Integrating a Microsimulation Model of Tax Policy with an OG Model

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Fundamental tension

Macroeconomic models

- General equilibrium effects
- Limits to heterogeneity
- Limits to non-convexity

Microsimulation models

- Fixed macro variables
- Allows more heterogeneity
- More rich policy

Macro models and tax functions

OG models for policy analysis

- Zodrow and Diamond ((*Elsevier Press*, 2013), Nishiyama and Smetters (*QJE*, 2007), Nishiyama (*JEDC*, 2015), JCT-OG (2007), CBO-OG (2013)

Several macroeconomic models of tax policy use “tax functions", similar to what we do:

- Fullerton and Rogers (*Brookings Press*, 1993) specify total income tax liability functions as functions of age and lifetime income (category)
  - Zodrow and Diamond (*NTJ*, 2003), Nishiyama (*JEDC*, 2015) follow similar approach
- JCT’s DSGE model uses individual income tax functions - estimated with administrative data

Gouveia-Strauss

- A common specification for these functions comes from Gouveia and Strauss (*NTJ*, 1994):

$$T = \varphi_0[I - (I^{-\varphi_1} + \varphi_2)^{\frac{-1}{\varphi_1}}],$$

  where I is income and T is the total tax liability
- This function is flexible enough to allow for progressive rates
- The typical application uses this functional form for modeling labor income taxes and applies a linear tax to capital income.
- Used by Guvenen et. al (*RED*, 2014), Nishiyama (*JEDC*, 2015), Holter et. al (NBER WP 20688)

Gouveia-Strauss

- Pros:
  - Parsimonious
  - Can get progressive tax rates
  - Can estimate using micro data or aggregate data
- Cons:
  - Marginal tax rates do not depend on the source of income
  - Leaves heterogeneity in the OG model on the table
    - e.g., Age is already a state variable in the OG model
    - Tax policy often relates directly to age
    - Tax policy also relates indirectly to age
    - So why not allow functions to vary by age?
  - Cannot accommodate negative tax rates

How our approach differs

- Use microsimulation model
  - Estimate tax functions from output
  - Estimate both marginal tax rates and effective tax rates
  - Allows one to have functions for policy baseline and a reform
- Allow marginal rates to vary over income (not just lifetime income group)
- Very flexible functional forms
- Full integration - run microsimulation model and macro model together

- The budget constraint:

$$c_{j,s,t} = (1 + r_t)\, b_{j,s,t} + w_t e_{j,s} n_{j,s,t} + - b_{j,s+1,t+1} - T^{I}_{j,s,t} + X_t \quad (1)$$

- FOC for choice of labor:

$$\left(w_t e_{j,s} - \frac{\partial T^{I}_{j,s,t}}{\partial n_{j,s,t}}\right) c_{j,s,t}^{-\sigma} = \chi^n_s \left(\frac{b}{\tilde{l}}\right)\left(\frac{n_{j,s,t}}{\tilde{l}}\right)^{\upsilon-1}\left[1 - \left(\frac{n_{j,s,t}}{\tilde{l}}\right)^{\upsilon}\right]^{\frac{1-\upsilon}{\upsilon}} \quad (2)$$

- FOC for choice of savings:

$$c_{j,s,t}^{-\sigma} = \beta\left[1 + r_{t+1} - \frac{\partial T^{I}_{s+1,t+1}}{\partial b_{j,s+1,t+1}}\right] c_{j,s+1,t+1})^{-\sigma} \quad (3)$$

Effective tax rates

- Let x = labor income = $w_t e_{j,s} n_{j,s,t}$
- Let y = capital income = $r_t b_{j,s,t}$
- Total income taxes are then given by:

$$T^I_{s,t}(x,y) = \tau_{s,t}(x,y)\big(x+y\big) \tag{4}$$

- Where $\tau_{s,t}(x,y)$ is an average, or “effective”, tax rate (ETR)

Marginal Tax Rates: Labor Income

- The change in taxes for a change in labor supply is given as:

$$\frac{\partial T^{l}_{j,s,t}}{\partial n_{j,s,t}} = \frac{\partial T^{l}_{s,t}(x,y)}{\partial x}\frac{\partial x}{\partial n_{j,s,t}} = w_t e_{j,s}\frac{\partial T^{l}_{s,t}(x,y)}{\partial x} \tag{5}$$

- $\frac{\partial T^{l}_{s,t}(x,y)}{\partial x}$ is the marginal tax rate on labor income (MTRx)

