Debt and (Future) Taxes: Financing Intergenerational Public Goods

J. Forrest Williams
Portland State University
February 25, 2015
Motivation

- Social projects impact current and future generations
  - Environmental quality, infrastructure, educational policies, research grants, etc.
- Most projects financed partly by future generations
- Study public goods environment experimentally
  - Can use debt (future player’s endowment) to finance
  - Investments in the public good help future group
Literature

Debt and (Future) Taxes: Financing Intergenerational Public Goods

Public Goods

- Ledyard (1995), Handbook Chapter
- Zelmer (2003), Experimental Economics

Intergenerational Resources

- Chermak & Krause (2002), JEEM
- Fischer et al. (2004), JEEM

Experimental Macroeconomics

- Duffy (2012), Working Paper

Intergenerational Externalities & Debt

- Cadby & Frank (1991), Economic Inquiry
- De Laurea & Ricciuti (2003), Economics Bulletin

Motivation and Literature
Contributions

- First experimental test of intergenerational PG spillovers
- Experimental test of endogenous debt and savings in PG
Preview of Results

- Debt use increases the spillovers from the public good
- These gains are offset by losses from debt repayment
- Debt’s losses have two causes:
  1. Underinvestment in the Public Goods
  2. Insufficient savings for the next generation
Intergenerational Transfers in PG Game

- Suppose agents borrow from and save for successors
  - Can borrow $b_{it} \leq \bar{B}$
  - Can save up to remaining wealth after public good game

\[
\pi_{it} = \frac{w_{it} - b_{it-1} + s_{it-1} - g_{it} + \gamma \sum_{j=1}^{N} g_{jt} - (s_{it} - b_{it})}{\text{Net Starting Endowment}} + \text{Net Savings for Next Gen.}
\]

- $\gamma$ is the marginal per capita return (MPCR)
- $b_{it}$ is amount borrowed in period $t$ by $i$ from her heir
- $s_{it}$ is amount saved in period $t$ by $i$ for her heir
Intergenerational Spillover

- Contributions impact the wealth of a future generation
- Assume a constant MPCR of $\theta$ for next generation

I consider

$$w_{it+1} = w_{it} + \theta(G_t - \tau(w_{it}))$$

where

- $G_t$ is total contributions
- $\tau(w_{it})$ is a threshold
Two Theoretical Predictions

- Nash Equilibrium:
  - \( b_{it}^{NE} = \bar{B} \)
  - \( g_{it}^{NE} = 0 \)
  - \( s_{it}^{NE} = 0 \)

- Socially Optimal:
  - \( b_{it}^{SO} = \bar{B} \)
  - \( g_{it}^{SO} = w_{it} + \bar{B} \)
  - \( s_{it}^{SO} = \text{s.t. } U'(c)_{it} = \beta \gamma (U'(c)_{it+1} + \beta \theta U'(c)_{it+2}) \)
Methods of Impacting Future Generations

1. Debt
2. Savings
3. Investment in the Public Good
   - Investments over $\tau(\cdot)$ increase future players’ wealth
   - Less than $\tau(\cdot)$ lower future players’ wealth
Why an Experiment?

- Controlled Environment
- Allows a clean test of question
- Can vary the parameters to test robustness
- See extra behavioral outcomes theory misses
- Can be replicated
**Who are the Subjects?**

- Subjects are Texas A&M undergraduates
- A&M students are a relatively unique population
  - Many care deeply about what it means to be an *Aggie*
  - 50,000 students with an us against world mentality
  - Have own vocabulary and unusual traditions
  - Arguably have “little brother” complex
Overview of Design

- Two treatments
  - Control – No Debt
  - Treatment – With Debt
- Played 10 rounds (one randomly selected for payment)
- Each round had multiple stages
  - Debt Voting Stage (Treatment Only)
  - PG Game
  - Savings Decision
Stages of the Control Condition:
Subjects played game with Tokens

Initial tokens (wages) and Net Savings from Previous Player/Group
5 Subjects per Group
Current Groups Connected to Future Players

with probability .6
Current Groups Plays Public Good Game...
.. and receives a benefit from investment

of $\gamma$ (MRPC) times total investment $G_t$
BUT – so does the future group

of $\theta$ (MRPC spillover) times total investment $G_t$
Additionally - Players can save tokens for future player
Treatment

Same as Control Except:

- Subjects can take tokens from Future players
- Timing of Actions
  1. Debt Withdrawn (Group Decision)
  2. Public Goods (Individual Choice, Group Impacts)
  3. Savings for Future Player (Individual Choice)
All players vote on tokens to withdraw
Median Amount is then added to all current players and subtracted from future players available tokens.
Debt Voting Stage

- Subjects allowed to *withdraw* tokens from future players
- They could withdraw up to 40% of the starting tokens
- Median vote selected
- All group members get that many additional tokens
Place your bid for tokens to withdraw from the future group.

| Percent of endowment Invested by Previous Group: | 0.94 |
| Impact on your endowment: | 1 |
| Your starting tokens: | 42 |
| Tokens withdrawn by Previous Generation: | 13 |
| Tokens deposited to you by member of previous group: | 3 |
| Current Tokens: | 32 |
| You may bid any amount up to: | 17 |
| Withdrawal Bid: |  |
Public Goods Game

- Invest any of their tokens (net starting + withdrawal)
- Current Generation MPCR, $\gamma = 0.3$
- Future Generation MPCR, $\theta = 0.08$
- Threshold $\tau(\cdot)$ is 50% of starting tokens.
Savings Decision

- Subjects shown five possible outcomes from the PG game
  - One is real
  - Four are randomly generated
- Each outcome impacts
  - Subject’s own tokens
  - Future player’s tokens
- For each outcome subjects make deposit choice

Nonparametric Comparison of Random and Real Outcomes
For each of the possible outcomes, indicate how much you would deposit back to a member of the future group.

Tokens initially withdrawn from future player: 12
Tokens you invested in Account A: 12

<table>
<thead>
<tr>
<th>Total Group Investment</th>
<th>Impact on Next Group’s Endowment</th>
<th>Net Impact on Next Group’s Endowment</th>
<th>Next Player’s Starting Tokens</th>
<th>Current Tokens</th>
<th>Deposit to Future Player</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>0</td>
<td>-12</td>
<td>36</td>
<td>58.6</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>2</td>
<td>-10</td>
<td>38</td>
<td>67.0</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>3</td>
<td>-9</td>
<td>39</td>
<td>70.0</td>
<td></td>
</tr>
<tr>
<td>47</td>
<td>2</td>
<td>-10</td>
<td>38</td>
<td>69.1</td>
<td></td>
</tr>
<tr>
<td>56</td>
<td>3</td>
<td>-9</td>
<td>39</td>
<td>71.8</td>
<td></td>
</tr>
</tbody>
</table>
Results

- Subjects borrow less than the amount available
- Debt leads to slightly higher contributions to public good
- Subjects insufficiently save to offset debt repayment
- Debt makes future generations worse off
## Summary Statistics

<table>
<thead>
<tr>
<th>Category</th>
<th>Control: No Debt</th>
<th>Treatment: With Debt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subjects</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Starting Tokens</td>
<td>50.07</td>
<td>49.73</td>
</tr>
<tr>
<td>Previous Debt</td>
<td>N/A</td>
<td>9.37</td>
</tr>
<tr>
<td>Previous Savings</td>
<td>9.67</td>
<td>9.95</td>
</tr>
<tr>
<td>Tokens Borrowed</td>
<td>N/A</td>
<td>16.1</td>
</tr>
<tr>
<td>% Available Tokens Borrowed</td>
<td>N/A</td>
<td>77.4</td>
</tr>
<tr>
<td>Invested Tokens</td>
<td>26.91</td>
<td>28.95</td>
</tr>
<tr>
<td>Tokens Saved</td>
<td>4.4</td>
<td>10.11</td>
</tr>
<tr>
<td>Total Impact on Next Gen</td>
<td>6.04</td>
<td>-2.07</td>
</tr>
</tbody>
</table>
## Table: Regressions on Total Change in Tokens for Next Generation

<table>
<thead>
<tr>
<th>Variable</th>
<th>Estimate 1</th>
<th>Estimate 2</th>
<th>Estimate 3</th>
<th>Estimate 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Debt</td>
<td>-8.111***</td>
<td>-8.273***</td>
<td>-7.862***</td>
<td>-7.858***</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>Starting Tokens</td>
<td>0.0685</td>
<td>0.0558</td>
<td>0.0577</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.089)</td>
<td>(0.122)</td>
<td>(0.108)</td>
<td></td>
</tr>
<tr>
<td>Previous PG Impact</td>
<td>-0.292***</td>
<td>-0.285***</td>
<td>-0.296***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>0.739</td>
<td>0.735</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.664)</td>
<td>(0.666)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caucasian</td>
<td>-1.453</td>
<td>-1.456</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.457)</td>
<td>(0.456)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Econ Major</td>
<td>-2.720</td>
<td>-2.728</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.196)</td>
<td>(0.195)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subjects</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>Rounds</td>
<td>10</td>
<td>9</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>Round Dummies</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Additional Demographics</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>adj. $R^2$</td>
<td>0.086</td>
<td>0.107</td>
<td>0.151</td>
<td>0.161</td>
</tr>
</tbody>
</table>

