Public Economics II: Public Expenditures
Lecture 3: Public Goods

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Spring 2023

Characteristics of Public Goods

1. **Non-excludable**: No household can be excluded from consuming the good.
   - e.g. National radio, street lights.
   - $\longrightarrow$ Free-rider problem.
2. **Non-rival**: Consumption of the good by one household does not reduce the quantity available for consumption by any other.
   - If a public good can accommodate any number of users: it is a **pure** public good. i.e. the marginal cost of adding an additional user $= 0$.
   - If congestion occurs, it is an **impure** public good (e.g. roads, parks...)

Examples of pure public goods?

- Examples sometimes given: National defence, public radio, public safety (police).

$\longrightarrow$ Pure public goods may not exist, but are a useful theoretical abstraction.

Public vs. Private Goods

Private goods benefit one individual *h*

$$\sum_h X_h \leq X$$

Pure public goods benefit many individuals simultaneously:

$$G_h \leq G \quad \forall h$$

Public Goods Model: Setup

- Economy has H households with $h \in \{1, ..., H\}$
- Two goods:
  - Private good: X, where $X = \sum_h X_h$
  - Public good: G, where $G_h <= G$
- Utility for h is $U_h = U_h(X_h, G)$
- Social Welfare: $\Phi = \sum_h \beta_h U_h(X_h, G)$
  - Where $\beta_h \geq 0$ and $\beta_h > 0$ for one h
- Production possibility $F(X, G) = 0$

Samuelson Rule: First Best Pure Public Good Provision

Social planner problem:

$$\max_{X_h, G} \sum_h \beta_h U_h(X_h, G)$$

$$s.t. \quad F(X, G) \leq 0$$

Lagrangian:

$$\mathcal{L} = \max_{X_h, G} \sum_h \beta_h U_h(X_h, G) - \lambda F(X, G)$$

FOCs:

$$[X_h] : \beta_h \frac{\partial U_h}{\partial X_h} = \lambda \frac{\partial F}{\partial X}$$

$$[G] : \sum_h \beta_h \frac{\partial U_h}{\partial G} = \lambda \frac{\partial F}{\partial G}$$

From FOC for X_h we have:

$$\beta^h = \lambda \frac{\frac{\partial F}{\partial X}}{\frac{\partial U_h}{\partial X}}$$

Plugging into FOC for G we get:

$$\sum_h \frac{\frac{\partial U_h}{\partial G}}{\frac{\partial U_h}{\partial X}} = \frac{\frac{\partial F}{\partial G}}{\frac{\partial F}{\partial X}}$$

Samuelson Rule:

$$\sum_h MRS_{GX}^h = MRT_{GX}$$

Samuelson (1954) Rule

- Pareto efficient allocation: sum of MRS for all individuals is equal to the MRT

$$\sum_h MRS_{GX}^h = MRT_{GX}$$

  - Compare to the private good case where individual $MRS = MRT$

- Intuition: Increasing G by one unit increases every HH's MB, so its impact on the total MB in society needs to be accounted for.

- Government could achieve Samuelson rule through lump sum taxes if they are feasible (they're probably not).

- Question: Can the Samuelson rule be achieved using decentralised provision?

Decentralised Provision

- Private Good X and pure public good G both with price normalised to 1 $\implies MRT_{GX} = 1$.
- Each h starts with endowment of Y_h of good X.
- Each h contributes G_h to fund the public good.
- Budget set for h is $X_h = Y_h - G_h$
- Consumption of public good is $G = \sum_h G_h \ \forall h$

Decentralised Provision

Individual h solves:

$$\max_{X_h, G_h} U^h(X_h, G_h + \sum_{i \neq h} G_i)$$

$$s.t. \quad X_h + G_h - Y_h = 0$$

- Free rider problem: individual h chooses G_h taking $G_i \ \forall \ i \neq h$ as given.
- Nash equilibrium: $\frac{\partial U^h}{\partial X} = \frac{\partial U^h}{\partial G} \iff MRS^h_{GX} = 1 \ \forall \ h$
- Samuelson rule not satisfied: $\sum_h MRS^h_{GX} = H > 1 = MRT_{GX}$

Crowd Out: Bergstrom, Blume, Varian (1986)

Individual h solves:

$$\max_{X_h, G_h} U^h(X_h, G_h + G_{-h})$$

$$s.t. \;\; X_h + G_h - Y_h = 0$$

- Nash equilibrium: $\frac{\partial U^h}{\partial X} = \frac{\partial U^h}{\partial G}$
- Let G^* denote private equilibriam public good provision.

