Do Tax Cuts Increase Consumption?
An Experimental Test of Ricardian Equivalence

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10/Oct/2014
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- In our experiment, we find the behavior of **about 62%** of our subjects to be inconsistent with the Ricardian proposition
- Taxation influences consumption beyond the current period
A Dynamic Stochastic Optimization Model

- Induced time-separable CARA utility: \( u(c_t) = 338[1 - e^{-0.0125c_t}] \)
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\max_{c_t} E_t \sum_{j=0}^{25-t} u(c_{t+j})
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$$\text{s.t. } c_t + a_{t+1} + \tau_t = y_t + a_t,$$  \hspace{1cm} (2)

- Stochastic exogenous i.i.d. (labor) income $y_t$ 120 or 250 with equal probability in each period; standard deviation $\sigma_y = 65$
- Cash on hands $w_t = y_t + a_t$
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a_1 = 1000, \ a_{26} = 0,
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- Constant sum of Taxes condition

\[
\sum_{t=1}^{25} \tau_t = 9 = 3000. \] (4)
Definition: Ricardian Equivalence

- Optimal consumption in period $t$ is equal to

$$c_t^*(w_t) = \frac{1}{T-t+1} \left[ w_t + (T-t)y_p - R_t - \Gamma_t(\theta \sigma_y) \right].$$  

(5)
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  \[
  \Gamma_t(\theta \sigma_y) = \sum_{j=0}^{T-t} \sum_{i=1}^{j} \frac{1}{\theta} \log \cosh \left[ \frac{\theta \sigma_y}{T-t+1-i} \right].
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- Taxes to be paid/Taxes already paid

\[ T_t = \sum_{j=0}^{T-t} \tau_{t+j} = 9 - \sum_{j=1}^{t-1} \tau_j. \] (7)
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- This is an extension of Caballero (1990, 1991)
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Definition

Ricardian Equivalence. Suppose the sum of all tax payments ($\sum_{t=1}^{25} t_t$) is certain and equal to the constant 9 over the life-cycle, the timing and the size of tax payments is irrelevant for optimal consumption.
25 Optimal Consumption Functions
Experimental Design

- 8 rounds with 25 periods each for each subject
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- Subjects were paid according to the sum of points they purchased (17.79 Euro on average)
Definition of Treatment and Control I

- **Control:**
  - Taxes are 25 times 120, no tax cuts, no increases
  - In the following two treatments: Tax cuts in early periods, tax increases after period 16
  - There are 3 tax cuts and 3 tax increases; each of them are always 120 Taler
  - Subjects are informed that the sum of taxes equals 3000 Taler over one life cycle

- Treatment Ricardian 1:
  - Tax cuts (increases) occur only if low (high) income shock
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- Treatment Ricardian 2:
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- Optimal consumption is the same across all treatments

- Subjects play either the Control, Ricardian 1 or Ricardian 2 (random selection, about 43 subjects per treatment)
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**Table:** The Different Tax Schemes for One Exemplary Realization of the Income Stream.
### Definition of Treatment and Control II

<table>
<thead>
<tr>
<th>Period</th>
<th>Income Realization</th>
<th>Income Taxes</th>
<th>Income Net Inc</th>
<th>Control Taxes</th>
<th>Control Net Inc</th>
<th>Ricardian 1 Taxes</th>
<th>Ricardian 1 Net Inc</th>
<th>Ricardian 2 Taxes</th>
<th>Ricardian 2 Net Inc</th>
<th>$c_t^* (w_t^*)$</th>
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|                | Mean (Round)       | 187.6        | 67.6            | 120           | 67.6           | 120               | 67.6              | 120               | 67.6             | 107.6          |
|                | Variance (Round)   | 4,394        | 4,394           | 3,600         | 4,094          | 3,600             | 11,894            | 489              |                  |                |
|                | Mean (All)         | 185          | 65              | 120           | 65             | 120               | 65                | 120               | 65              | 105            |
|                | Variance (All)     | 4,246.2      | 4,246.2         | 3,473.4       | 3,956.8        | 3,473.4           | 11,482.4          | 383.6            |                  |                |
|                | $E[(y - \mu y)^2]$ | 4,225        | 4,225           | 4,225         | 4,225          | 4,225             | 4,225             | 4,225             | 4,225           |                |

