

Disaggregating WiNDC Consumer Accounts by Income Group

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- 1 Overview
- 2 Calibration Routine
- 3 Modeling Applications
- 4 Next Steps

- First version of WiNDC featured a state level dataset with a single representative agent by region.
- Provided means for spatially denominated distributional analysis, but not within consumer types.
- A key advantage of IMPLAN was its disaggregation of regional consumer demands and incomes by household income groups.
- Many ways to go about this type of disaggregation. Incomes vs. expenditures.
- We approach this problem from the income side. Key challenges: denominate reasonable transfer income, understand income tax liabilities, savings, capital ownership vs. demands, salaries and wages.
- Additional wrinkle: static vs. steady state calibration.
- Income elasticities used to separate household level commodity expenditures.

Recalibration routine:

- Two versions of a household dataset is produced. One primarily based on the Current Population Survey (CPS), and the other based primarily on IRS's Statistics of Income (SOI).
- Both versions use a bit of information from the other. Transfers and capital gains.
- Roughly comparable with 5 household types by region. Households vs. returns.

Modeling applications:

- Static vs. steady state static vs. dynamic models.
- Marginal cost of funds.
- Energy tax example.
- Impacts of COVID [partially finished].
- Subnational carbon leakage [partially finished].

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Income Balance in the Benchmark Equilibrium

Original regional representation (subscripted by r) – limited by information in the reference input output tables:

$$cons_r + inv_r = wages_r + cap_r + other_r \quad \forall \quad r$$

- Investment based on location of state level investment demands. May not follow location of entity actually doing the investing.
- Wages and capital income based on sectors in a given state doing the demanding. Again, same issue. Furthermore, they are gross of taxes.
- Other is a closure parameter – all the stuff that can't be explained by consumption, investment, wages and capital.

Obvious issues when thinking about welfare impacts.

Toward a Better Income Balance Representation

While regional representation may limit ability to do reasonable welfare analysis, it does provide useful *control totals* that are consistent with both the National Income and Product Accounts (NIPA) and accounting identities for the rest of the economy.

This work seeks to reconcile the issues outlined in the previous slide. Move toward the following income balance representation:

$$cons_{rh} + tax_{rh} + save_{rh} = wages_{rh} + cap_{rh} + trn_{rh} \quad \forall (r, h)$$

- Break out each category by region and household income type (h).
- Estimate savings for household-region pairs investing in new capital.
- Estimate wage and extant capital endowments consistent with where people actual live and work. Incorporate income taxes into WiNDC structure.
- Break out the “other” category into cash payment transfers consistent with benefits programs in US. Assume all transfers are between households and government. No intra-household transfers assumed here.

Datasets Used in Disaggregation

Current Population Survey (CPS)

Survey dataset

Observation level micro-use dataset

Census defined households

Respondents report taxable and non-taxable income

No income tax payments

Denominates all major cash transfer payments from government programs

Wages and salaries

Interest income (no capital gains)

Savings limited to retirement income

Statistics of Income (SOI)

Administrative dataset

Only have access to precompiled state-level statistics -- micro-use public file prohibitively expensive, no spatial identifier

Number of tax returns

Only reports taxable income (including transfers)

All income tax payments for those paying taxes

Transfer payments that are taxed (very limited)

Wages and salaries

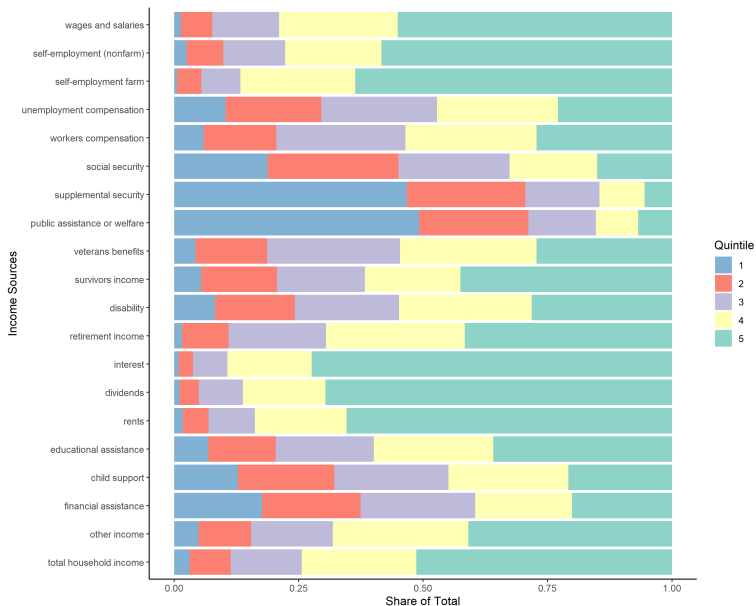
Interest income (with capital gains)

Savings limited to retirement income

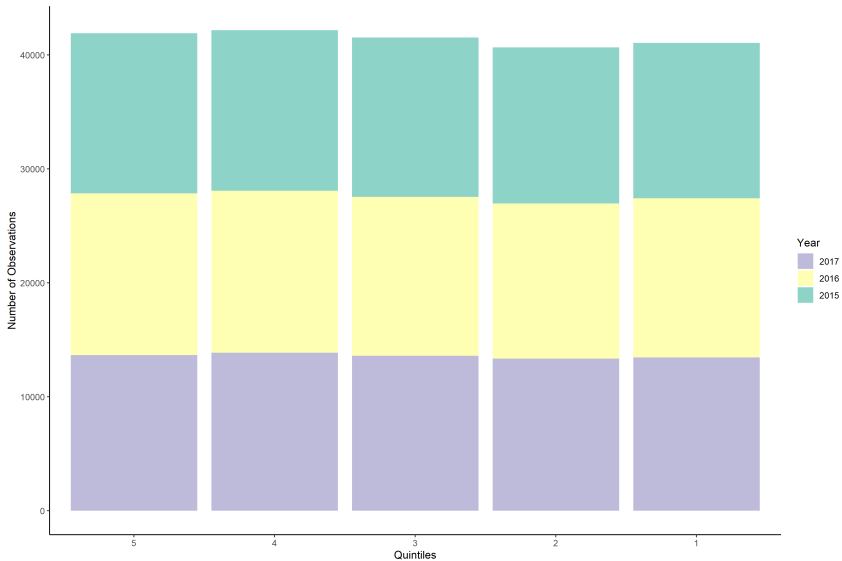
CPS Categories (2016)