- Suppose government introduces lump sum tax t^h on each h to increase revenue for public good.
- $T = \sum_h t^h$ will be "added" to the public good.
- Individual optimisation problem becomes:

$$\max_{X_h, G_h} U^h(X_h, G_h + G_{-h} + T)$$

$$s.t. \quad X_h + G_h + t^h - Y_h = 0$$

- Suppose government introduces lump sum tax t^h on each h to increase revenue for public good.
- $T = \sum_h t^h$ will be "added" to the public good.
- Individual optimisation problem becomes:

$$\max_{X_h, G_h} U^h(X_h, (G_h + t^h) + (G_{-h} + T_{-h}))$$

$$s.t. \quad X_h + (G_h + t^h) - Y_h = 0$$

Crowd Out: Bergstrom, Blume, Varian

- Suppose government introduces lump sum tax t^h on each h to increase revenue for public good.
- $T = \sum_h t^h$ will be "added" to the public good.
- Individual optimisation problem becomes:

$$\max_{X_h, Z_h} U^h(X_h, Z_h + Z_{-h})$$

$$s.t. \quad X_h + Z_h - Y_h = 0$$

- Let $Z_h = G_h + t_h$.

- FOC and NE outcome will satisfy: $\frac{\partial U^h}{\partial Z} = \frac{\partial U^h}{\partial X}$
- This is isomorphic to the original problem $\Longrightarrow Z^* = G^*$
- Public good provision is unchanged.
- Each individual just reduces their voluntary provision by t^h.

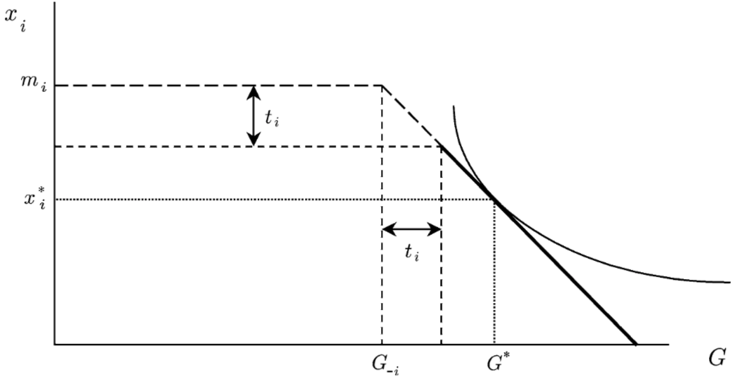


Figure 5. Complete crowding out.

Source: Andreoni 2006

BBV: Departures from Key Assumptions

- Corner solutions:
  - If corner solutions present transfer neutrality breaks down. There will be no private contribution from h with $G_h^* \leq t_h$, but contributions will increase on net.
- "Warm glow" giving (Andreoni, 1990)
  - i.e. $U(X_h, G_h, G)$
  - Stigler and Becker (1977) critique: should not just modify preferences to explain patters (you can explain anything this way.
- Prestige/signalling motives
  - Plaques or building/parks named after donor.
  - Glazer and Konrad (1996)

Decentralised Provision: Lindahl Prices

- Same basic set up as previously
- Now each individual chooses G given they will contribute $\tau_h G$ to funding G.
- $\tau_h \in [0,1]$ and $\sum_h \tau_h = 1$
- Budget set becomes: $X_h = Y_h - \tau_h G$.
- Lindahl equilibrium requires:
  1. Set of prices: $\{\tau_1, ..., \tau_h\}$ $s.t.$ $\sum_h \tau_h = 1$
  2. Each individual chooses the same G

Decentralised Provision: Lindahl Prices

- H.H. Problem: $max\ U_h(Y_h - \tau_h G, G)$
- F.O.C.: $MRS^h_{GX} = \tau_h$
- Summing over h: $\sum_h MRS_{GX} = \sum_h \tau_h = 1$
- Samuelson rule satisfied: $MRT_{GX} = 1$
- Takeaway: If we set personal prices that reflect each HH's private valuation of the public good, we can achieve the first best allocation.

Great, but Lindahl equilibrium is basically infeasible:

- Must choose the set of prices that induces every individual to choose the same level of G:
  - Requires knowledge of everyone's preferences, or;
  - Possibly using trial and error until you find the right set of prices.
  - Maybe possible with a few agents, but becomes increasingly infeasible as H increases.
- Individuals have incentive to misreport their preferences:
  - If everyone else accurately reports I have incentive to under report.
  - The return of the free rider problem.

