A Carbon Tax: The Lesser of Several Evils?

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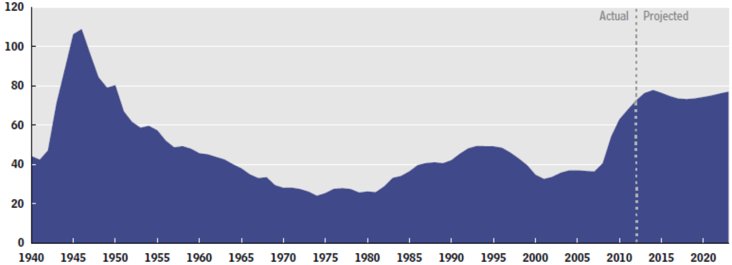
Introduction

- Putting a price on carbon has potential to address two long-term problems.
- Growing public debt with potentially detrimental implications for economic growth.
  - Revenue from a carbon tax could be used to reduce deficit, avoid spending cuts, or finance reductions in rates of existing taxes while holding the deficit constant (or some combination of thereof).
- Build-up of carbon dioxide in atmosphere contributing to global climate change derived from burning fossil fuels.
- Projected U.S. federal budget deficit and corresponding growth in national debt are well above levels that are deemed sustainable in the long run.
- Many other nation's fiscal situations are similarly unsustainable.

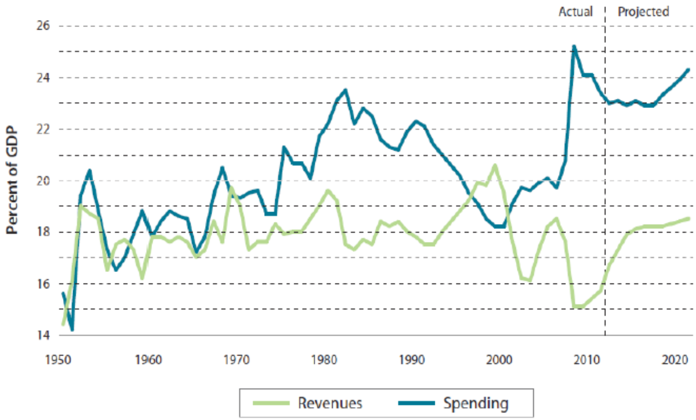
U.S. federal debt (% of GDP)



Source: CBO (February, 2013), The Budget and Economic Outlook: Fiscal Years 2013 to 2023.

- Under current law, federal debt is projected to stay at historically high levels relative to GDP.
- Current bi-partisan view in US is that "deficit reduction must be on agenda" (differences as to what measures are appropriate exist)
- Tax increases and/or spending cuts are required

Why fiscal reform will be on agenda



Source: The Hamilton Project (May, 2012), A Dozen Facts About Tax Reform.

Why do we need to prevent high debt-to-GDP ratio?

- Borrowing costs for everyone go up and makes problem worse.
- US beholden to foreign buyers of US debt.
- People buy treasury bonds instead of making other productive investments.
- Reduces the option to spend more later.
- Financial markets could react badly to poor governance.

Potential reasons to embed carbon tax within broader U.S. fiscal reform

Lower costs of tax and regulatory system

- Reduce deficit.
- Lower/reform other taxes.
- Reduce need for Clean Air Act Regulation, state policies, and other regulation and subsidies.

Lower burden on poor households

- Limit cuts in social safety net spending.
- Allow progressive tax reforms.

Raise possibility of success?

- Build larger platform for deal-making.
- Limit rent-seeking and delay on climate policy.

Research question

What are the efficiency and distributional effects of including a carbon tax in a package of debt-reduction measures?

- If a carbon tax were implemented: How does the use of its revenue affect the outcomes?
- Societal welfare assessment of carbon tax if its revenue is used for debt reduction?
- If deficit reduction were undertaken: How does a carbon tax stack up against other revenue raisers?
- Inter- and intra-generational distributional implications?