<u>Income Balance</u>	<u>CGE category</u>	<u>Data category</u>	<u>Total/%</u>
Income	Labor	Wages and salaries	\$7,883.57 100%
		Capital	\$952.66
		Self-employment (farm and nonfarm)	43.54%
		Interest	31.26%
		Dividends	13.58%
		Rents	10.37%
		Other income	1.24%
		Transfers	\$1,113.66
		Social security	69.03%
		Educational assistance	6.09%
		Veteran's benefits	5.21%
		Supplemental security	4.44%
		Survivor's income	4.05%
		Disability	3.36%
		Financial assistance	2.43%
	Child support	2.09%	
	Unemployment compensation	1.65%	
	Workers compensation	1.05%	
	Public assistance or welfare	0.61%	
Expenditures	Savings		\$545.81
		Retirement income	100%

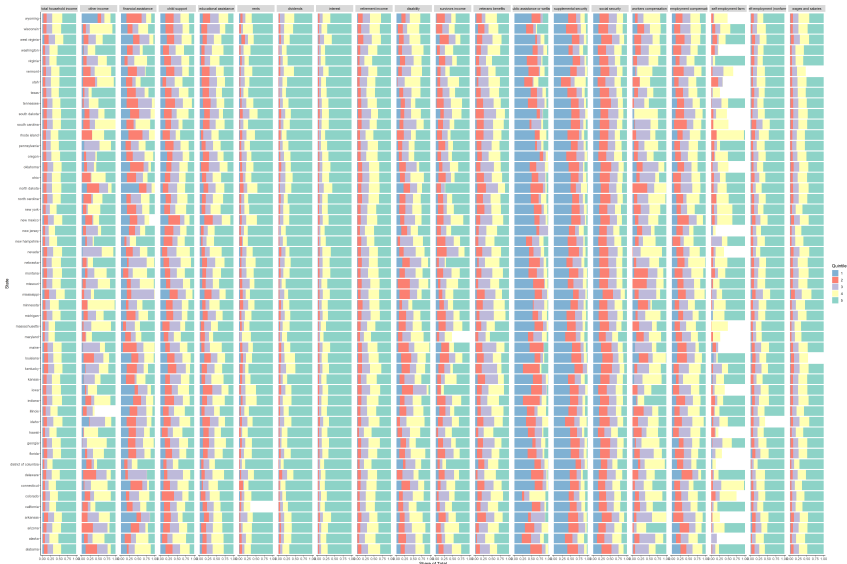
CPS: National Level Shares (2016)



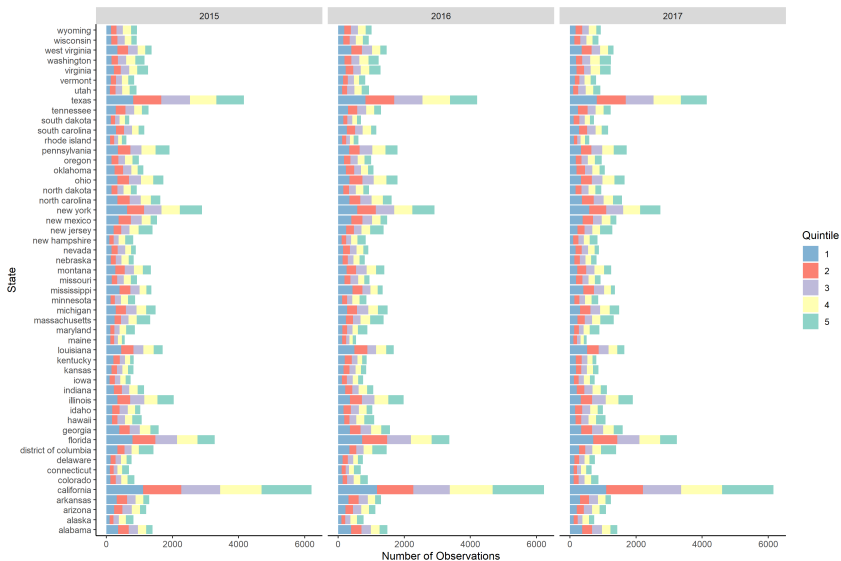
CPS: National Level Observation Count



CPS: State Level Shares (2016)



CPS: State Level Observation Count (2016)



CPS Literature on Underreporting

There is a healthy literature assessing CPS underreporting. Two papers that are particularly useful here:

- Meyers et al. (2009): compares CPS transfer data to administrative totals and reports share of total.
- Rothbaum (2015): compares CPS data to NIPA accounts and reports share of total for transfers not in Meyers et al. (2009) and capital income.