Atkinson & Stern (1974): Funding the public good with distortionary taxes.

- k private goods x_i with $i \in \{1, ..., k\}$ with price p_k and after tax price $q_k = p_k + t_k$.
- Let x_1 be the numaraire: $p_1 = q_1 = 1$
- G: single public good with price p_g.
- H identical households with preferences $U(x, G)$ and budget set $\sum_k q_k x_k = y$.
- Production Possibilities: $F(X, G) = 0$, where $X = Hx$.
  - market prices correspond to $F_{x_k} = p_k$.

Atkinson & Stern (1974): Households

H.H.s solve:

$$V(q,G) = \max_{G} U(x,G) - \alpha(\sum_i q_i x_i - y)$$

F.O.C.:

$$U_{x_k} = \alpha q_k, \quad \forall k$$

- α is the marginal utility of income (and the numeraire).
- $V(q,G)$ indirect utility.
- Note: from budged constraint $q_k \frac{\partial x_k}{\partial G} = 0$.

Atkinson & Stern (1974): Households

Government solves:

$$\mathcal{L} = \max_{G} HV(q, G) - \lambda F(X, G)$$

F.O.C.:

$$HV_G - \lambda(\sum_i F_i \frac{\partial X_i}{\partial G} + F_g) = 0$$

using $F_i = p_i$ and multiplying both sides by $\frac{1}{\alpha q_k}$:

$$H \frac{V_G}{\alpha q_k} = \frac{\lambda}{\alpha q_k}(\sum_i p_i \frac{\partial X_i}{\partial G} + p_k \frac{F_G}{F_k})$$

Evaluating the first order condition for X_1 and rearranging:

$$\frac{F_G}{F_1} = \frac{\alpha}{\lambda} H \frac{V_G}{\alpha} - \sum_i (q_i - t_i) \frac{\partial X_i}{\partial G}$$

Notice:

- $\frac{F_G}{F_1} = MRT_{G1}$
- $H \frac{V_G}{\alpha} = H \frac{V_G}{U_1} = H \times MRS_{G1} = \sum_i MRS_{G1}$ (from consumer FOC)
- $\sum_i q_i \frac{\partial X_i}{\partial G} = 0$ (consumer B.C.)

Thus we have:

$$MRT_{G1} = \frac{\alpha}{\lambda} \sum_i MRS_{G1} + \sum_i \frac{\partial t_i X_i}{\partial G}$$

Samuelson Rule with Distortionary Commodity Taxation

$$MRT_{G1} = \underbrace{\frac{\alpha}{\lambda}\sum_i MRS_{G1}}_{\text{scaled Samuelson term}} + \underbrace{\sum_i \frac{\partial t_i X_i}{\partial G}}_{\text{revenue effect}}$$

1. Revenue effect:
    - If provision of the public good increases tax revenue (e.g. G is a compliment to some X_i) then this reduces the cost of the public good measured by the MRT increasing public good provision.
    - Vice-versa for substitutes.
2. Suppose public good is revenue neutral (revenue effect=0):
    - Diveregence from the F.B. is determined by $\frac{\alpha}{\lambda}$
    - If $\alpha < \lambda$ benefit of the public good is $< \sum MRS$. $G^{dt} \downarrow$
    - If $\alpha > \lambda$ benefit of the public good is $> \sum MRS$. $G^{dt} \uparrow$

Samuelson Rule with Distortionary Commodity Taxation

Taking the condition for optimal q_k from the government Lagrangian we can express how $\frac{\alpha}{\lambda}$ diverges from 1 as:

$$\frac{\alpha}{\lambda} = 1 - \underbrace{\sum_i t_i \frac{\partial X_i}{\partial I}}_{\text{revenue effect}} + \underbrace{\sum_i t_i \frac{S_{ik}}{X_k}}_{\text{distortionary effect}}$$

Derive

- Distortionary effect: $\sum_i t_i \frac{S_{ik}}{X_k} \leq 0$ (Slutsky matrix is negative definite)
  - Consumption more expensive for HH's would tend to reduce their MB of income $\alpha \downarrow$
- Revenue effect: $\sum_i t_i \frac{\partial X_i}{\partial I}$ is probably > 0 (if taxed goods are normal)
  - Taxing reduces disposable income $\rightarrow \alpha \downarrow$
- Takeaway: It is most likely that $G^{dt} < G^*$
  - $\frac{\alpha}{\lambda} < 1$ (assuming most goods are normal)
  - Public good is probably close to revenue neutral on balance (parks are compliments to frisbees, substitutes to video games)

Empirical Evidence on Public Goods

We'll look at empirical evidence on two questions related to public goods:

1. Free-rider behaviour
   - This literature has classically used lab experiments to test the free-rider hypothesis
2. Crowd out
   - Has used both lab experiments and non-experimental evidence, with the latter becoming more prominent in the era of big data.