*p-values in parentheses, Clustered by Subject
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Decomposing Negative Effect of Debt

1. Debt is not fully invested in Public Good
2. Savings do not cover future debt obligations
Table: Determinants of Investment in the Public Good

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Debt</td>
<td>0.632</td>
<td>(0.159)</td>
<td>0.633</td>
<td>(0.174)</td>
</tr>
<tr>
<td>Net Starting Tokens</td>
<td>0.432**</td>
<td>(0.006)</td>
<td>0.460**</td>
<td>(0.008)</td>
</tr>
<tr>
<td>Female</td>
<td>0.587</td>
<td>(0.935)</td>
<td>0.750</td>
<td>(0.917)</td>
</tr>
<tr>
<td>Caucasian</td>
<td>3.277</td>
<td>(0.680)</td>
<td>3.225</td>
<td>(0.690)</td>
</tr>
<tr>
<td>Voter</td>
<td>3.999</td>
<td>(0.565)</td>
<td>4.062</td>
<td>(0.565)</td>
</tr>
<tr>
<td>Econ Major</td>
<td>9.092</td>
<td>(0.425)</td>
<td>8.982</td>
<td>(0.438)</td>
</tr>
<tr>
<td>Texan</td>
<td>3.535</td>
<td>(0.640)</td>
<td>3.683</td>
<td>(0.634)</td>
</tr>
<tr>
<td>CRT Fail</td>
<td>-2.931</td>
<td>(0.713)</td>
<td>-2.965</td>
<td>(0.714)</td>
</tr>
</tbody>
</table>

| Subjects             | 30     | 30     |
| Rounds               | 10     | 10     |
| Round Dummies        | No     | Yes    |
| adj. $R^2$           | 0.190  | 0.175  |

$p$-values in parentheses, Clustered by Subject

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
**Under-savings**

- Savings in Debt Treatment are higher than the Control
- They are not, however, enough to cover the debt
  - Finding is counter to Ricardian Equivalence
Testing Ricardian Equivalence

Token Saved vs. Debt in Tokens

- Observed Relationship in Treatment
- Ricardian Prediction

kernel = epanechnikov, degree = 0, bandwidth = 1.57
Concluding Remarks

- Public Goods have intergenerational spillovers
  - The good itself has a positive spillover
  - Debt-financing is a negative spillover
- I find debt leads to more contributions to PG
- Yet – Debt harms next generation in net
  - Debt is not fully invested in the public good
  - Savings are not enough to offset debt when it exists
Supplemental Material
Timing of Actions

\[ t \text{ Begins} \quad w_{it}, b_{it-1} \quad s_{it-1}, G_{t-1} \quad B_t \quad G_t \quad t \text{ Ends} \]

where

- \( w_{it} = \) endowment
- \( b_{it} = \) debt
- \( s_{it} = \) savings
- \( g_{it} = \) contribution to public good
- \( G_t \equiv \sum_N g_{it} \)

1. Born into world

2. Cast debt vote

3. Debt determined via median vote

4. PG contribution

5. G revealed

6. Savings/Consumption Decision
**Timing of Actions**

$t$ Begins: $w_{it}, b_{it-1}$

$t$ Ends: $s_{it-1}, G_{t-1}$

$B_t$

$G_t$

$s_{it}, c_{it}$

where

- $w_{it} = \text{endowment}$
- $b_{it} = \text{debt}$
- $s_{it} = \text{savings}$
- $g_{it} = \text{contribution to public good}$
- $G_t \equiv \sum_N g_{it}$

1. Born into world
2. Cast debt vote
Timing of Actions

\[ t \text{ Begins} \quad w_{it}, b_{it-1} \quad s_{it-1}, G_{t-1} \quad B_t \quad G_t \quad s_{it}, c_{it} \quad t \text{ Ends} \]

where

- \( w_{it} = \) endowment
- \( b_{it} = \) debt
- \( s_{it} = \) savings
- \( g_{it} = \) contribution to public good
- \( G_t \equiv \sum_N g_{it} \)