All transfers	0.804
Public assistance	0.487
Social security old age, survivors and disability insurance (oasdi)	0.893
Social security old age and survivors insurance (oasi)	0.908
Social security disability insurance (ssdi)	0.819
Supplemental security income	0.759
Unemployment insurance	0.679
Workers compensation	0.527
Veteran's payments	0.679
Interest, dividends, royalties (capital payments)	0.53

SOI Categories (2016)

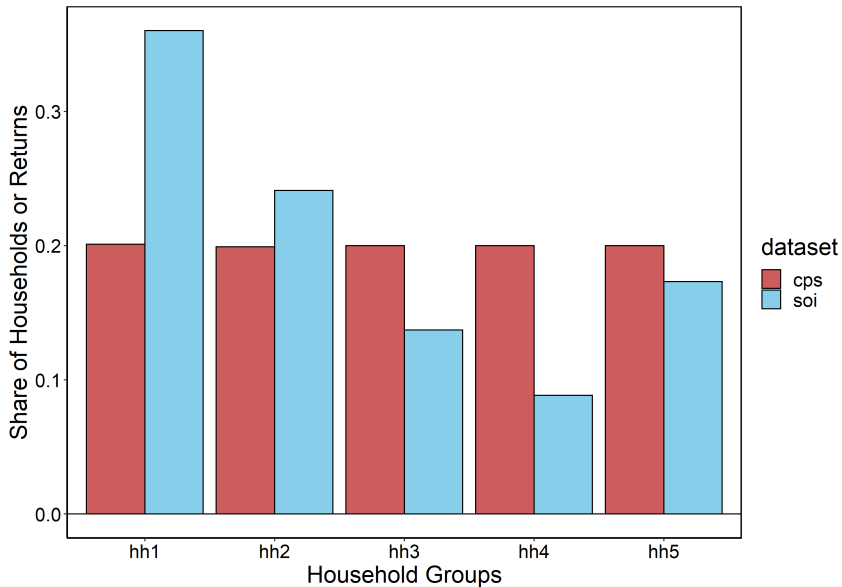
<u>Income Balance</u>	<u>CGE category</u>	<u>Data category</u>	<u>Total/%</u>
Income	Labor	Wages and salaries	\$7,114.21 100%
		Capital	\$3,073.52
		Rental real estate, royalties, partnerships, S corporations, trusts, etc.	21.69%
		Capital gains	19.41%
		Business income	11.22%
		Ordinary dividends	7.89%
		Qualified dividends	6.27%
		Taxable interest	2.91%
		Transfers	\$310.56
			Social security benefits (taxable portion)
		Unemployment compensation	8.39%
Expenditures	Taxes	Federal	\$1,552.37 97.86%
		State and local tax credits	2.14%
	Savings	Self-employed SEP, SIMPLE, and qualified plans	\$37.33 65.02%
		IRA deduction	34.98%

Households vs. Number of Returns

In what follows, we aggregate households into 5 groups that *roughly* correspond with one another. Comparison between two datasets not perfect.

<u>ID</u>	<u>CPS</u>	<u>SOI</u>
hh1	under \$24,000	under \$25,000
hh2	\$24,000 to \$45,442	\$25,000 to \$50,000
hh3	\$45,442 to \$74,567	\$50,000 to \$75,000
hh4	\$74,567 to \$120,951	\$75,000 to \$100,000
hh5	over \$120,951	over \$100,000

Households vs. Number of Returns



Structure of Recalibration Routine

4 step process:

1. Solve for steady state equilibrium investment demands (if option is selected – static vs. steadystate).
 - Important because investment levels tie directly to the income balance constraint for households in the form of savings.
Considering this upfront circumvents issues down the line.
2. Solve income routine for aggregated regions (here Census regions).
3. Solve income routine at the state level enforcing control totals at the aggregated region level.
4. Solve expenditure routine at the state level.

Successive calibration is akin to the LES calibration used in SAGE.
Enhances reliability in when solving a larger model.

Structure of Recalibration Routine

The above process is repeated for both the CPS and SOI data with both a static and steady state assumption (4 iterations).

- CPS based recalibration: augmented with SOI capital gains.
- SOI based recalibration: augmented with CPS transfer totals. SOI transfer data is insufficient for us because it is only taxable transfers. Most cash payment benefits aren't taxed.

Bit of synergy between the two to get them roughly lined up.

Step 1: Steady State Recalibration

A steady state equilibrium requires that investment and capital demands have the following relationship:

$$\sum_g i0_{rg} = \sum_s \frac{(gr + \delta)}{(ir + \delta)} kd0_{rs} \quad \forall r$$

Using *gross* capital demands, reference investment is scaled by a lot ($\approx 2x$).

We impose a capital tax rate taken from SAGE (33%), which is inclusive of corporate and income taxes on capital. Using *net* capital demands, reference investment is scaled by $\approx 1.4x$.

Note that we also recalibrate other commodity parameters to accommodate changes in $i0_{rg}$ (production, intermediate demand, regional demand).

Step 1: Steady State Recalibration

Assuming a capital tax rate requires adjustment of reference income tax rates from the data to only specify labor taxes. Net out non-corporate capital tax rate.

- Overall income tax rates calculated directly from data for SOI recalibration.
- For the CPS recalibration, we assume reference income tax rates for now (5,10,15,20,25%).

Reconciled labor income tax rates:

	<u>CPS</u>	<u>SOI</u>
hh1	-0.037	-0.036
hh2	0.047	0.025
hh3	0.112	0.053
hh4	0.167	0.067
hh5	0.17	0.16

Step 2: Income (Aggregated Regions)

Objective: minimize the deviation from either CPS or SOI data.

s.t.

* income balance constraint

```
incbal_ag(ar,h)..  CONS_AG(ar,h) + SAVE_AG(ar,h) + TAXES_AG(ar,h) =e=  
                   WAGES_AG(ar,h) + INTEREST_AG(ar,h) + TRANS_AG(ar,h);
```

* fix the income tax rate from the household data

```
taxdef_ag(ar,h)..  TAXES_AG(ar,h) =e= taxrate0_ag(ar,h) * WAGES_AG(ar,h);
```

* aggregation definition on total household consumption

```
consdef_ag(ar)..  sum(h, CONS_AG(ar,h)) =e= c0_ag(ar);
```

(continued)

Step 2: Income (Aggregated Regions)

Assumptions on wages:

- labor markets clear within census regions
- fringe benefits are shared evenly across household types

* wage income must sum to total labor demands by region

```
wagedef_ag(ar)..    sum(h, WAGES_AG(ar,h)) =e= sum(s, ld0_ag(ar,s));
```

