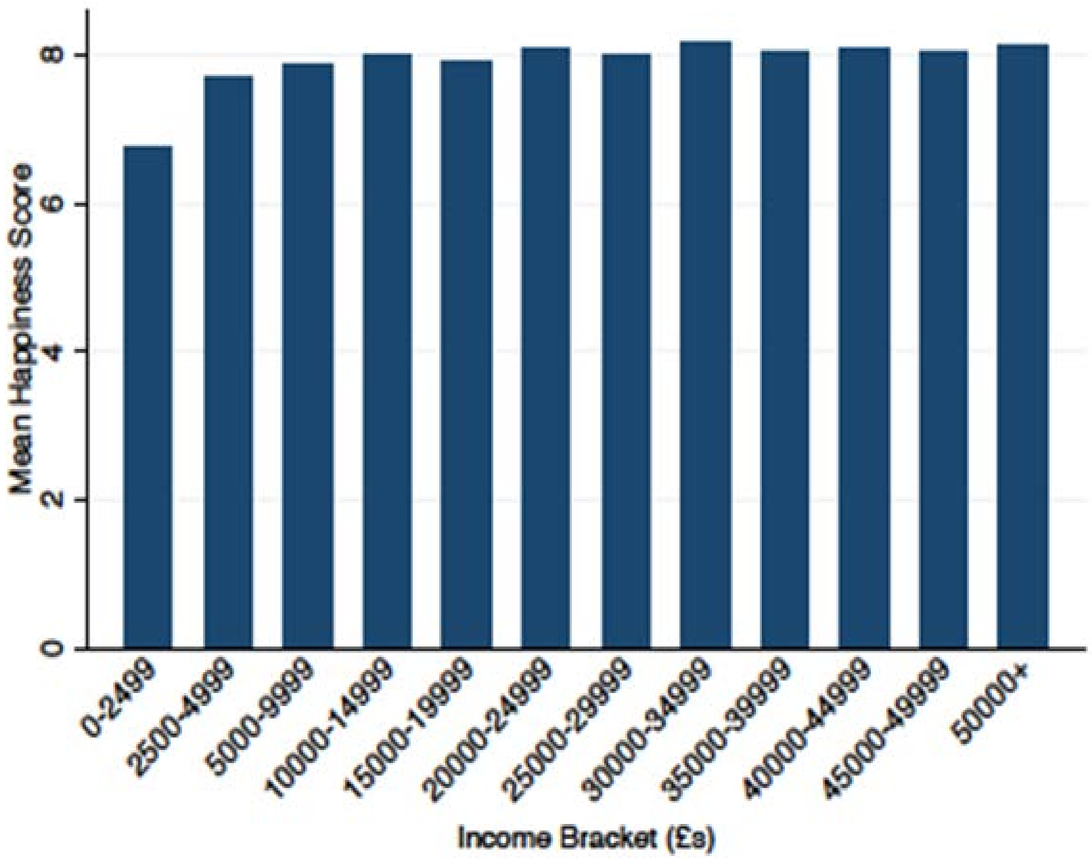
- W falls as PG score rises
  - For both DSM and PGSI
  - But neither have a step down at the critical value





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
  - $W_i = e + \mathbf{f} \,.\, PG_i + \mathbf{g} \,.\, \text{Log Income}_i + \text{otherstuff}_i$
    - 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

- $f/g \equiv$ % Δ income that makes $W_{PG=1} = W_{PG=0}$
- For DSM
  - $f = -1.38$, $g = 2.65 \Rightarrow$ $f/g = -0.52$
  - $PG_{dsm} = 1 \Rightarrow$ Loss in W (pa) $\approx$ - £ 9 k
- For PGSI
  - $f = -0.40$, $g = 2.62 \Rightarrow$ $f/g = -0.15$
  - $PG_{pgsi} = 1 \Rightarrow$ Loss in W (pa) $\approx$ - £ 2.5 k !
- Aggregate
  - **ΔW_{pgsi} = - £ 0.75 b**
  - **ΔW_{dsm} = - £ 3.5 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
    - **ΔW_{pgsi} = - £ 1.2 b** or **ΔW_{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

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- 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