**Table:** The Different Tax Schemes for One Exemplary Realization of the Income Stream.
Table: The Different Tax Schemes for One Exemplary Realization of the Income Stream.
### Definition of Treatment and Control II

Table: The Different Tax Schemes for One Exemplary Realization of the Income Stream.
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</table>

Mean (Round): 187.6, 120, 67.6, 120, 67.6, 120, 67.6, 107.6
Variance (Round): 4,394, 0, 4,394, 3,600, 4,094, 3,600, 11,894, 489
Mean (All): 185, 120, 65, 120, 65, 120, 65, 105
Variance (All): 4,246.2, 0, 4,246.2, 3,473.4, 3,956.8, 3,473.4, 11,482.4, 383.6

$E[(y - \mu y)^2]$: 4,225, 4,225, 4,225, 4,225

**Table:** The Different Tax Schemes for One Exemplary Realization of the Income Stream.
## Definition of Treatment and Control II

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### Mean (Round)

- Income: 187.6
- Control: 67.6
- Ricardian 1: 67.6
- Ricardian 2: 67.6

### Variance (Round)
- Income: 4,394
- Control: 3,600
- Ricardian 1: 4,094
- Ricardian 2: 11,894

### Mean (All)
- Income: 185
- Control: 65
- Ricardian 1: 65
- Ricardian 2: 65

### Variance (All)
- Income: 4,246.2
- Control: 3,473.4
- Ricardian 1: 3,956.8
- Ricardian 2: 11,482.4

| E[(y - μ_y)^2] | 4,225 | 4,225 | 4,225 | 4,225 |

### Table: The Different Tax Schemes for One Exemplary Realization of the Income Stream.
**Table: The Different Tax Schemes for One Exemplary Realization of the Income Stream.**
Table: The Different Tax Schemes for One Exemplary Realization of the Income Stream.
### Definition of Treatment and Control II

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Table: The Different Tax Schemes for One Exemplary Realization of the Income Stream.
Definition of Treatment and Control III

- If we observe deviations from optimal consumption to be

  \[ \text{Control} = R1 = R2 = \text{random} \]

  Theoretical prediction holds
Definition of Treatment and Control III

- If we observe deviations from optimal consumption to be

\[ \text{Control} = R_1 = R_2 = \text{random} \]

Theoretical prediction holds

- If we observe deviations from optimal consumption to be

\[ \text{Control} < R_1 = R_2 \]

Only variation in taxes matters
Definition of Treatment and Control III

- If we observe deviations from optimal consumption to be
  \[ Control = R_1 = R_2 = \text{random} \]
  Theoretical prediction holds
- If we observe deviations from optimal consumption to be
  \[ Control < R_1 = R_2 \]
  Only variation in taxes matters
- If we observe deviations from optimal consumption to be
  \[ R_1 < Control < R_2 \text{ or } Control < R_1 < R_2 \]
  Difficulty to smooth consumption and variation in taxes \textit{might} matter
Definition of Treatment and Control III

- If we observe deviations from optimal consumption to be
  \[ Control = R1 = R2 = \text{random} \]
  Theoretical prediction holds
- If we observe deviations from optimal consumption to be
  \[ Control < R1 = R2 \]
  Only variation in taxes matters
- If we observe deviations from optimal consumption to be
  \[ R1 < Control < R2 \text{ or } Control < R1 < R2 \]
  Difficulty to smooth consumption and variation in taxes \textit{might} matter
- If we observe deviations from optimal consumption to be
  \[ Control < R1 < R2 \]
  Difficulty to smooth consumption and variation in taxes \textit{do} matter
Figure: Screenshot of the Experimental Interface (z-tree Fischbacher (2007)).
Income
Taxes
Net Inc
Wealth
Cash on Hands

Round Period

Ihr Einkommen in dieser Periode (in Taler): 250.00
Ihre Steuern in dieser Periode (in Taler): 120.00
Einkommen - Steuern (in Taler): 130.0

Ihr Vermögen in dieser Periode (in Taler): 716.00
Einkommen + Vermögen - Steuern (in Taler): 846.00

Bitte geben Sie den Betrag ein den Sie ausgeben möchten um Punkte zu erwerben (in Taler):

Choose consumption here

Are you sure?