* without more information, assume wages scale the same across households

```
lincdef_ag(ar,h).. WAGES_AG(ar,h) =e=  
                    sum(s, ld0_ag(ar,s)) / sum(h.local, wages0_ag(ar,h))  
* wages0_ag(ar,h);
```

* capital rents must sum to total capital demands

```
interestdef_ag..    sum((ar,h), INTEREST_AG(ar,h)) =e=  
                    sum((ar,s), kd0_ag(ar,s) + yh0_ag(ar,s));
```

* ignore enterprise and government saving

```
savedef_ag..        sum((ar,h), SAVE_AG(ar,h)) + FSAV_AG =e=  
                    sum((ar,g), i0_ag(ar,g));
```

(continued)

Step 2: Income (Aggregated Regions)

Note that wages, interest payments, transfers, consumption and taxes are all well controlled. Savings is calculated as a residual of the income balance condition which also determines foreign savings.

```
* disaggregate transfer payments
disagtrn_ag(ar,h)..  sum(trn, TRANSHH_AG(ar,h,trn)) =e= TRANS_AG(ar,h);

* verify totals on specific transfers
trntype_ag(trn)$cps.. sum((ar,h), TRANSHH_AG(ar,h,trn)) =e=
                      sum((ar,h), hhtrans0_ag(ar,h,trn))*trn_weight(trn);

* if using soi, require total regional transfers line up with CPS totals
totaltrnless_ag(ar)$ (not cps).. sum(h, TRANS_AG(ar,h)) =l=
                                  1.2 * trn_agg_weight * tottrn0_ag(ar);

totaltrnmore_ag(ar)$ (not cps).. sum(h, TRANS_AG(ar,h)) =g=
                                  0.8 * trn_agg_weight * tottrn0_ag(ar);
```


Step 2: Income (Aggregated Regions)

Additional assumptions:

- Capital income in data is upper bound for bottom 4 household groups.
- Retirement income is an approximate upper bound for savings for lower income groups.
- Reference transfers for upper income groups are an upper bound.

Step 2: Income (Aggregated Regions) – CPS

Aggregate results:

		<u>hh1</u>		<u>hh2</u>		<u>hh3</u>		<u>hh4</u>		<u>hh5</u>	
		calib	data	calib	data	calib	data	calib	data	calib	data
Expenditures	Total (billions \$)	372.02	322.37	1029.21	821.78	1790.72	1393.89	2957.36	2266.25	10911.21	5742.04
	Consumption (shr)	0.99	0.99	0.91	0.91	0.84	0.84	0.70	0.80	0.72	0.83
	Savings (shr)	0.02	0.02	0.06	0.06	0.08	0.08	0.17	0.07	0.20	0.04
	Tax (shr)	-0.01	-0.01	0.03	0.03	0.08	0.08	0.13	0.14	0.08	0.13
Income	Total (billions \$)	372.02	322.37	1029.21	821.78	1790.72	1393.89	2957.36	2266.25	10911.21	5742.04
	Wages (shr)	0.35	0.33	0.60	0.61	0.72	0.75	0.78	0.83	0.49	0.76
	Interest (shr)	0.10	0.06	0.11	0.07	0.11	0.07	0.12	0.08	0.49	0.21
	Transfers (shr)	0.55	0.61	0.29	0.31	0.18	0.18	0.10	0.09	0.02	0.04

Matches literature well on small savings for poorer households (e.g. Zucman and Saez type work).

hh5 has much larger totals than what is in the CPS. In part due to top-coding in the survey data and smaller capital payments in CPS data.

Step 2: Income (Aggregated Regions) – SOI

Aggregate results:

		<u>hh1</u>		<u>hh2</u>		<u>hh3</u>		<u>hh4</u>		<u>hh5</u>	
		calib	data	calib	data	calib	data	calib	data	calib	data
Expenditures	Total (billions \$)	1059.54	680.93	1889.70	1302.51	1834.16	1256.02	1482.31	1138.51	10575.25	6120.33
	Consumption (shr)	1.02	1.03	0.98	0.98	0.96	0.96	0.78	0.95	0.65	0.90
	Savings (shr)	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.27	0.00
	Tax (shr)	-0.02	-0.03	0.02	0.02	0.04	0.04	0.05	0.05	0.08	0.10
Income	Total (billions \$)	1059.54	680.93	1889.70	1302.51	1834.16	1256.02	1482.31	1138.51	10575.25	6120.33
	Wages (shr)	0.67	0.75	0.77	0.81	0.72	0.77	0.78	0.75	0.48	0.61
	Interest (shr)	0.13	0.23	0.09	0.15	0.11	0.18	0.15	0.20	0.50	0.37
	Transfers (shr)	0.21	0.02	0.14	0.03	0.18	0.05	0.07	0.05	0.02	0.02

Step 3: Income (State Level)

Key differences to aggregated region routine:

1. Labor market

- labor demands account for overhead outside of what employees get paid directly for wages and salary
- some people live and work in different states (e.g. for DC and AK)

Key innovation – adding a subscript to match the data well:

```
* wage income must sum to total labor demands by region
```

```
wagedef(rr).. sum((r,h), WAGES(r,rr,h)) =e= sum(s, ld0(rr,s));
```

```
* define constraint on labor income
```

```
lincdef(r,h).. sum(rr, WAGES(r,rr,h)) =l= le0mult(r) * wages0(r,h);
```

Step 3: Income (State Level)

Key differences to aggregated region routine:

2. Summing up constraints. Implicitly assume that labor markets clear at the Census region level.

```
* require that state level accounts match those at the census region
ar_trans(ar,h)..      sum(mapr(ar,r), TRANS(r,h)) =e= TRANS_AG.L(ar,h);

ar_transhh(ar,h,trn).. sum(mapr(ar,r), TRANSHH(r,h,trn)) =e=
TRANSHH_AG.L(ar,h,trn);

ar_wages(ar,h)..      sum(mapr(ar,r), sum(rr, WAGES(r,rr,h))) =e=
WAGES_AG.L(ar,h);

ar_interest(ar,h)..   sum(mapr(ar,r), INTEREST(r,h)) =e= INTEREST_AG.L(ar,h);

ar_save(ar,h)..       sum(mapr(ar,r), SAVE(r,h)) =e= SAVE_AG.L(ar,h);
```