Economists Free Ride, Does Anyone Else? (Marwell & Ames 1981)

- Lab experiment testing free-rider behaviour
  - Groups of 5 subjects given 10 tokens, each subject given the choice to invest them in an individual account or donate to a group account.
  - Keep token personal payoff of \$1, donate token payoff for everyone of \$0.5.
  - If all donate then each player gets a payoff of \$25. If no one donates each player gets \$10.
  - But for any level of donation a player is better off not donating at all $\Rightarrow$ NE 100% individual account.

Economists Free Ride, Does Anyone Else? (Marwell & Ames 1981)

Table 2

Summary of results: Experiments 1–11.

Experiment	Mean % of resources invested
1. Basic experiment	42%
2. Skewed resources and/or interest	53%
Experiments 1 and 2, combined	51%
3. Provision point	51%
4. Small groups with provision point (except those with sufficient interest to provide the good themselves)	60%
5. Experienced subjects	47%
6. High stakes	
Experienced interviewers	35%
All interviews	28%
7. Feedback, no changing initial investment	46%
8. Feedback, could change investment in individual account	50%
9. Feedback, could change investment in individual account — college students	49%
10. Manipulated feedback	
Low	43%
Medium	50%
High	44%
11. Non-divisibility	
Divisible (control)	43%
Non-divisible	84%
12. Economics graduate students	20%

Andreoni (1993): Repeated Donation Game (repeated prisoner dilemma)

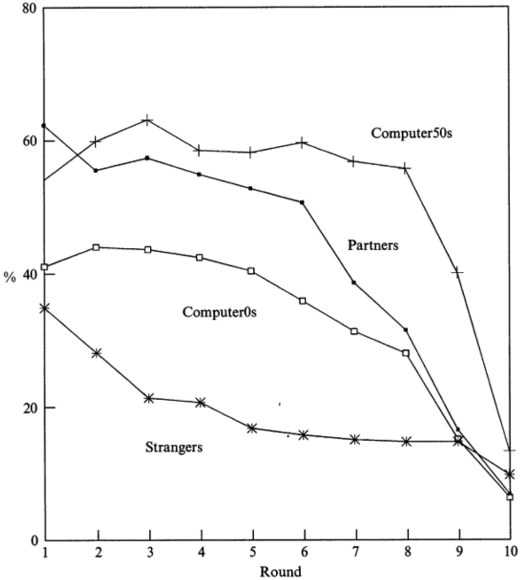


Fig. 2. Percent cooperation by round. Averaged over all 20 10-period games.

Andreoni (1993): Repeated Donation Game (repeated prisoner dilemma)

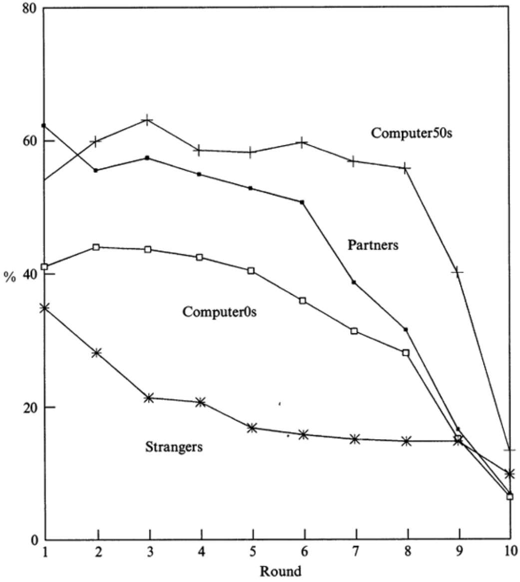


Fig. 2. Percent cooperation by round. Averaged over all 20 10-period games.