Marginal Tax Rates: Capital Income

- The change in taxes for a change in savings is given as:

$$\frac{\partial T^{I}_{j,s,t}}{\partial b_{j,s,t}} = \frac{\partial T^{I}_{s,t}(x,y)}{\partial y}\frac{\partial y}{\partial b_{j,s,t}} = r_t b_{j,s}\frac{\partial T^{I}_{s,t}(x,y)}{\partial y} \tag{6}$$

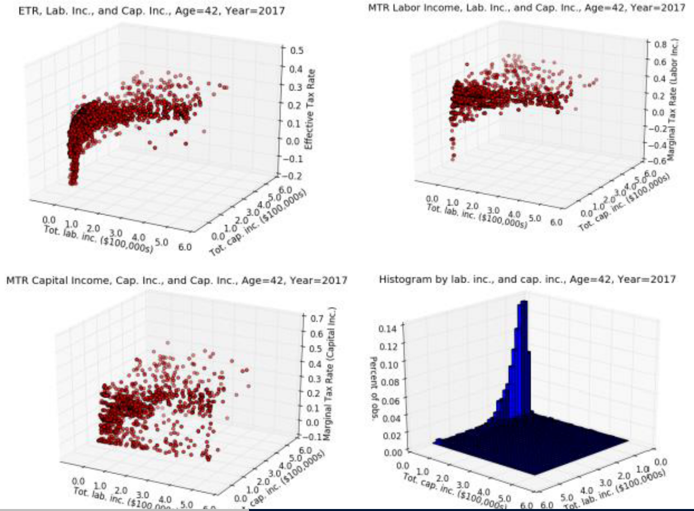
- $\frac{\partial T^{I}_{s,t}(x,y)}{\partial y}$ is the marginal tax rate on capital income (MTRy)

Tax Functions

Our goal is to parameterize and estimate those three functions:

1. $\tau_{s,t}(x, y) = \text{ETR}$
2. $\frac{\partial T^{I}_{s,t}(x,y)}{\partial x} = \text{MTRx}$
3. $\frac{\partial T^{I}_{s,t}(x,y)}{\partial y} = \text{MTRy}$

Scatter Plot of ETR, MTRx, MTRy, and Histogram



Functional Form

Let x be total labor income, $x \equiv w_t e_{j,s} n_{j,s,t}$, and let y be total capital income, $y \equiv r_t b_{j,s,t}$. We then write our tax rate functions as follows.

$$\tau(x,y) = \Big[\tau(x) + shift_x\Big]^{\phi}\Big[\tau(y) + shift_y\Big]^{1-\phi} + shift$$

$$\text{where} \quad \tau(x) \equiv (max_x - min_x)\left(\frac{Ax^2 + Bx}{Ax^2 + Bx + 1}\right) + min_x$$

$$\text{and} \quad \tau(y) \equiv (max_y - min_y)\left(\frac{Cy^2 + Dy}{Cy^2 + Dy + 1}\right) + min_y$$

Symbol	Description
A	Coefficient on squared labor income term x^2 in $\tau(x)$
B	Coefficient on labor income term x in $\tau(x)$
C	Coefficient on squared capital income term y^2 in $\tau(y)$
D	Coefficient on capital income term y in $\tau(y)$
max_x	Maximum tax rate on labor income x given $y = 0$
min_x	Minimum tax rate on labor income x given $y = 0$
max_y	Maximum tax rate on capital income y given $x = 0$
min_y	Minimum tax rate on capital income y given $x = 0$
$shift_x$	shifter $> \lvert min_x \rvert$ ensures that $\tau(x) + shift_x > 0$ despite potentially negative values for $\tau(x)$
$shift_y$	shifter $> \lvert min_y \rvert$ ensures that $\tau(y) + shift_y > 0$ despite potentially negative values for $\tau(y)$
$shift$	shifter (can be negative) allows for support of $\tau(x, y)$ to include negative tax rates
ϕ	Cobb-Douglas share parameter between 0 and 1

Estimation

We estimate the 12 parameters:

1. A
2. B
3. C
4. D
5. min_x
6. max_x
7. min_y
8. max_y
9. $shift_x$
10. $shift_y$
11. phi
12. $shift$

Separately for **each age** $E < s <= E + S$, and **each year** $t \in$ Budget Window, and ETR, MTRx, MTRy

