The Welfare Consequences of Carbon Tax in an Economy with Endogenous Labor Migration

April. 20. 2006

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Double Dividend (DD) Debate

- Tax on environmental externality: environmental improvement but negative effect on economic growth
- Revenue from environmental (carbon) taxes: Reduction of conventional taxes (labor income taxes)
- Welfare gains or loss?
- General Criteria: relative size of tax interaction effect and tax revenue recycling effect

Double Dividend (DD) Debate

- Major result: tax interaction > revenue recycling effect
- Recent debates: health effects from non-separable utility function, subsidy-interaction effect from 'tax-favored' consumption
- Some recent result: tax interaction<revenue recycling effect
- Main contribution of this study on DD debates: labor migration effect from open economy assumption

Labor Migration Effects

- Pulling effects: Relative real wage differential, relative environmental quality differential

$$L_{mfg} = \varepsilon_1 \log(w_{PA} / w_{RUS}) + \varepsilon_2 \log(AMEN_{PA} / AMEN_{RUS})$$

$$AMEN = \overline{ENV} - \frac{\pi}{2} \times TCE$$

$$w_i = \frac{p_L(1-t_L)}{P_C}$$

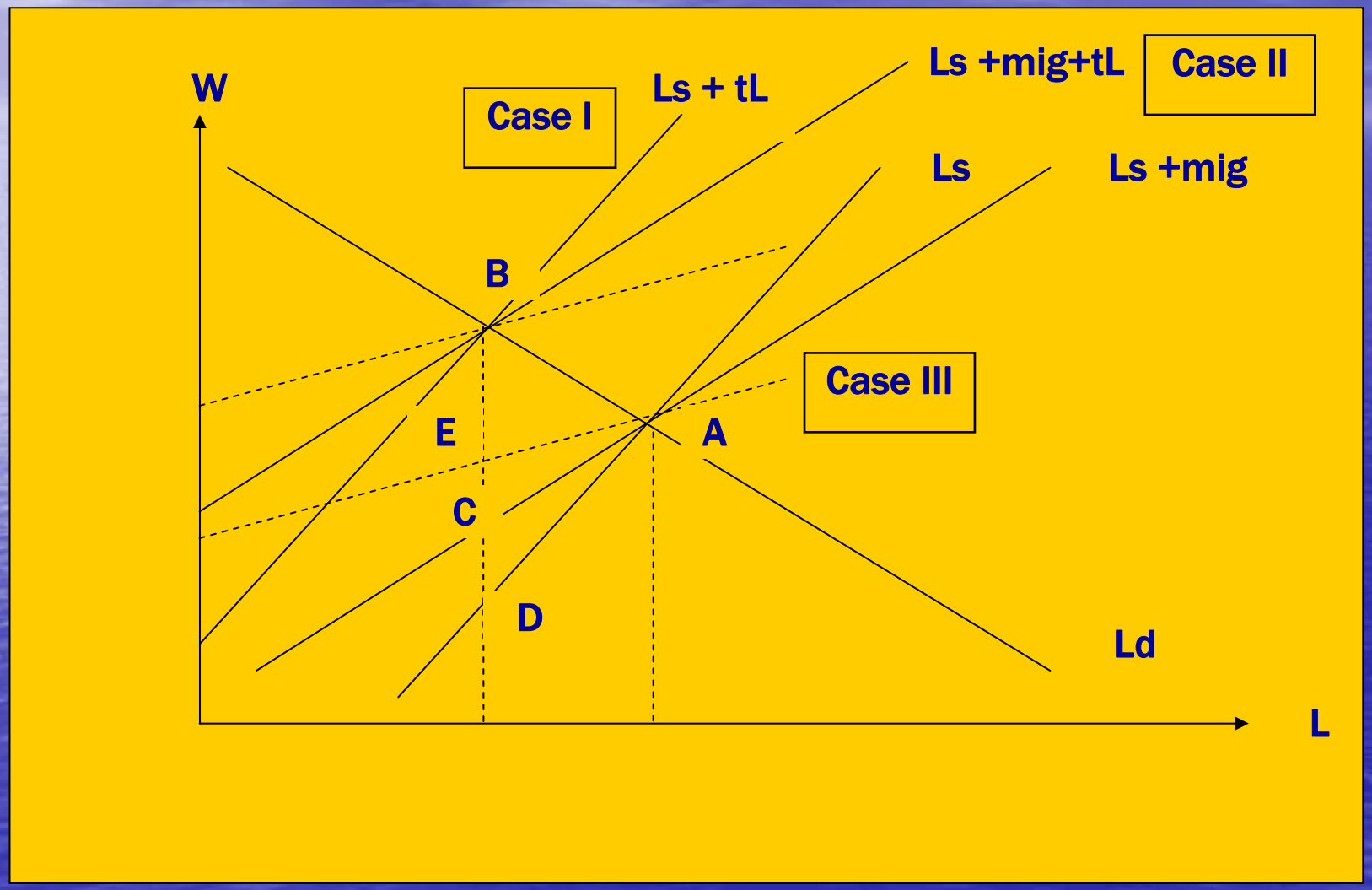
Co-benefits Assumption

- Primary benefit from carbon taxes: mitigation of GHGs and climate change
- But the primary benefit is possible if and if only every country works on the abatement of GHGs
- When the cooperative game on the mitigation of GHGs fails: Still co-benefits exist
- Co-benefits: Health effect, ecosystem effect, economic effect, and social effects