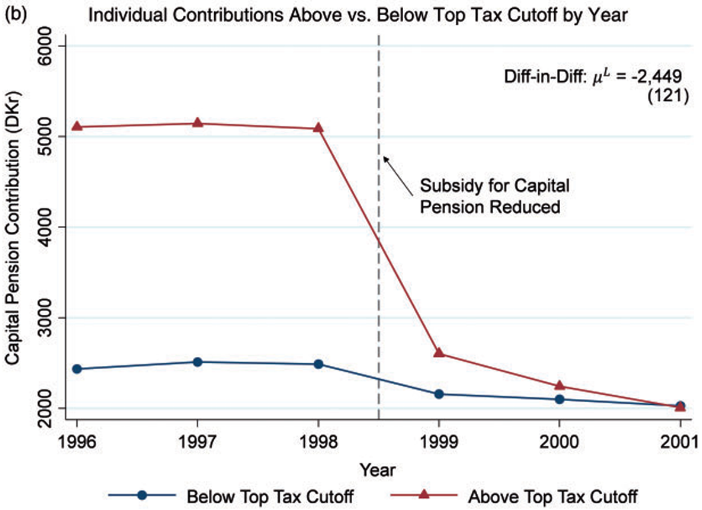
Active vs. Passive Savers (Chetty et. al., 2014)

- Studies the impact of two different types of policy meant to induce individuals to save move.
  1. **Subsidies**: Usually in the form of tax benefits from saving in certain dedicated savings accounts.
  2. **Automatic Contributions**: e.g. Payroll pension contributions made on the behalf workers by their employers.

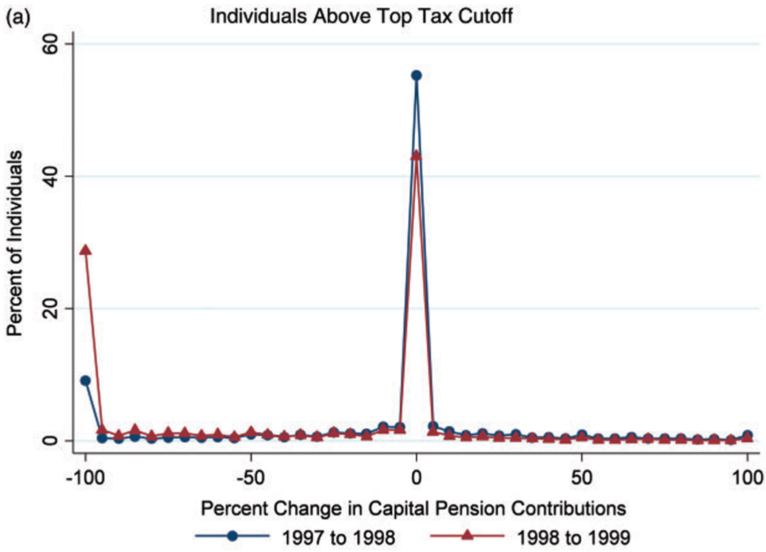
Subsidies for Saving (Chetty et. al., 2014)

- Denmark has two types of pension accounts: capital pensions and annuity pensions.
- Reform in 1999 lowered the subsidy for saving in capital pensions, for those in the top income tax bracket (20% of working age population).
- Motivates and event-study empirical design that examines:
  - What was the effect of this on contributions to capital pensions?
  - Were savings shifted to other accounts?

Chetty et. al. (2014)



Chetty et. al. (2014)