Quick Example on Labor Representation

```
$demand:RA(r,h)
      d:PC(r,h)      q:c0_h(r,h)
      e:PFX          q:sum(trn,hhtrans0(r,h,trn))
      e:PL(q)        q:le0(r,q,h)
      e:PK           q:ke0(r,h)
      e:PL(q)        q:(-tx(r,h)*le0(r,q,h))
      e:PFX          q:(-sav0(r,h))
```

Step 3: Income (State Level)

Range of results – income shares for aggregate categories:

		<u>CPS</u>			<u>SOI</u>		
		mean	min	max	mean	min	max
hh1	Wages	0.35	0.24	0.51	0.67	0.57	0.75
	Capital	0.10	0.04	0.20	0.13	0.08	0.19
	Transfers	0.55	0.39	0.70	0.21	0.12	0.27
hh2	Wages	0.60	0.44	0.77	0.77	0.69	0.83
	Capital	0.11	0.06	0.20	0.09	0.06	0.14
	Transfers	0.29	0.15	0.45	0.14	0.11	0.22
hh3	Wages	0.72	0.61	0.84	0.72	0.65	0.82
	Capital	0.11	0.07	0.20	0.11	0.06	0.15
	Transfers	0.18	0.09	0.29	0.18	0.12	0.24
hh4	Wages	0.78	0.70	0.85	0.78	0.73	0.88
	Capital	0.12	0.07	0.24	0.15	0.10	0.19
	Transfers	0.10	0.06	0.14	0.07	0.02	0.08
hh5	Wages	0.49	0.20	0.57	0.48	0.28	0.56
	Capital	0.49	0.41	0.79	0.50	0.42	0.70
	Transfers	0.02	0.01	0.03	0.02	0.01	0.03

Step 4: Goods Expenditures (State Level)

Overview: use income elasticities to approximate the distribution of consumption shares across households.

```
* impute consumption shares using income elasticities of demand
theta(r,g,h) = theta0(r,g) * consumption_index(r,h)**eta0(g);

* objective function
objcd..      OBJ =e= sum((r,g,h), sqr(CD(r,g,h)-theta(r,g,h)*CONS.L(r,h)) )
              - sum((r,g,h)$theta(r,g,h), LOG(CD(r,g,h)));

* marget clearence
market(r,g)..  sum(h, CD(r,g,h)) =e= cd0(r,g);

* income balance
budget(r,h)..  sum(g, CD(r,g,h)) =e= CONS.L(r,h);
```


Step 4: Goods Expenditures (State Level)

Household expenditures based on expenditure elasticities from SAGE model.
Mapped to WiNDC sectors using the PCE Bridge.

Estimated Expenditure Elasticities (methodology from Aguiar and Bils (2015))	
CEX Category	Elasticity
Alcoholic Beverages	1.1
Food and Other Beverages	0.85
Tobacco Products	0.34
Clothing and Apparel	1.13
Personal Care	1.07
Reading	0.74
Education	1.5
Medical Treatment	1.16
Entertainment	1.39
Electricity Utilities	0.31
Natural Gas Utilities	0.32
Heating Fuels	0.31
Telephone	0.65
Water Utilities	0.26
Housing	0.45
Housing Supplies and Furnishings	1.58
Vacation Home Rentals	0.6
Transportation Fuels	0.66
Vehicle Maintenance	0.78
Vehicle Financing	0.27
Vehicle Services	1.1

Step 4: Goods Expenditures (State Level)

Examples results:

		<u>all</u>	<u>hh1</u>	<u>hh2</u>	<u>hh3</u>	<u>hh4</u>	<u>hh5</u>
Necessities	Housing	0.16	0.305	0.232	0.194	0.196	0.103
	Utilities	0.02	0.036	0.029	0.025	0.025	0.013
Luxuries	Hospitals	0.081	0.035	0.064	0.073	0.064	0.099
	Education	0.027	0.008	0.01	0.012	0.012	0.04

- CPS is the preferred approach. Standardize income bins across years? One advantage of using pure quintiles is representativeness. However, income bins would then change by year.
- Fringe benefit allocation – one idea is to leverage the National Compensation Survey which breaks out fringe benefits by occupation. Could leverage Occupational Employment Survey from BLS to approximate fringe benefit shares by income group and state.
- Adapting Alex's TAXSIM routine.
- Jury's still out about how in-kind benefits are incorporated into input output tables. We've begun to bug BEA folks...
- Comparison to IMPLAN. Will bring this work back. Initial motivation is to undergo the exercise before comparison to limit any influence.

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- Marginal Cost of Funds [done].
- Energy taxes [done].
- COVID (requires augmenting dataset with occupations) [partially finished].
- Leakage from subnational climate policy (requires augmenting dataset with bluenote routine) [partially finished].

Q is the ratio of a physical asset's market value and its replacement value. James Tobin (1977) describes two quantities which determine this value:

One, the numerator, is the market valuation: the going price in the market for exchanging existing assets. The other, the denominator, is the replacement or reproduction cost: the price in the market for newly produced commodities. We believe that this ratio has considerable macroeconomic significance and usefulness, as the nexus between financial markets and markets for goods and services.

In our steady-state equilibrium we assume that $Q = 1$.