Environmental taxes and fiscal policy (I)

- Extensive prior literature on how environmental taxes interact with the broader tax system (the "double-dividend" or "tax-interaction" literature, Bovenberg & Goulder, 1996).
  1. Tax-interaction effect: pollution taxes implicitly tax capital & labor, thus exacerbating distortions from the existing tax system.
  2. Revenue-recycling effect: use of revenue can provide efficiency gains (e.g., by financing marginal rate cuts for other taxes).
- Under central case assumptions, these two effects lead to a lower optimal pollution tax (but this can vary substantially for non-central-case assumptions).
- Important implications for instrument choice for reducing CO_2 emissions (some policies generate costly tax-interaction effect, but only some of them can exploit the offsetting revenue-recycling effect).

Environmental taxes and fiscal policy (II)

- Very little prior research has looked at use of environmental tax revenue for deficit reduction.
  - McKibbin et al. (2012), Carbone, Morgenstern, Williams (2012).
- Moreover, existing models in this literature are poorly suited for looking at debt consolidation.
  - Most tax-interaction models are static, but budget deficit is an inherently dynamic problem.
  - The few dynamic models in this literature (e.g., Bovenberg & Goulder, 1996) all assume infinitely-lived agents.
  - Forward-looking models with infinitely-lived agents exhibit full Ricardian equivalence, so deficits have no effect: if government borrows, agents save an exactly offsetting amount.

Model overview (I)

New dynamic general equilibrium overlapping generations (OLG) model for the U.S. economy

- Model setup similar to Auerbach & Kotlikoff (1987) and Altig et al. (2001): households with rational point expectations (perfect foresight) live for a finite number of periods and maximize lifetime utility by choosing optimal life-cycle consumption, labor supply, and savings decisions.
- Multi-sector structure with particular focus on energy as is typically adopted in energy-economy CGE models.
- Fiscal structure includes taxes, government spending and transfers, and budget deficit/surplus.

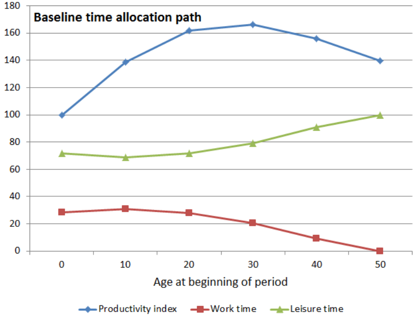
Overlapping generations households

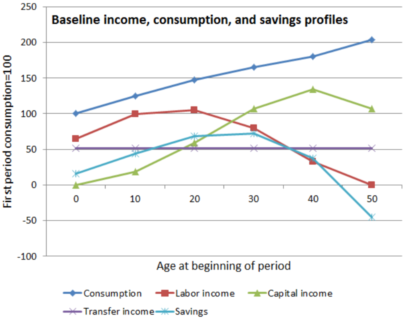
Household of generation g born in year $t = g$ lives for $N + 1$ years. Optimal life-cycle material ($c_{g,t}$) and leisure ($\ell_{g,t}$) consumption paths solve:

$$
\begin{aligned}
\max_{c_{g,t},\, \ell_{g,t}} u_g\left(z_{g,t}\right) &= \sum_{t=g}^{g+N} \left(\frac{1}{1+\rho}\right)^{t-g} \frac{z_{g,t}^{1-1/\sigma}}{1-1/\sigma} \\
s.t. \qquad z_{g,t} &= \left(\alpha c_{g,t}^{\nu} + (1-\alpha)\, \ell_{g,t}^{\nu}\right)^{\frac{1}{\nu}} \quad \text{(instantaneous utility)} \\
\sum_{t=g}^{g+N} p_{a,t}\, c_{g,t} &\leq p_{k,t}\, \overline{k}_{g,g} + \sum_{z} p_{z,t}\, \overline{z}_{z,g} + \sum_{t=g}^{g+N} p_{l,t}\, \pi_{g,t}\left(\omega_{g,t} - \ell_{g,t}\right) \\
&\quad + p_{a,t}\, \zeta_{g,t} \qquad \text{(lifetime budget constraint)} \\
\ell_{g,t} &\leq \omega_{r,g} \qquad \text{(feasibility for leisure)}
\end{aligned}
$$