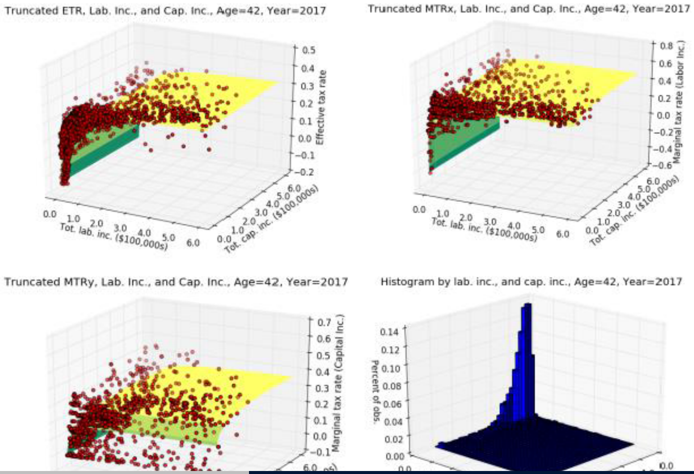
- For a model with $S = 80$, this is something like $80 \times 10 \times 3 = 2,400$ functions with $2,400 \times 12 = 28,800$ parameters

Estimation

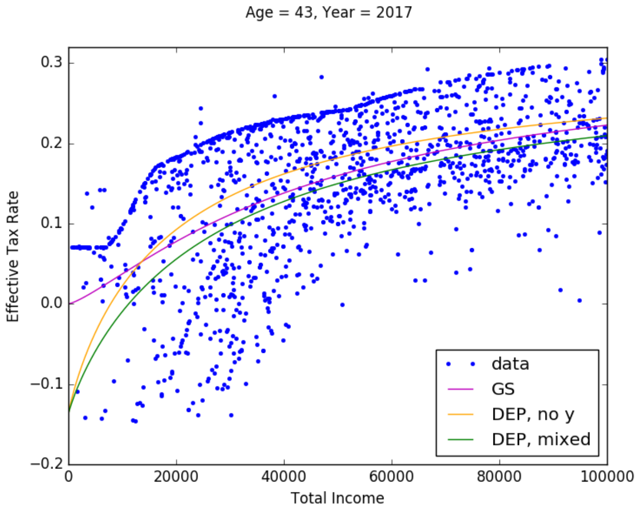
- Start by fitting the values for $\bar{\theta}_{s,t} = \{min_x, min_y, shift_x, shift_y\}$ directly from the data
- Then estiamte the remaning 8 parameters: $\tilde{\theta}_{s,t} = (A, B, C, D, max_x, max_y, shift, \phi)$
- To estimate these non-linear functions, we use a weighted least squares estimator:

$$\hat{\theta}_{s,t} = \arg\min_{\tilde{\theta}_{s,t}} \sum_{i=1}^{N} \Big[\tau_i - \tau_{s,t}\big(x_i, y_i | \tilde{\theta}_{s,t}, \bar{\theta}_{s,t}\big)\Big]^2 w_i,$$
$$\text{subject to} \quad A, B, C, D, max_x, max_y > 0, \tag{7}$$
$$\text{and} \quad max_x \geq min_x, \quad \text{and} \quad max_y \geq min_y \quad \text{and}$$
$$\phi \in [0, 1]$$

Estimated Functions for ETR, MTRx, MTRy, and Histogram



Plot of *ETR* functions for 42-year-olds in 2017



Relevance of Age

Table: Average values of ϕ for ETR, MTRx, and MTRy for age bins in period $t = 2017$

	Age ranges			
	21 to 54	55 to 65	66 to 80	All years
ETR	0.66	0.28	0.38	0.44
MTRx	0.89	0.31	0.23	0.48
MTRy	0.77	0.25	0.14	0.43

* Note: Even though agents in the OG model live until age 100, the tax data was too sparse to estimate functions for ages greater than 80. For ages 81 to 100, we simply assumed the age 80 estimated tax functional forms.

Microsimulation Model

Open Source Policy Center's `Tax Calculator`:

- Underlying micro data:
  - 2009 IRS cross-section of tax returns (PUF)
    - About 200,000 observations
    - Filers are weighted to hit control totals for each line item
    - Not top coded, but some information removed (e.g. location of filer)
    - Does not have all line items from the filers' tax returns.
    - Can use survey data (Current Population Survey) instead if you don't have the PUF
  - Filing units in PUF statistically matched to survey data (CPS) to get:
    - Filer and dependent age
    - Non-filers
- Extrapolate/Age 2009 data to 2015-2027
- Tax calculator similar to NBER's TaxSim
- Rich detail on federal individual income tax code

Aging the data

- Micro data are old (2011!)
- Thus they need to be aged to be consistent with current filer population/economy
- How's this done?
  - Apply growth rates for wages, interest income, dividend income, etc. to the 2011 micro data to grow out to present year
  - Adjust weights on each observation to hit control totals from 2011-present
    - This re-weighting is a constrained optimization problem
    - Want to hit control totals for a large number of line items on tax returns
    - But also want to minimize the amount any observations' weight is adjusted year to year