The Steady-State Closure

```
$constraint:SSK
    sum((r,g),i0(r,g)*PA(r,g)) =e= sum((r,g),i0(r,g))*RKS;

$demand:RA(r,h)    s:esubL(r,h)
    d:PC(r,h)      q:c0_h(r,h)
    d:PLS(r,h)     q:lsr0(r,h)

    e:PLS(r,h)     q:(ls0(r,h)+lsr0(r,h))
    e:PFX          q:(sum(trn, hhtrn0(r,h,trn)))    r:TRANS

    e:PK           q:ke0(r,h)
    e:PFX          q:(-sav0(r,h))                  r:SAVRATE

$demand:NYSE
    d:PK
    e:RKS          q:(sum((r,s),kd0(r,s)))    r:SSK

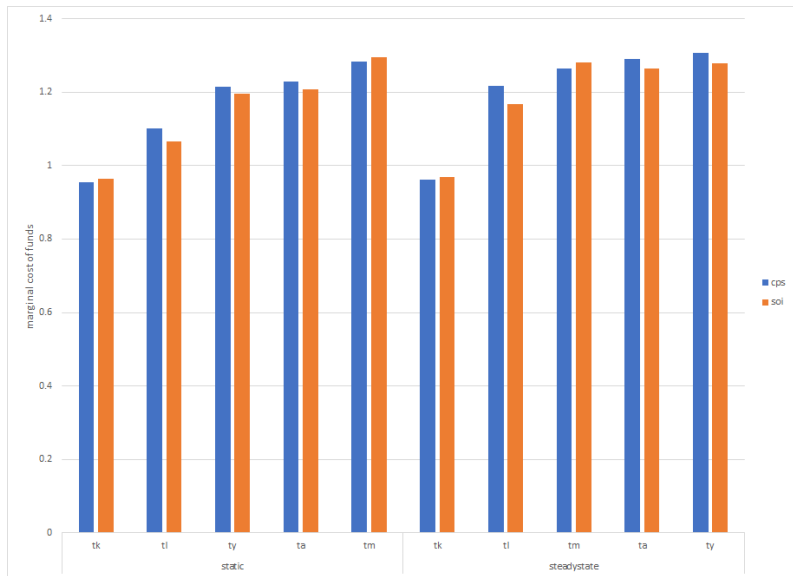
$constraint:SAVRATE
    INVEST =e= sum((r,g), PA(r,g)*i0(r,g))*SSK;
```

Diagnostic Simulation Number One: the MCF

Having implemented the model we do some initial calculations in which we assess the welfare cost of various tax instruments in the model. In each calculation we proportionally increase tax rates by 10%. The tax streams we evaluate are the capital tax (TK), the labor tax (TL), indirect taxes on production (TY), sales and property taxes (TA) and the import tariff (TM).

When we increase tax rates, consumers and producers adjust behavior to produce a new equilibrium consistent with a new level of government income and expenditure. Government expenditure increases less than proportionally to the tax rate as a result of changes in individual behavior.

CPS versus SOI and Static versus Steadystate



Reporting Economic Cost

With multiple households, one is faced with the challenge of reporting economic cost (welfare impacts) which reflect economic burdens which differ across households in different income groups. Of course, it is always possible to adopt a utilitarian perspective and simply sum up money metric welfare.

We feel that it is helpful to adopt alternative social welfare perspectives and cost estimates that summarize the progressive or regressive nature of household effects. The alternative perspectives place different emphasis on the distribution of induced changes in per capita consumption.

For this calculation, we formulate the following money-metric social welfare function:

$$SWF = \Phi \left(\sum_{hr} P_{hr} c_{hr}^{1-1/\sigma} \right)^{1/(1-1/\sigma)}$$

in which P_{rh} is the population represented by household quintile h in region r and c_{hr} is *per-capita* consumption by the same group.

N.B. Appropriate choice of Φ permits us to measure social welfare in money-metric units, i.e. SWF reports welfare as a proportional change in income for all members of society at benchmark prices.

In the formula for SWF the parameter reflecting inequality aversion is σ . The alternative welfare perspectives are simply different specifications for σ . When $\sigma = +\infty$ social welfare is equivalent to the sum of regional consumption, i.e., $SWF = \sum_{rh} P_{rh} c_{rh}$. In this case, social welfare is “utilitarian” in that it does not differentiate between differences in income levels.

When $\sigma = 0$, global social welfare reduces to a measure of the impact on the lowest income quintile across all regions. This case is “Rawlsian” in that regard. In between, are intermediate cases in which there is a compromise between concern with inequality and aggregate consumption, with a smaller value of σ implying greater weighting of the effects in poorer regions, which have a higher marginal value of a dollar.

Regional differences in the marginal value of a dollar will over time with relative incomes, but changes in income induced through policy simulations are unlike to substantially change these levels.

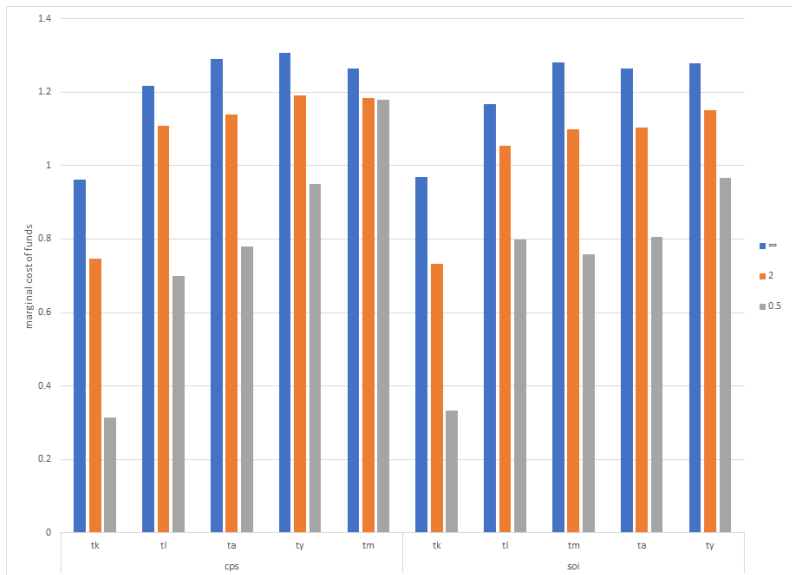
Here we illustrate different welfare perspectives using three specifications: $\sigma = +\infty$, $\sigma = 2$, and $\sigma = 0.5$. The latter two are referred to as “inequality averse” perspectives in which the marginal social welfare of an additional dollar is substantially higher for households in the lowest quintile.