1. Born into world
2. Cast debt vote
3. Debt determined via median vote
Timing of Actions

\[ w_{it}, b_{it-1} \]
\[ s_{it-1}, G_{t-1} \]
\[ B_t \]
\[ G_t \]
\[ s_{it}, c_{it} \]

where

- \( w_{it} = \) endowment
- \( b_{it} = \) debt
- \( s_{it} = \) savings
- \( g_{it} = \) contribution to public good
- \( G_t \equiv \sum_N g_{it} \)

1. Born into world
2. Cast debt vote
3. Debt determined via median vote
4. PG contribution
Timing of Actions

\[ w_{it}, b_{it-1} \]
\[ s_{it-1}, G_{t-1} \]
\[ B_t \]
\[ G_t \]
\[ s_{it}, c_{it} \]

\[ t \text{ Begins} \]
\[ B_t \text{ Begins} \]
\[ G_t \text{ Begins} \]
\[ t \text{ Ends} \]

where

- \( w_{it} = \) endowment
- \( b_{it} = \) debt
- \( s_{it} = \) savings
- \( g_{it} = \) contribution to public good
- \( G_t = \sum N g_{it} \)

- 1. Born into world
- 2. Cast debt vote
- 3. Debt determined via median vote
- 4. PG contribution
- 5. G revealed
Timing of Actions

\[
\begin{align*}
\text{\(t\) Begins} & & \text{\(w_{it}, b_{it-1}\)} & & \text{\(t\) Ends} \\
\text{\(s_{it-1}, G_{t-1}\)} & & \text{\(B_t\)} & & \text{\(G_t\)} & & \text{\(s_{it}, c_{it}\)} \\
\text{\(b_{it}\)} & & \text{\(g_{it}\)} & & \text{\(s_{it}, c_{it}\)} \\
\end{align*}
\]

where

- \(w_{it} = \) endowment
- \(b_{it} = \) debt
- \(s_{it} = \) savings
- \(g_{it} = \) contribution to public good
- \(G_t \equiv \sum_N g_{it} \)

1. Born into world
2. Cast debt vote
3. Debt determined via median vote
4. PG contribution
5. \(G\) revealed
6. Savings/Consumption Decision
Scatter of Debt Vote Outcomes to Debt Limit, in Tokens
Kernel density estimate

Total Change in Tokens for the Next Generation

Density

-50 0 50 100 150

Treatment -- With Debt
Control -- No Debt

kernel = epanechnikov, bandwidth = 2.3952

Average Total Impact
### Decide your Investment in Account A

50% of starting Tokens: 24

Each token under the 50% point lowers future Aggies' tokens by .08 and above it increases it by .08 tokens for each token.

<table>
<thead>
<tr>
<th>Percent of endowment invested by Previous Group:</th>
<th>0.13</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impact on your endowment:</td>
<td>-1</td>
</tr>
<tr>
<td>Your starting tokens:</td>
<td>48</td>
</tr>
<tr>
<td>Tokens withdrawn by Previous Generation:</td>
<td>9</td>
</tr>
<tr>
<td>Tokens deposited to you by member of previous group:</td>
<td>16</td>
</tr>
<tr>
<td>Winning Bid for Withdrawal</td>
<td>12</td>
</tr>
<tr>
<td>Current Tokens:</td>
<td>67</td>
</tr>
<tr>
<td>Investment Amount:</td>
<td></td>
</tr>
</tbody>
</table>

---

**Public Goods Stage Design**
Kernel-weighted Polynomial Estimation

Net Change in Tokens

Net Starting Tokens

-10
0
10
20

20
40
60
80
100

Treatment -- With Debt
Control -- No Debt

kernel = epanechnikov, degree = 0, bandwidth = 3.7
Kernel-weighted Polynomial Estimation

Net Change in Tokens

Net Starting Tokens

-10
0
10
20
20
40
60
80
100

Treatment -- With Debt
Control -- No Debt

kernel = epanechnikov, degree = 0, bandwidth = 3.7
Testing Ricardian Equivalence

-20 -10 0 10 20 30
Savings

-20 0 20 40 60
Negative Net Spillover

- Treatment -- With Debt
- Control -- No Debt
- Ricardian Prediction

kernel = epanechnikov, degree = 0, bandwidth = 2.91

Traditional Ricardian Graph
Fun Graph

Savings by Debt Vote Ranking

- Lowest Votes
- 2nd Lowest Votes
- Median Vote
- 2nd Highest Vote
- Highest Vote

Negative Net Spillover

Savings