- Time endowment: $\omega_{g,t} = \omega\,(1+\gamma)^g$ where γ is exogenous growth rate. Index of labor productivity over life-cycle: $\pi_{g,t}$.
- Capital holdings at the beginning of life $t = g$ for generations born prior to year zero: $\overline{k}_{g,g}$ (assume that $\overline{k}_{g,g} = 0$ for $g \geq 0$, i.e. no bequests).
- Government transfers: $\zeta_{g,t}$. Fossil-fuel resource rents: $\overline{z}_{z,g}$.

Baseline profiles for time allocation, income, consumption, and savings





- Desire to increase consumption over life-cycle means that capital income is growing reflecting positive saving while young and subsequent dissaving.
- Labor income (as well as time devoted to labor) first increasing then decreasing consistent with humped shaped productivity profile.

Intra-generational household heterogeneity

- $h = h_1, \ldots, h_5$ household types within each generation representing quintiles of lifetime-wage income.
- Earnings-ability profiles taken directly from Altig et al. (AER 2001)

$$\pi_{h,\text{age}} = \exp\left(\lambda_{h,0} + \lambda_{h,1}\text{age} + \lambda_{h,2}\text{age}^2 + \lambda_{h,3}\text{age}^3\right) \ .$$

- Population shares and level of government transfers for each type taken from Bureau of Labor Statistics' Consumer and Expenditure Survey 2011.
- For now, we assume symmetric preferences for different households types (hence focus is on sources side of income effects).

Government budget

- Annual identity for the government budget states that the deficit run by the government through year t is equal to the change in the stock of debt (D_t) between (beginning-of-years) $t+1$ and t:

$$p_t^G G_t + T_t - \Phi_t + rD_t = B_t - R_t = D_{t+1} - D_t \, ,$$

  $p_t^G G_t$: value of public spending; T_t: transfers; Φ_t: tax revenue; r: real interest rate; B_t: additional borrowing; R_t: repayment of the principal.

- Debt repayment affects the net public expenditures (N_t) in current and future periods according to the equation:

$$N_t = R_t + rD_t - B_t = R_t + r\left(D_0 - \sum_{\tau=0}^{t}(R_\tau - B_\tau)\right) \, .$$

- Public budget can then be written:

$$p_t^G G_t + T_t + N_t = \Phi_t \, .$$

- Throughout analysis, G_t and T_t grow exogenously with steady-state growth rate.

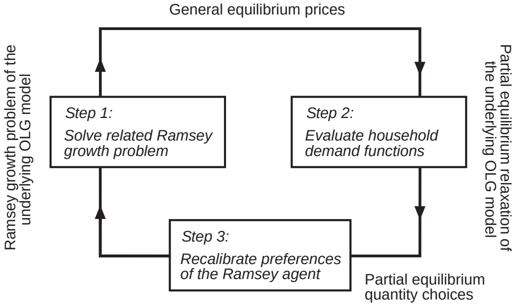
Model overview (II)

- Otherwise standard neoclassical CGE growth model with perfectly competitive product and factor markets.
- Nested CES functions describe production and consumption technologies.
- Small open economy model and Armington (1969) trade specification.
- Firms use 6 factors of production (capital, labor, coal, natural gas, crude oil, land) and intermediate goods
- Firms produce 15 intermediate goods (including 5 energy goods), plus consumption, investment, and government services goods
    - GTAP commodities (or aggregates thereof): *Agriculture (AGR), Coal (COA), Natural gas (GAS), Crude oil (OIL), Electricity (ELE), Refined oil (P_C), Paper products, publishing (PPP), Chemical, rubber, plastic products (CRP), Ferrous metals (I_S), Metals (NFM), Non-metallic minerals (NMM), Transportation (TRN), Other energy-intensive industries (EIS), Services (SER), Manufacturing (MAN).*