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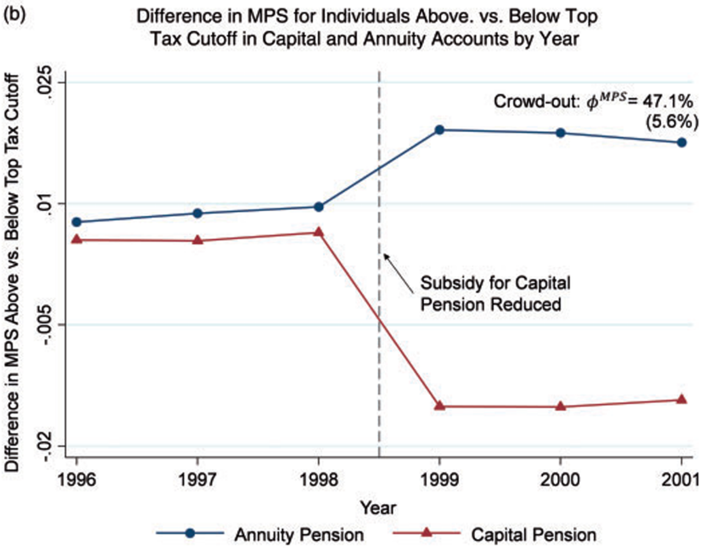
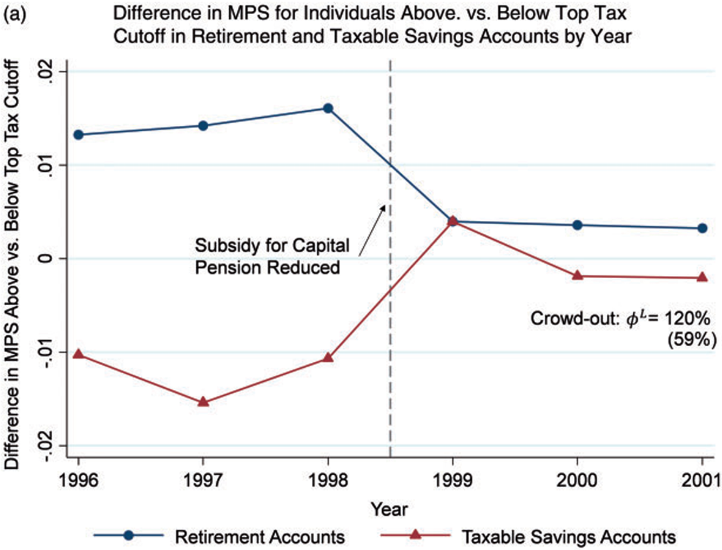
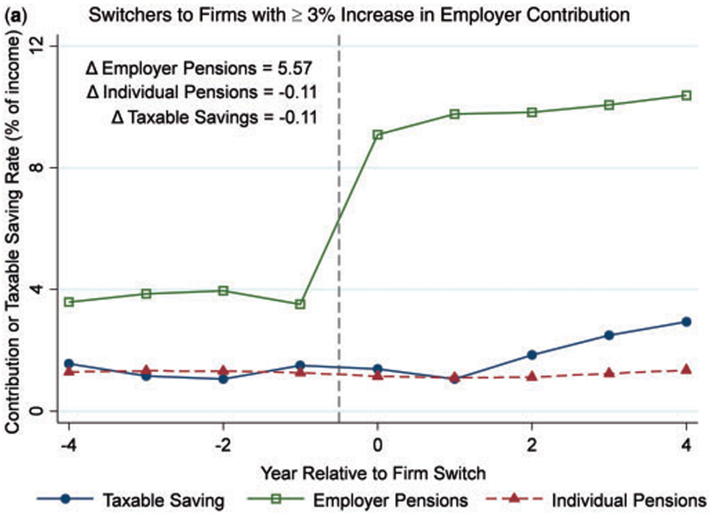


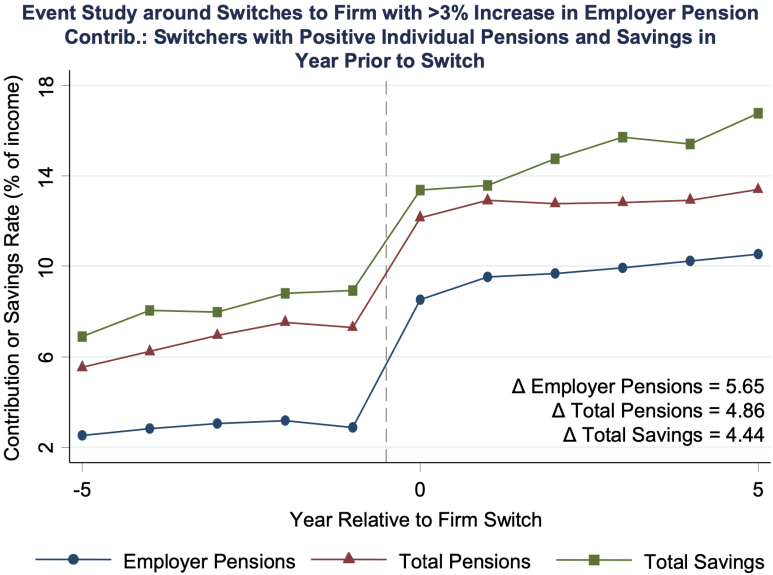

(a)
Difference in MPS for Individuals Above. vs. Below Top Tax Cutoff in Retirement and Taxable Savings Accounts by Year
Difference in MPS Above vs. Below Top Tax Cutoff
.02
.01
0
-.01
-.02
Subsidy for Capital Pension Reduced
Crowd-out: ϕ^L= 120% (59%)
1996
1997
1998
1999
2000
2001
Year
Retirement Accounts
Taxable Savings Accounts

Automatic Contributions (Chetty et. al., 2014)

- Employers make pension contributions on behalf of their workers automatically, but the amount is heterogenous across firms.
- When workers switch firms these contributions can change dramatically
- Empirical design: event study when workers switch to a firm that has a $\geq$ 3% higher automatic contribution rate.
  - Do these automatic contributions crowd out other savings?