Extrapolating the data

- Aging of the micro data brings it out to (about) the present year
- But we want to forecast what happens in the future due to tax policy changes!
- So we need to extrapolate these data out over some horizon
  - Since US federal budget policy involves 10-year projections, this is the typically horizon
  - But in principle, you could do more/less
- How to extrapolate?
  - Apply *projected* growth rates for wages, interest income, dividend income, etc to the micro data to grow from present year forward
  - Adjust weights on each observation to match forecasts of certain tax-related items/distributional projections

Extrapolating the data

- One key issue when extrapolating these data - what's the projection of fiscal policy?
- In other words, what is your “baseline”?
- i.e., do we expect current law? Or what about current policy? Something else?

Determining a baseline

- The choice of a baseline can have very important consequences on a score:
    - E.g. before 2013 in the US the “Alternative Minimum Tax” was not index to inflation
    - Thus, due to growth in nominal incomes, millions of taxpayers would be subject to the AMT without legislative action to raise the income threshold
    - But virtually every year before indexing, a “patch" was approved by Congress and the President to increase the income threshold
    - But which do you use to extrapolate your data - current law (AMT now applies to millions more) or current policy (a patch will be passed)?

Extrapolating the data

Key is to:

1. Be clear
2. Be consistent - are your underlying macro growth rates and targets consistent with your baseline?

Microsimulation Output

The output from a run of the `Tax Calculator` includes:

- Static revenue estimates
- Select distributional tables
- Micro-data based in tax inputs:
  - Marginal tax rates
  - Total tax liability
  - Amounts of income and deduction items

Microsimulation Output

Assumptions underlying `Tax Calculator` output:

- No changes in economic behavior
  - No labor supply responses
  - No changes in timing of income realizations, etc.
- Macro variables are not affected by tax policy
- Individuals optimize in their reporting of income and deduction items and their use of tax credits

Computing Marginal Tax Rates

- Marginal tax rates computed through a numerical derivative:
  1. Compute filer's tax liability
  2. Add one cent to filers' income
  3. Recompute filer's tax liability
  4. $MTR = \frac{\Delta\text{Tax Liability}}{0.01}$

  - Can do this for each income and deduction source
  - Need to be careful about knife-edge cases (though there tend to be few)

Defining income

- We need to be consistent with income definitions used between the models
- Tax policy includes many different income concepts:
  - Total income
  - Adjusted gross Income
  - Taxable Income
  - ...
- Our OG model two income sources: capital and labor
- Thus the analogy to total model income is something like “adjusted total income":
  - Start with total income as reported on tax return
  - Add back tax exempt income items (e.g. tax exempt interest income)

Defining income

In practice, the split between capital and labor income is not always clear.
We do the following:

- Labor Income $\equiv$ wages and salaries + self-employment income
- Capital income $\equiv$ adjusted total income - labor income
    - Not a perfect definition of capital income
    - E.g. includes income from alimony payments
    - But need capital and labor income to sum to total - where else put this?

Defining income

Important inputs to estimating the tax function parameters will be the marginal tax rates on capital and labor income observed in the data

- Both “labor” and “capital” income include income from multiple income sources, which may be taxed differently
- Thus when computing empirical MTRS, we use weighted averages:
    - Income sources are weighted by their share of income in the capital/labor category
    - Some income sources can be negative, in this case we use absolute values

Other important definitions

- Model units are “households", data units are “filing units", we treat these as identical
- The age of the primary filer corresponds to the age of the model household
- Whatever tax policy is after the end of the window forecast by the microsimulation model, it remains that forever
  - Though this could be adjusted for a budget closure rule relying on tax changes

Integrating the Results of the Microsimulation

- For each year 2018 - 2027, the `Tax Calculator` computes (for each observation in the micro data):
  1. Effective (i.e., Average) Tax Rates
  2. MTRs on labor income
  3. MTRs on capital income
- These data will also include:
  4. Observation weights
  5. Age of the primary filer
  6. Adjusted total income
  7. Total labor income
  8. Total capital income

Integrating the Results of the Microsimulation

To these data we make the following adjustments:

- Delete observations with very low income (<$5)
  - Main reason for this is to exclude observations with extreme ETR values
- Drop observations with a MTR on labor or capital income > 99%
- Drop observations with MTR on labor or capital income < -45%

Integrating the Results of the Microsimulation

It's with these data that we begin our estimation routine...