Model calibration and approximation of infinite-horizon economy

- Model is calibrated to a steady-state baseline extrapolated from GTAP8 data for the year 2007.
- Steady-state calibration procedure following Rasmussen and Rutherford (2004) ensures consistency of OLG behavior and base-year aggregate SAM.
- Lifespan of households is 50 years.
- Model is solved for 200 years. Then terminal conditions that assume steady state continues on indefinitely outside the horizon of the model:
  - "State-variable targeting" (Lau, Pahlke, Rutherford, 2002) determines post-terminal capital stock.
  - Additional constraints characterizing behavior of generations alive in post-terminal years (Rasmussen and Rutherford, 2004).

Computational approach



- Due to reasons of computational complexity, equilibrium of OLG model is computed using a decomposition algorithm (Rausch and Rutherford, 2009)
- Idea is to approximate solution by computing equilibria for a sequence of “related” Ramsey optimal growth problems. OLG demand system is replaced by an ILA whose preferences are successively re-calibrated based on partial equilibrium demands of OLG households.

Policy simulations

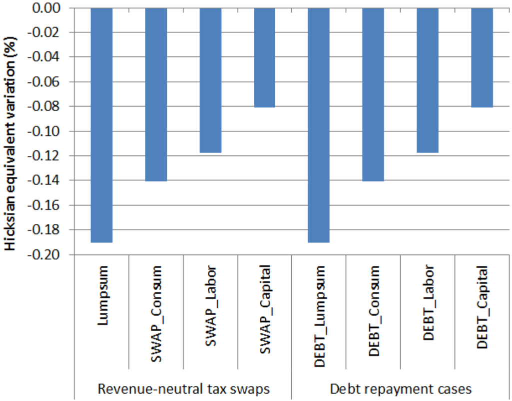
$20 carbon tax starting in first period of model increasing at 4% per year

- Carbon policy runs for 50 years (afterwards emissions can grow without constraints)
- Why this setup?
    - Motivated by CBO (2012) assumption + current discussion in U.S.
    - Focus is more on carbon tax as revenue source and not as climate policy.
    - Limited policy period eases interpretation of intergenerational impacts.

Alternative uses of revenue from carbon tax:

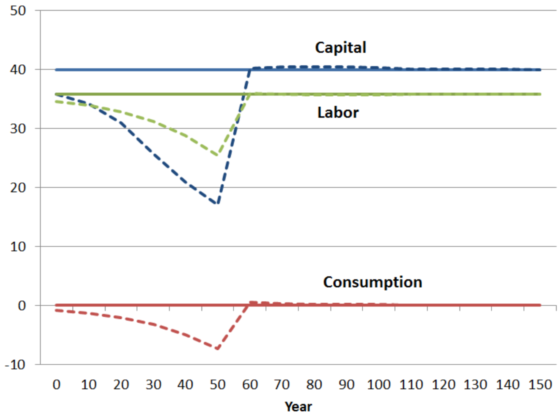
1. Revenue-neutral tax swaps (offsetting cut in capital, labor, or consumption tax rate to keep government revenue in each period unchanged).
2. Carbon revenue is used to repay principal debt (future budget surpluses from lower interest obligations are recycled through cuts in capital, labor, or consumption tax rate).

Welfare impacts for model with infinitely-lived agent (ILA)



- Weak double dividend for revenue-neutral tax swaps. Highest efficiency gains for capital tax recycling (standard result in “tax interaction” literature).
- Tax swap and debt repayment cases produce identical welfare impacts (Ricardian equivalence).