(a)
Switchers to Firms with ≥ 3% Increase in Employer Contribution
Δ Employer Pensions = 5.57
Δ Individual Pensions = -0.11
Δ Taxable Savings = -0.11
Contribution or Taxable Saving Rate (% of income)
0
4
8
12
-4
-2
0
2
4
Year Relative to Firm Switch
Taxable Saving
Employer Pensions
Individual Pensions

Chetty et. al. (2014)



Automatic Contributions (Chetty et. al., 2014)

- Why do automatic contributions increase savings (not crowd out) so much more than price subsidies?

  $\longrightarrow$ Active vs. Passive savers (Carrol et al., 2009)

- Active savers already optimizing and/or pay attention to incentives/changes in policy and shift savings around accordingly.

- Passive savers may have low savings to begin with and can be induced into higher savings if contributions are automatic. Also may not pay attention to different to different savings/tax incentives.

- Question: Does this logic also pertain to public good contributions?

Empirical Evidence of Crowd Out (Hungerman 2005)

- Studies the impact of government welfare (food stamps, cash welfare, child subsidies etc.) on church provided services.
- Uses 1996 federal welfare reform in the US which hugely reduced/eliminated welfare for *legal* immigrants.
- IV strategy:

$$c_{ikt} = \alpha + \delta gov_{kt} + X_{ikt}\beta + \epsilon_{ikt}$$
$$gov_{kt} = \eta + \theta post96_t \times \%noncitizen_{tk} + X_{ikt}\beta + u_{ikt}$$

  - c_{ikt} church spending per-member in county k at time t, gov_{kt} government welfare spending.
- Thoughts on the exclusion restriction here?

Empirical Evidence of Crowd Out (Hungerman 2005)

- Estimates that a \$1 decrease in per-capita government welfare spending led to a \$0.40 increase in per-member church welfare spending.
- Crowd out not 100% but not trivial either.
- Questions:
  - Do churches (people) react differently to an decrease in government funds than to a decrease in government funds? (increase in need vs decrease in need)
  - Even if there is full crowd out: is it desirable for welfare to be provided by private interests?

Does Government Crowd Out Public Donations? (Payne, 1998)

- Estimates how donations to charities react to government grants to that charity using the model:

$$D_{ijt} = \alpha + \beta Gov_{ijt} + \gamma Z_{jt} + \epsilon_{it}$$

- Instruments for Gov_{ijt} using government transfers in state j to individuals (iffy).
- Estimates that \$0.50 crowd out for every \$1.00 in government grants.
- Only partial crowd out, suggests we are not fully in a BBV world.

Government Grants Impact on a Charity Income (Andreoni et. al. 2014)

$$\frac{\partial Y}{\partial G_1} = 1 + \underbrace{\frac{\partial D}{\partial G_1}}_{\text{private donations}} + \underbrace{\frac{\partial D}{\partial FR}\frac{\partial FR}{\partial G_1}}_{\text{fundraising}} + \underbrace{\frac{\partial G_2}{\partial G_1} + \frac{\partial G_2}{\partial GA_2}\frac{\partial GA_2}{\partial G_1}}_{\text{other gov. grants}} + \underbrace{\frac{\partial G_3}{\partial G_1} + \frac{\partial GA_3}{\partial GA_3}\frac{\partial GA_3}{\partial G_1}}_{\text{private grants}}$$

- Where: Y - total charity funding; D - private donations; FR - fundraising; G_2 - grants from goverment; G_3 - private grants; GA_i - grant applications
- $\frac{\partial Y}{\partial G_1} = 0 \rightarrow$ full crowd out; $\frac{\partial Y}{\partial G_1} = 1 \rightarrow$ no crowd out
- Payne's study above arguably captures the bundled effect of private donations, private grants and fundraising effects.
- is it possible that $\frac{\partial D}{\partial G_1} > 0$ That is, can government expenditure **crowd in** private donations.
  - Andreoni et. al. find that, controlling for all other channels, private donations from individuals increased for medium to small charities after they received a government grant.
  - Two channels:

    1. Grants provide information to private individuals about the quality or importance of a charity.

    2. Grants provide seed money for important project which then requires donations to operate.

- Decomposes the impact of government grants on donations into the direct giving channel and the fundraising channel by estimating the system of equations given by:

$$Donations_{ist} = \alpha_i^1 + \lambda_t^1 + A \cdot GovtGrants_{ist} + Controls_{ist}\omega^1 + \varepsilon_{ict}^1$$

$$Donations_{ist} = \alpha_i^2 + \lambda_t^2 + B \cdot Fundraising_{ist} + Controls_{ist}\omega^2 + \varepsilon_{ict}^2$$

$$Fundraising_{ist} = \rho_i + \varphi_t + C \cdot GovtGrants_{ist} + Controls_{ist}\kappa + \eta_{ict}$$

- Instruments for grants using seniority of members of congress in a state (idea: they have more sway in getting federal money directed towards their state).