The Value of a Dollar

$\sigma = 2.0$	q1	q2	q3	q4	q5
neg	3.1	2.0	1.5	1.3	0.6
mid	3.0	1.8	1.4	1.2	0.6
enc	2.9	1.8	1.5	1.2	0.7
wnc	3.1	1.9	1.5	1.3	0.6
sac	3.0	1.9	1.5	1.2	0.7
esc	3.2	1.9	1.5	1.3	0.7
wsc	3.0	1.9	1.4	1.2	0.7
mtn	2.9	1.8	1.5	1.5	0.6
pac	3.0	1.9	1.5	1.3	0.6

$\sigma = 0.5$	q1	q2	q3	q4	q5
neg	20.9	3.5	1.3	0.7	0.0
mid	18.2	2.5	1.0	0.5	0.0
enc	15.9	2.5	1.1	0.5	0.0
wnc	20.8	2.9	1.2	0.6	0.0
sac	19.0	2.9	1.1	0.5	0.0
esc	23.7	3.2	1.2	0.6	0.0
wsc	19.9	3.1	1.0	0.5	0.0
mtn	15.6	2.7	1.1	1.0	0.0
pac	18.7	2.9	1.1	0.8	0.0

Marginal Cost of Funds : SWF

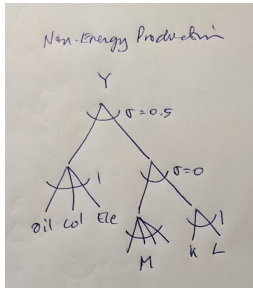


Diagnostic Simulation Number Two: the Double Dividend

Fullerton & Metcalf (1997): “Environmental Taxes and the Double-Dividend Hypothesis: Did You Really Expect Something for Nothing?”

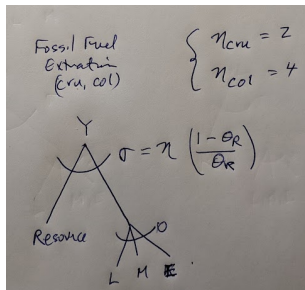
The double-dividend hypothesis' suggests that increased taxes on polluting activities can provide two kinds of benefits. The first is an improvement in the environment, and the second is an improvement in economic efficiency from the use of environmental tax revenues to reduce other taxes such as income taxes that distort labor supply and saving decisions.

Minimal Energy Model



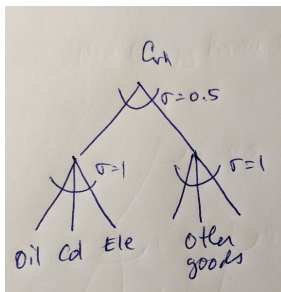
```
$prod:Y(r,s)$y_(r,s) and nx(s)) t:0 s:0.5 e:1 m:0 va(m):1
o:PY(r,g) q:ys0(r,s,g) a:GOVT t:ty(r,s)
i:PA(r,g) q:id0(r,g,s) a:GOVT t:te(r,g)
+ e:$eg(g) and (not sameas(g,s))
+ m:$((not eg(g)) or sameas(g,s))
i:PL(r) q:ld0(r,s) va:
i:RK(r,s) q:kd0(r,s) va: a:GOVT t:tk(r,s) p:(1+tk0)
```

Fossil Fuel Supply



```

$prod:Y(r,s)$y_(r,s) and xi(s)  t:0 s:sigmax(r,s) m:0
o:PY(r,g)          q:ys0(r,s,g)    a:GOVT t:ty(r,s)
i:PA(r,g)          q:id0(r,g,s)    a:GOVT t:te(r,g)      m:
i:PL(r)           q:ld0(r,s)      a:GOVT t:tk(r,s) p:(1+tk0)
i:PR(r,s)         q:rd0(r,s)      a:GOVT t:tk(r,s) p:(1+tk0)
    
```



```

$prod:C(r,h)  s:0.5  e:1  c:1
o:PC(r,h)    q:c0_h(r,h)
i:PA(r,g)    q:cd_h(r,g,h)  a:GOVT  t:te(r,g)  e:$eg(g)  c:$(not eg(g))
    
```

An Illustrative Policy Shock

* Proportionally adjust transfers to balance the public bud

```
TRANS.UP = +inf;
```

```
TRANS.LO = -inf;
```

* Apply 50% ad-valorem tax on both oil (and gas) and coal:

```
te(r,"oil") = 0.5;
```

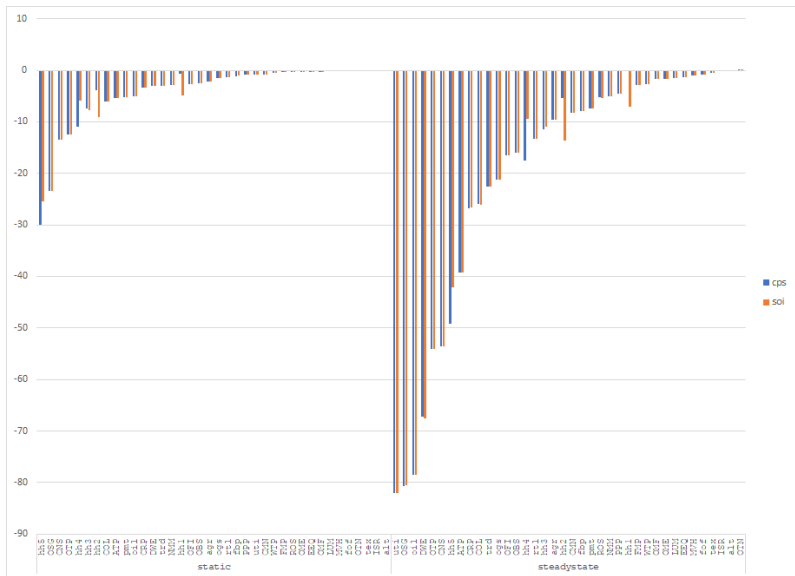
```
te(r,"col") = 0.5;
```

* Solve the model:

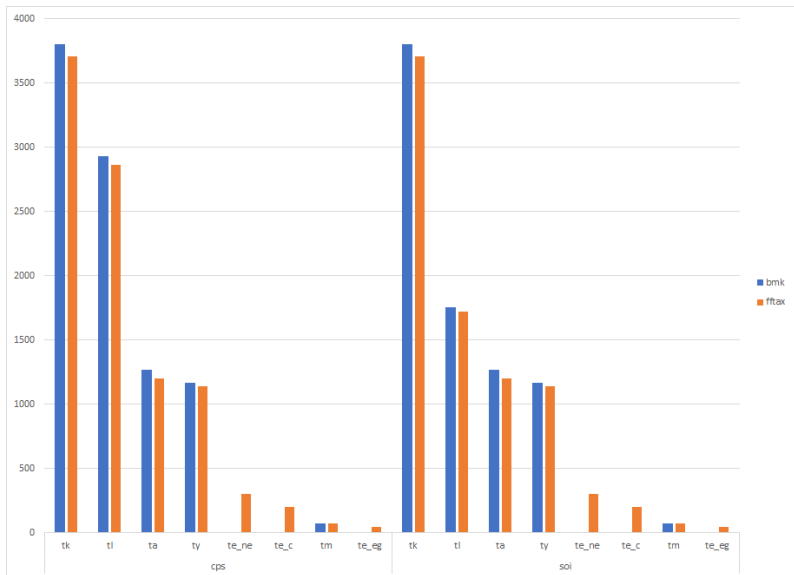
```
$include ENERGY_%hhdata%_%dynamic%.GEN
```

```
solve energy using mcp;
```

Fossil Fuel Tax and Energy Demand

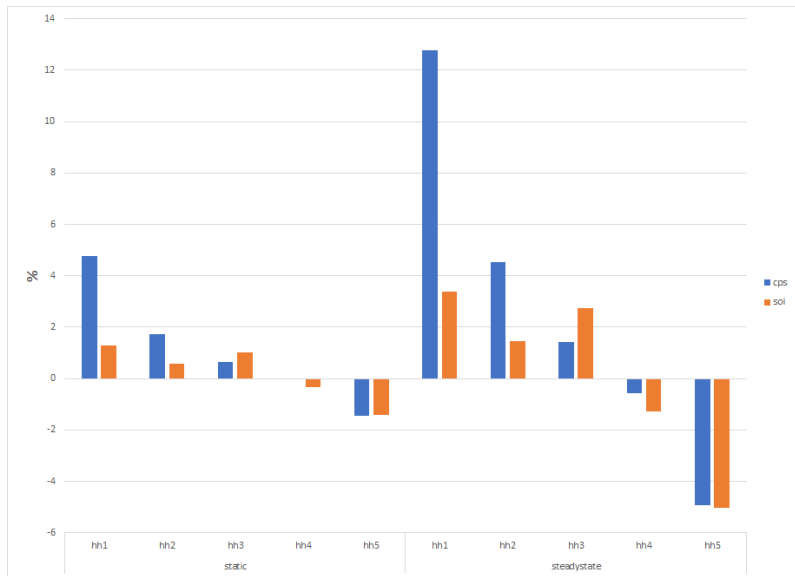


Fossil Fuel Tax and Tax Revenue



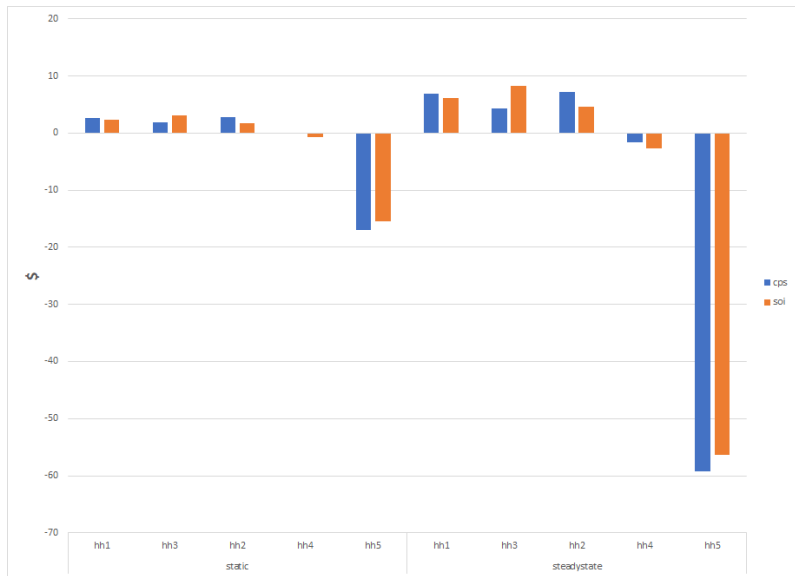
Economic Cost of Energy Tax (%)

N.B.! Revenue recycled proportional to existing household transfers.



Economic Cost of Energy Tax (\$)

N.B.! Revenue recycled proportional to existing household transfers.



- 1 Overview
- 2 Calibration Routine
- 3 Modeling Applications
- 4 Next Steps

- Write up a manuscript summarizing the calibration approach and modeling applications.
- Submit to a journal.
- WiNDC 3.0 – will also incorporate other changes (notably, changes to the blueNOTE routine that fixes some bugs).
- Looking for a post doc.