Tax rates for benchmark and revenue-neutral tax swaps (in %)

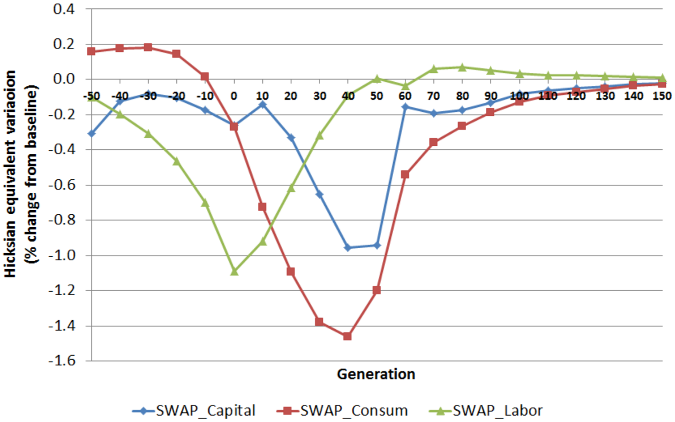


- Tax rates in equilibrium endogenously determined to satisfy (note that left-hand side is fixed):

$$p_t^G G_t + T_t + N_t = \Phi_t + \text{Carbon revenue} \, .$$

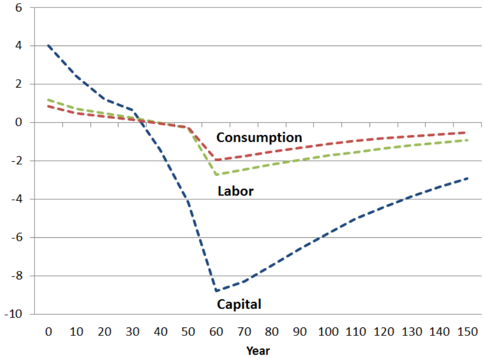
- Substantial reductions in tax rates for periods when carbon policy is active.
- Differences in magnitudes of tax rate cuts reflects different size of tax base.

Average welfare impacts by generation for revenue-neutral carbon tax swaps



- No unambiguous ranking of instruments in terms of efficiency (would depend on how welfare impacts are traded-off across regions).
- With labor tax recycling, most of burden falls on elderly and young generations, while capital recycling tax puts most of burden on future generations.
- Largest differences in intergenerational equity for consumption tax recycling.

Percentage-points difference in tax rates (debt repayment case relative to corresponding tax swap scenario)



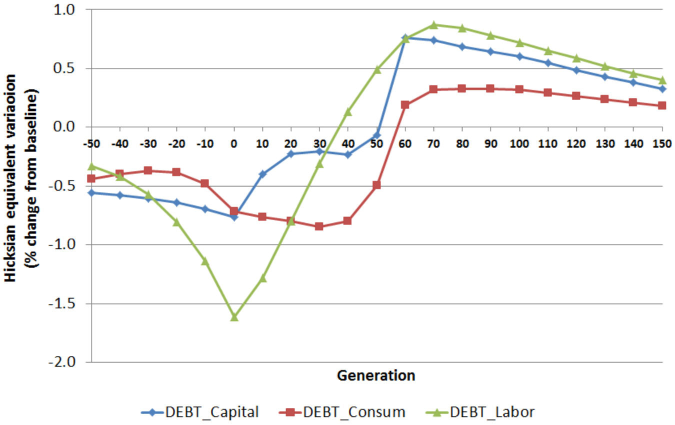
- Tax rates in equilibrium endogenously determined to satisfy (note that G_t and T_t are fixed):

$$p_t^G G_t + T_t + N_t = \Phi_t + \text{Carbon revenue}$$

where carbon revenue is used to repay debt hence relaxing future budgets through lower interest obligations:

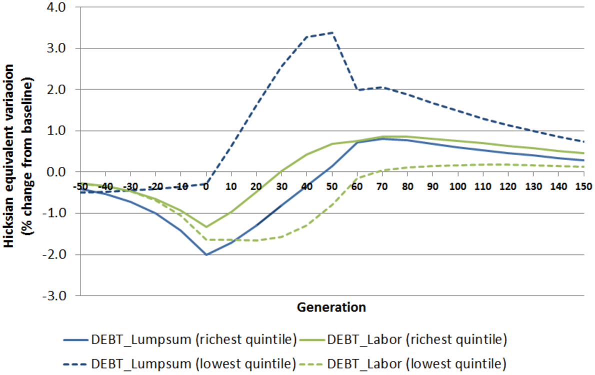
$$N_t = R_t + r\left(D_0 - \sum_{\tau=0}^{t}(R_\tau - B_\tau)\right).$$

Average welfare impacts by generation for debt repayment scenarios



- Costs of fiscal consolidation are borne by elderly and subsequent young generations, while future generations gain.
- Larger losses for elderly generations but similar pattern for alternative instruments as for tax swap cases.
- Consumption tax scenario forgoes efficiency gains from increased labor and capital supply.

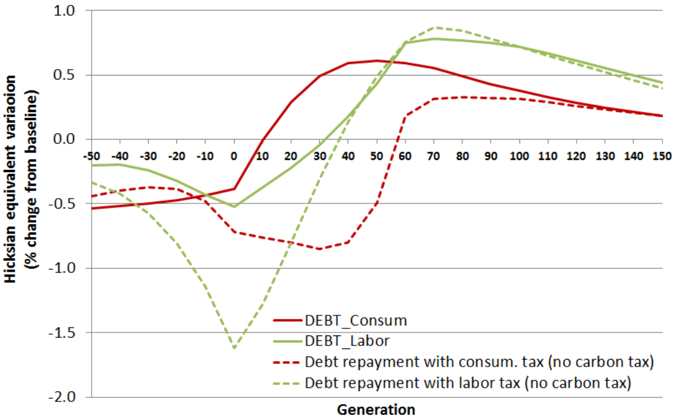
Welfare impacts by top and bottom income quintile for debt repayment scenarios



- Substantial variation in intra-cohort impacts depending on recycling instrument (even with “coarse” specification of household heterogeneity).
- Per capita lump-sum transfers implies gains for poorest quintile and losses for rich households (max welfare diff. $\approx 4\%$).
- Intra-cohort ranking reversed for labor tax recycling that benefits households with high earnings-ability.

How does a carbon tax stack up against other revenue raisers?

Average welfare impacts by generation



- Suppose same debt repayment schedule is implemented using labor and consumption taxes to raise/recycle revenue.
- Using carbon tax to raise revenue is less efficient vis-à-vis any of the other taxes considered here (ignoring environmental benefits from reduced CO_2 emissions).
- Ranking among other (=non-CO_2) tax instruments not unambiguous.

Social welfare function

- Social welfare function (SWF) approach assuming that aggregate social welfare can be measured as:

$$\text{EV}_{\text{SWF}} = \left(\sum_{g,h} \theta_{g,h} u_{g,h}^{\rho} \right)^{1/\rho}$$

$\epsilon = 1/(1-\rho)$: index of the elasticity of substitution across welfare for different households.

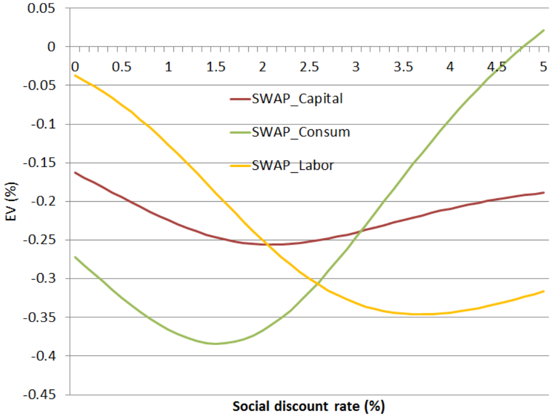
- θ_g: weighting factor that accounts for population and discounting

$$\theta_{g,h} = N_{g,h}(1-\Delta)^g$$

$N_{g,h}$: number of households represented by generation g and type h. Δ: parameter that discounts contribution of future generations.