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<th>Steuern</th>
<th>Summe der g Steuer</th>
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Wealth next period

Sie sparen in dieser Periode (in Taler): 130.00

Ihr Vermögen in der nächsten Periode (in Taler): 846.00

Ihre Ausgaben in dieser Periode (in Taler): 0.00

Erworbene Punkte: 0.00

Period expenditures points

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Weiter
Consumption Behavior

![Graph showing consumption behavior with observed and fitted values at different time points.](image-url)

- **Observed Ctrl**: Red squares
- **Fitted Ctrl**: Orange dots
- **Observed R1**: Blue circles
- **Fitted R1**: Green dashes
- **Observed R2**: Green triangles
- **Fitted R2**: Brown dashes
- **T−24**: Red dashes
- **T**: Black line
- **∞**: Black line

**Axes**:
- **Consumption (in Taler)**
- **Cash On Hands (in Taler)**

**Time Points**:
- T−24
- T
- ∞
Consumption Behavior

![Graph showing consumption behavior with different markers and lines for observed and fitted values.]

- Observed Ctrl
- Fitted Ctrl
- Observed R1
- Fitted R1
- Observed R2
- Fitted R2
- T−22
- T
- ∞
Consumption Behavior

- Observed Ctrl
- Fitted Ctrl
- Observed R1
- Fitted R1
- Observed R2
- Fitted R2
- T−20
- T
- ∞
Consumption Behavior

![Graph showing consumption behavior with observed and fitted data points for cash on hands versus consumption in Taler. The graph includes markers for observed and fitted data, with lines indicating different time periods and trends.](image-url)
Consumption Behavior

![Graph showing consumption behavior with observed and fitted controls, T-17, T, and infinity markers.]
Consumption Behavior

![Graph showing consumption behavior with observed and fitted values.](image)

- **Y-axis**: Consumption (in Taler)
- **X-axis**: Cash On Hands (in Taler)

Legend:
- **Observed Ctrl**
- **Fitted Ctrl**
- **Observed R1**
- **Fitted R1**
- **Observed R2**
- **Fitted R2**
- **T−16**
- **T**
- **∞**
Consumption Behavior
Consumption Behavior

![Graph showing consumption behavior with various lines and markers representing observed and fitted controls, R1, and R2. The x-axis represents cash on hands in taler, while the y-axis represents consumption in taler. The graph includes data points and trend lines to illustrate the relationship between consumption and cash on hands.](image-url)
Consumption Behavior

![Graph showing consumption behavior with observed and fitted models.]
Consumption Behavior

- Observed Ctrl
- Fitted Ctrl
- Observed R1
- Fitted R1
- Observed R2
- Fitted R2
- T−11
- T
- ∞
Consumption Behavior

![Graph showing consumption behavior](image)

- Observed Ctrl
- Fitted Ctrl
- Observed R1
- Fitted R1
- Observed R2
- Fitted R2
- T−10
- T
- ∞
Consumption Behavior

![Graph showing consumption behavior with observed and fitted models for different scenarios: Observed Ctrl, Fitted Ctrl, Observed R1, Fitted R1, Observed R2, Fitted R2, T−9, T, and infinity.]
Consumption Behavior

![Graph showing consumption behavior with various fitted and observed lines.]

- Observed Ctrl
- Fitted Ctrl
- Observed R1
- Fitted R1
- T-8
- Observed R2
- Fitted R2
- T
- \( \infty \)
Consumption Behavior

- Observed Ctrl
- Fitted Ctrl
- Observed R1
- Fitted R1
- Observed R2
- Fitted R2
- T−7
- T
- ∞
Consumption Behavior

- Observed Ctrl
- Fitted Ctrl
- Observed R1
- Fitted R1
- Observed R2
- Fitted R2
- T−3
- T
- ∞
Consumption Behavior

![Graph showing consumption behavior with Observed, Fitted, and R1/R2 marker types, along with Cash On Hands and Consumption axes.](image)

- Observed Ctrl
- Fitted Ctrl
- Observed R1
- Fitted R1
- Observed R2
- Fitted R2
- T−2
- T
- ∞
Consumption Behavior