Is Crowding Out Due to Fundraising (Andreoni and Payne, 2011)

Table 5
Total, direct, and indirect (due to fund-raising) crowding out.

	(1) Base	(2) Includes charities with 0 govt grants for All Years	(3) Excludes crime charities (I)	(4) Excludes employment charities (J)	(5) Excludes food charities (K)	(6) Excludes housing charities (L)	(7) Excludes community charities (S)
Panel A							
A: dD/dG = Changed donations by grants	**−0.757**	**−1.233**	**−0.548**	**−0.656**	**−0.570**	**−0.768**	**−0.579**
Significantly different from base organizations?		No	No	No	No	No	No
B: dD/dF = Changed donations by fundraising	**5.644**	**5.101**	**5.695**	**5.525**	**5.654**	**5.666**	**4.278**
Significantly different from base organizations?		No	No	No	No	No	No[b]
C: dF/dG = Changed fund-raising by grants	**−0.141**	**−0.206**	**−0.077**	**−0.127**	**−0.133**	**−0.142**	**−0.116**
Significantly different from base organizations?		No	Yes[a]	No	No	No	No
Panel B							
Crowding out of donations							
Total crowd-out = A	−0.757	−1.233	−0.548	−0.656	−0.570	−0.768	−0.579
Direct crowd-out = A − B C	0.041	−0.182	−0.109	0.045	0.182	0.035	−0.085
Percent	−5%	15%	20%	−7%	−32%	−5%	15%
Indirect crowd-out = B C	−0.798	−1.051	−0.439	−0.701	−0.752	−0.803	−0.494
Percent	105%	85%	80%	107%	132%	105%	85%

Is Crowding Out Due to Fundraising (Andreoni and Payne, 2011)

- Find significant crowd out, up to 75%, but that at least 70% of this crowd out is due to a reduction in fundraising effort.
- Suggests that individuals a relatively passive actors (like passive savers?)
- Is crowding out of fundraising effort a problem
  - What is more efficient?:
    a) $10,000 government grant that because of crowding out raises the charity's revenue by $2340
    b) Increasing fundraising expenditure by $757 to increase the charity's operating revenue by $2340
  - Depends on the marginal cost of fundraising and the marginal cost of public funds.
- Related question: Does fundraising result in the optimal allocation of private donations?
  - Ice-Bucket Challenge: Did it over provide funds to ALS at the expense of other important charities for other diseases?

Other Costs of Fundraising? (Andreoni et. al., 2017)

- Does fundraising cause people to give beyond what is optimal?
- Andreoni et. al. run a field experiment with Salvation Army fundraising campaign.
- They randomized fundraisers outside of stores to 5 treatment conditions:
  - Fundraisers at one or both entrances/exits from the store, and,
  - Fundraisers are either silent or directly ask those passing by to give.
- Results:
  - Silent fundraisers at one door → no change in traffic through doors
  - When one door had fundraisers asking to give → traffic through the other door increases by 30%
  - When both doors covered with asker → giving up by 50%.
- At least some individuals were avoiding saying "yes" rather than "no".
- Psychic cost? Is this sort of pressure optimal?

Condition for optimal tax from the Government Lagrangian:

$$H\frac{\partial V}{\partial q_k} = \lambda \sum_i F_i \frac{\partial X_i}{\partial q_k} = \lambda \frac{\partial \sum_i p_i X_i}{\partial t_k}$$

Using Roy's identity (envelope theorem) and $\sum_i q_i \frac{\partial X_i}{\partial G} = 0$ we can write:

$$\frac{\alpha}{\lambda} = \frac{\frac{\partial \sum_i t_i X_i}{\partial t_k}}{X_k}$$

Finally, using Slutsky's Equation:

$$\frac{\alpha}{\lambda} = 1 - \sum_i t_i \frac{\partial X_i}{\partial I} + \sum_i t_i \frac{S_{ik}}{X_k}$$

Back