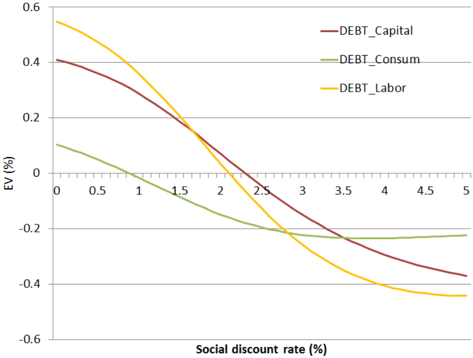
- Inequality aversion parameter ρ. $\rho = 1$: utilitarian (Bentham) social welfare function corresponding to no inequality aversion; $\rho \longrightarrow -\infty$: Rawlsian (max min) case.

Social welfare assessment of tax swap cases ($\rho = 1$)



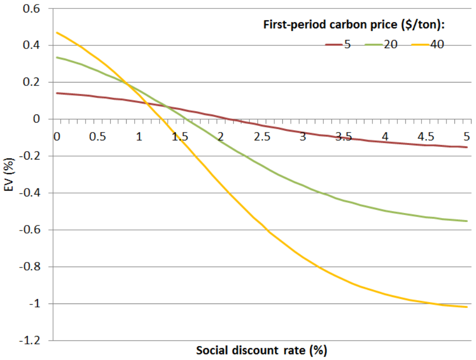
- ILA approach imposes explicit social welfare function.
- Virtue of OLG approach is to leave normative question of how to weigh current versus future generations as such.
- Utilitarian SWF: negative societal assessment for tax swap cases.

Social welfare assessment of debt repayment cases ($\rho = 1$)



- If high enough weight is placed on welfare of future generations, combined carbon and fiscal consolidation policy is socially desirable.
- More likely to be the case if efficient instruments are used (capital or labor tax vs. consumption tax).
- Just one possible cardinalization of welfare.

Social welfare assessment of debt repayment cases for different stringency of carbon policy (for DEBT_Capital, $\rho = 1$)



- Less stringent carbon policies (combined with fiscal consolidation) seem to be desirable for a larger range of social discount rates than those that aggressively reduce CO_2.
- This suggests that benefits from linking carbon tax and debt reduction policies are limited.
- Higher carbon tax means more revenue but also larger erosion of tax base (thus higher taxes are required and/or less revenue is available for debt repayments).

Conclusions

- Overall cost and distribution of that cost vary widely based on how carbon tax revenues are used.
- Revenue-neutral carbon tax swaps imply welfare losses for all generations (average impacts).
- Using carbon revenue to repay principal debt relaxes future public budgets and results in lower future interest obligations
  - Current old and subsequent young generations are worse off as compared to revenue-neutral tax swap, future generations stand chance of sustained welfare gains.
- Revenue-raising carbon pricing policy combined with fiscal consolidation program likely to receive more favorable societal assessment than just carbon policy alone.

Conclusions (cont.)

- Substantial intra-generational variation in impacts: poor or rich households can gain depending on recycling instrument.
- Benefits from linking carbon policy with debt consolidation are limited: increasingly stringent carbon policy erodes tax base and less revenue is available for debt reduction.

Some general remarks:

- Long time frame inherent in policies aimed at mitigating climate change (and public debt) naturally raises question of intergenerational equity.
- Numerical investigations have largely been limited to infinitely-lived agent (ILA) models.
- Schelling (1995): ILA approach in context of climate change involves fallacy of composition, i.e. generations making sacrifices will not be alive to reap benefits.