![Graph showing consumption behavior with Observed Ctrl, Fitted Ctrl, Observed R1, Fitted R1, Observed R2, Fitted R2, T, and ∞ markers.](image)
Deviations from Optimal Behavior

Two measures of deviation from optimal behavior

\[ m_1 = \sum_{t=1}^{T} |c_t^*(w_t) - c_t| \]  

(8)  

where \( c_t^*(w_t) \) is conditionally optimal consumption (depending on current wealth \( w_t \)), and \( c_t \) is observed consumption in period \( t \)

\[ m_2 = \sum_{t=1}^{T} [u(c_t^*(w_t^*)) - u(c_t)] \]  

(9)  

where \( c_t^*(w_t^*) \) denotes unconditionally optimal consumption at period \( t \) as a function of optimal period wealth \( w_t^* \).
Nonparametric Analysis I:

Figure: Medians and Means of Aggregate Absolute Deviations from Optimal Consumption ($m_1$) in Taler and Utility Loss ($m_2$) in points by Treatments and Rounds.
Nonparametric Analysis II:

<table>
<thead>
<tr>
<th></th>
<th>Median per subject</th>
<th>Mean per subject</th>
<th>p-Value per subject</th>
</tr>
</thead>
<tbody>
<tr>
<td>m1 Ctrl</td>
<td>586.37</td>
<td>732.89</td>
<td>R1-Ctrl</td>
</tr>
<tr>
<td>m1 R1</td>
<td>696.93</td>
<td>788.37</td>
<td>R1-Ctrl</td>
</tr>
<tr>
<td>m1 R2</td>
<td>848.90</td>
<td>866.04</td>
<td>R1-R2</td>
</tr>
<tr>
<td>m2 Ctrl</td>
<td>210.79</td>
<td>389.79</td>
<td>R1-Ctrl</td>
</tr>
<tr>
<td>m2 R1</td>
<td>288.05</td>
<td>444.73</td>
<td>R1-Ctrl</td>
</tr>
<tr>
<td>m2 R2</td>
<td>389.49</td>
<td>502.01</td>
<td>R1-R2</td>
</tr>
</tbody>
</table>

Notes: P-values were calculated by use of Mann-Whitney U-tests.

Source: Own calculations based on data from our experiment.

Table: Medians and Means of the Measures $m_1$ and $m_2$ by Treatments and Rounds.

Payments differ by treatment groups slightly (Control: 17.57 Euro, R1: 16.24 Euro, R2: 15.73 Euro on average excluding lottery)
Baseline specification (from equation (5))

\[ c_{itr} = \beta_1 \tilde{y}_{tr} + \beta_2 \tilde{a}_{itr} + \beta_3 (T - t) \tilde{y}_p - \beta_4 \tilde{T}_{itr} + \beta_5 \tilde{\Gamma}_{tr} (\theta \sigma_y), \] (10)

for all subjects \( i = 1, \ldots, 127 \), periods \( t = 1, \ldots, 25 \), and rounds \( r = 1, \ldots, 8 \) where \( \tilde{\Gamma} = \frac{1}{(T-t+1)} \Gamma, \) and \( \Gamma \) represents the variables of equation (5).
Panel Regression II

Extended specification

\[ c_{itr} = \beta_1 \hat{y}_{tr} + \beta_2 \tilde{a}_{itr} + \beta_3 (T - t)\hat{y}_p - \beta_4 \tilde{T}_{itr} + \beta_5 \tilde{\Gamma}_{tr}(\theta \sigma_y) \]  
\[ + \beta_0.txd_{0.tx} + \beta_{240}.txd_{240.tx} + \sum_{j=1}^{3} \beta_{t-j,0.txt}d_{t-j,0.txt} \]  
\[ + \sum_{j=1}^{3} \beta_{t-j,240.txt}d_{t-j,240.txt} \]  
\[ + \beta_6 dR_{1i} + \beta_7 dR_{2i} + \beta_8 X_i \]  
\[ + \sum_{k=1}^{8} \beta_{r,k}d_{r,k} + \beta_9 t + \beta_{10} t^2 + \text{constant.} \]
Panel Regression III

<table>
<thead>
<tr>
<th></th>
<th>OLS</th>
<th>FE</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\bar{y}$</td>
<td>1.158</td>
<td>1.210</td>
</tr>
<tr>
<td>$\hat{a}$</td>
<td>0.700</td>
<td>0.891</td>
</tr>
<tr>
<td>$\hat{\beta}$</td>
<td>0.339</td>
<td>0.467</td>
</tr>
<tr>
<td>$\hat{\Phi}(\theta \sigma_Y)$</td>
<td>1.598</td>
<td>2.006</td>
</tr>
<tr>
<td>$(T-t)\bar{y}_p$</td>
<td>1.145</td>
<td>1.277</td>
</tr>
<tr>
<td>$d_{0,tx}$</td>
<td>19.100</td>
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</tr>
<tr>
<td>$d_{240,tx}$</td>
<td>-25.660</td>
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</tr>
<tr>
<td>$d_{t-1,0,tx}$</td>
<td>2.684</td>
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<td>$d_{t-2,0,tx}$</td>
<td>3.146</td>
<td>3.333</td>
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<tr>
<td>$d_{t-3,0,tx}$</td>
<td>0.066</td>
<td>0.195</td>
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<td>$d_{t-1,240,tx}$</td>
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<td>-5.684</td>
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<tr>
<td>$d_{t-2,240,tx}$</td>
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<td>-0.674</td>
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<tr>
<td>$d_{t-3,240,tx}$</td>
<td>-4.688</td>
<td>-4.620</td>
</tr>
<tr>
<td>$t$</td>
<td>-1.629</td>
<td>-1.435</td>
</tr>
<tr>
<td>$t^2$</td>
<td>0.058</td>
<td>0.058</td>
</tr>
<tr>
<td>Treatment (base: control):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$d_{R1}$</td>
<td>-6.752</td>
<td>-9.962</td>
</tr>
<tr>
<td>$d_{R2}$</td>
<td>-9.962</td>
<td>-9.962</td>
</tr>
<tr>
<td>Round dummies (base: round 1):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$d_{r,2}$</td>
<td>5.980</td>
<td>5.550</td>
</tr>
<tr>
<td>$d_{r,3}$</td>
<td>-1.671</td>
<td>1.717</td>
</tr>
<tr>
<td>$d_{r,4}$</td>
<td>3.922</td>
<td>3.078</td>
</tr>
<tr>
<td>$d_{r,5}$</td>
<td>5.147</td>
<td>5.338</td>
</tr>
<tr>
<td>$d_{r,6}$</td>
<td>0.431</td>
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<tr>
<td>Constant</td>
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<tr>
<td>Controls</td>
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Adjusted $R^2$ | 0.357 | 0.409

Table: Panel Regression on Observed Consumption.
### Panel Regression III

<table>
<thead>
<tr>
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<th>OLS</th>
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<tbody>
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<td>0.891***</td>
</tr>
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<td>( \bar{T} )</td>
<td>0.339***</td>
<td>0.467***</td>
</tr>
<tr>
<td>( \bar{f}(\theta \sigma y) )</td>
<td>1.598</td>
<td>2.006*</td>
</tr>
<tr>
<td>( (T - t)\bar{y}_p )</td>
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<td>( t^2 )</td>
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</tbody>
</table>

Treatment (base: control):
- \( d_{R1} \): -6.752***
- \( d_{R2} \): -9.962***

Round dummies (base: round 1):
- \( d_{r.2} \): 5.980***
- \( d_{r.3} \): -1.671
- \( d_{r.4} \): 3.922*
- \( d_{r.5} \): 5.147**
- \( d_{r.6} \): 0.431
- \( d_{r.7} \): 2.103
- \( d_{r.8} \): 1.022
- Constant: -78.430***

Controls: ✓

<table>
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<tr>
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<tr>
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<td>Treatment (base: control):</td>
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<td></td>
</tr>
<tr>
<td>$dR_1$</td>
<td>-6.752***</td>
<td>(-2.71)</td>
</tr>
<tr>
<td>$dR_2$</td>
<td>-9.962***</td>
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<td>Controls</td>
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</tr>
<tr>
<td>Adjusted $R^2$</td>
<td>0.357</td>
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</table>

**Table:** Panel Regression on Observed Consumption.
### Panel Regression III

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<td>0.339***</td>
<td>0.467***</td>
</tr>
<tr>
<td>( \tilde{\Gamma}(\theta \sigma_y) )</td>
<td>1.598 (0.93)</td>
<td>2.006* (1.69)</td>
</tr>
<tr>
<td>((T - t)\tilde{y}p)</td>
<td>1.145* (1.83)</td>
<td>1.277*** (3.81)</td>
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<tr>
<td>( d_{0,t} \times t )</td>
<td>19.100*** (5.10)</td>
<td>19.780*** (5.27)</td>
</tr>
<tr>
<td>( d_{240,t} \times t )</td>
<td>-25.660*** (-9.52)</td>
<td>-25.930*** (-9.57)</td>
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<tr>
<td>( d_{t-1,0,t} \times t )</td>
<td>2.684** (2.09)</td>
<td>2.910** (2.29)</td>
</tr>
<tr>
<td>( d_{t-2,0,t} \times t )</td>
<td>3.146*** (2.63)</td>
<td>3.333*** (2.84)</td>
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<tr>
<td>( d_{t-3,0,t} \times t )</td>
<td>0.066 (0.05)</td>
<td>0.195 (0.15)</td>
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<tr>
<td>( d_{t-1,240,t} \times t )</td>
<td>-6.560*** (-3.93)</td>
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<tr>
<td>( d_{t-2,240,t} \times t )</td>
<td>-0.645 (-0.37)</td>
<td>-0.674 (-0.40)</td>
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<tr>
<td>( d_{t-3,240,t} \times t )</td>
<td>-4.688*** (-3.44)</td>
<td>-4.620*** (-3.44)</td>
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<tr>
<td>( t \times t )</td>
<td>-1.629*** (-3.52)</td>
<td>-1.435*** (-3.22)</td>
</tr>
<tr>
<td>( t \times t^2 )</td>
<td>0.058** (2.31)</td>
<td>0.058** (2.37)</td>
</tr>
<tr>
<td>Treatment (base: control): ( d_{R1} \times t )</td>
<td>-6.752*** (-2.71)</td>
<td></td>
</tr>
<tr>
<td>( d_{R2} \times t )</td>
<td>-9.962*** (-3.31)</td>
<td></td>
</tr>
<tr>
<td>Round dummies (base: round 1): ( d_{r,2} \times t )</td>
<td>5.980*** (2.76)</td>
<td>5.550** (2.23)</td>
</tr>
<tr>
<td>( d_{r,3} \times t )</td>
<td>-1.671 (-0.74)</td>
<td>1.717 (0.64)</td>
</tr>
<tr>
<td>( d_{r,4} \times t )</td>
<td>3.922* (1.77)</td>
<td>3.078 (1.15)</td>
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<td>( d_{r,7} \times t )</td>
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<td>3.218 (1.28)</td>
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<tr>
<td>( d_{r,8} \times t )</td>
<td>1.022 (0.49)</td>
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</tbody>
</table>
Conclusions

- Ricardian Equivalence does not hold generally.
Conclusions

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  - **Larger deviations** from optimal consumption with **increased difficulty**
    to smooth consumption in treatments with Ricardian taxation
  - Overall, deviations from optimal behavior are lowest in the treatment
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Conclusions

- Ricardian Equivalence does not hold generally
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  - Both difficulty and Ricardian taxation affect consumption behavior.
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- Ricardian taxation has a significant and strong effect on consumption in our sample
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  - A tax benefit in early periods increases consumption by about 22% of the tax benefit on average
Conclusions

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Conclusions

- Ricardian Equivalence does not hold generally
  - Larger deviations from optimal consumption with increased difficulty to smooth consumption in treatments with Ricardian taxation
  - Overall, deviations from optimal behavior are lowest in the treatment with constant taxation
  - Both difficulty and Ricardian taxation affect consumption behavior.
- Ricardian taxation has a significant and strong effect on consumption in our sample
  - A tax benefit in early periods increases consumption by about 22% of the tax benefit on average
  - A tax increase causes a reduction by 30% of the tax increase.
- Behavior of about 62% of our subjects can be classified as inconsistent with the Ricardian Equivalence proposition
Thanks for your attention!

davud.rostam-afschar@fu-berlin.de
CARA Utility

Erworbene Punkte

Buy Points

Ausgegebene Taler

Sell Points