Labor Migration Effects on DD hypothesis

- As labor mobility increases, the slope of labor supply declines
- Social deadweight loss due to the labor income tax and env. Tax can be relieved with higher labor migration elasticity given that no other externality exists
- Positive effect on DD from partial equilibrium analysis

Partial Equilibrium Analysis



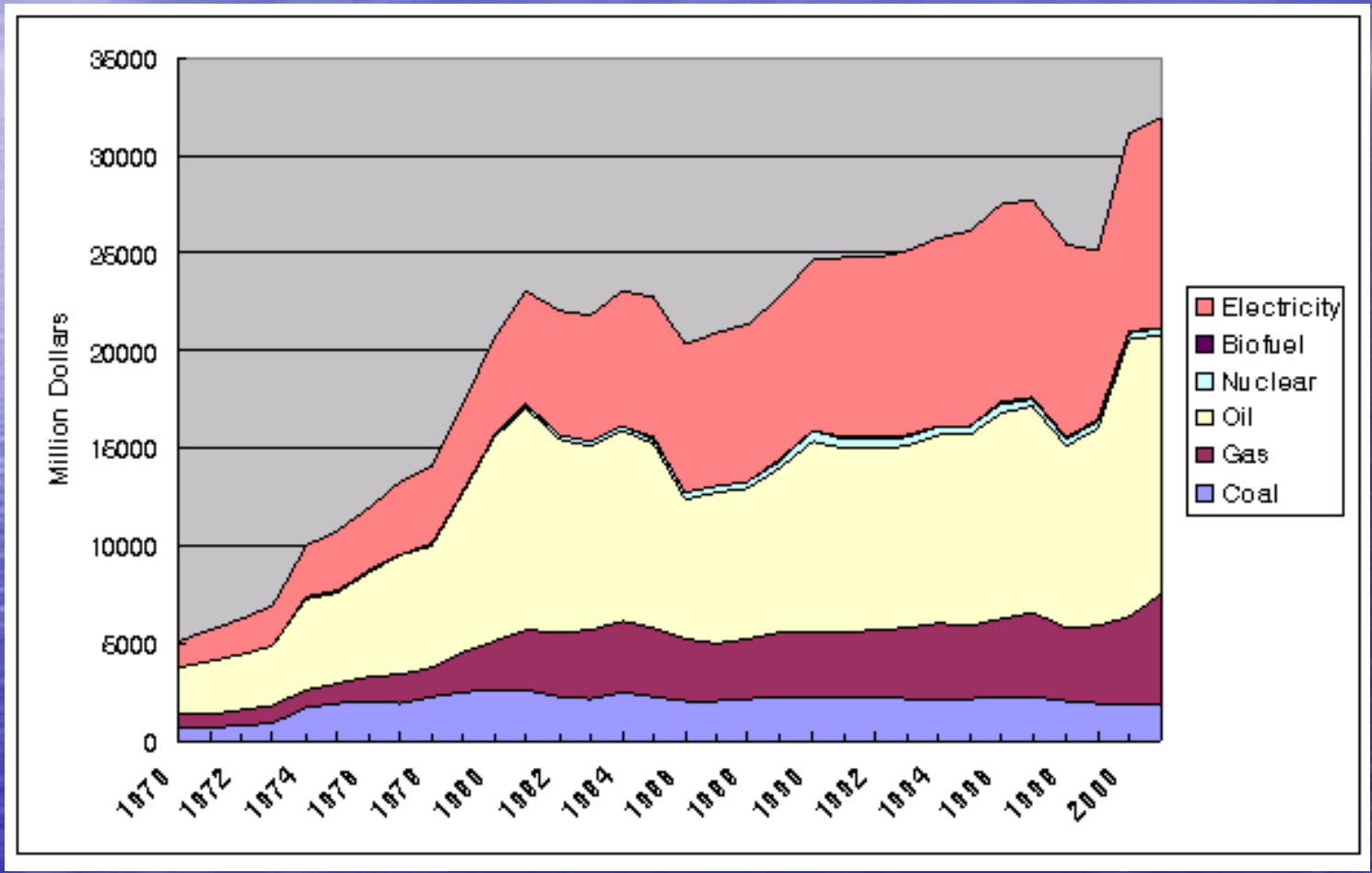
Case Study: Pennsylvania

- Fourth state emitting GHGs in the U.S. (1998)
- Main source of GHGs: fossil fuel consumption
- Observer in RGGI (Regional Greenhouse Gas Initiative)
- Population growth: 86% increase for U.S. average, but only 39% increase for northeast states bet. 1950 and 2000
- Population share: 36% → 22% in the northeast states
- Net out-migration: 1,283,752 bet. 1995 and 2000

RGGI:The Regional Greenhouse Gas Initiative

- A cooperative effort by Northeastern and Mid-Atlantic states to reduce carbon dioxide emissions
- A regional strategy for controlling emissions
  - This strategy will more effectively control greenhouse gases, which are not bound by state or national borders
- Key mechanism: the implementation of a multi-state cap-and-trade program with a market-based emissions trading system
  - This will require electric power generators in participating states to reduce carbon dioxide emissions

Energy statistics of PA



CGE model for PA: Main Feature

- A static CGE model with endogenous labor migration using GAMS/CONOPT solver
- 17 industrial sectors
- Primary input factor: labor/capital
- The explicit consideration of new and renewable energy sector in the model
- Energy mix among fossil fuels and new and renewable energy
- Two-tier trade system: domestic/foreign
- Utility derived from leisure and consumption

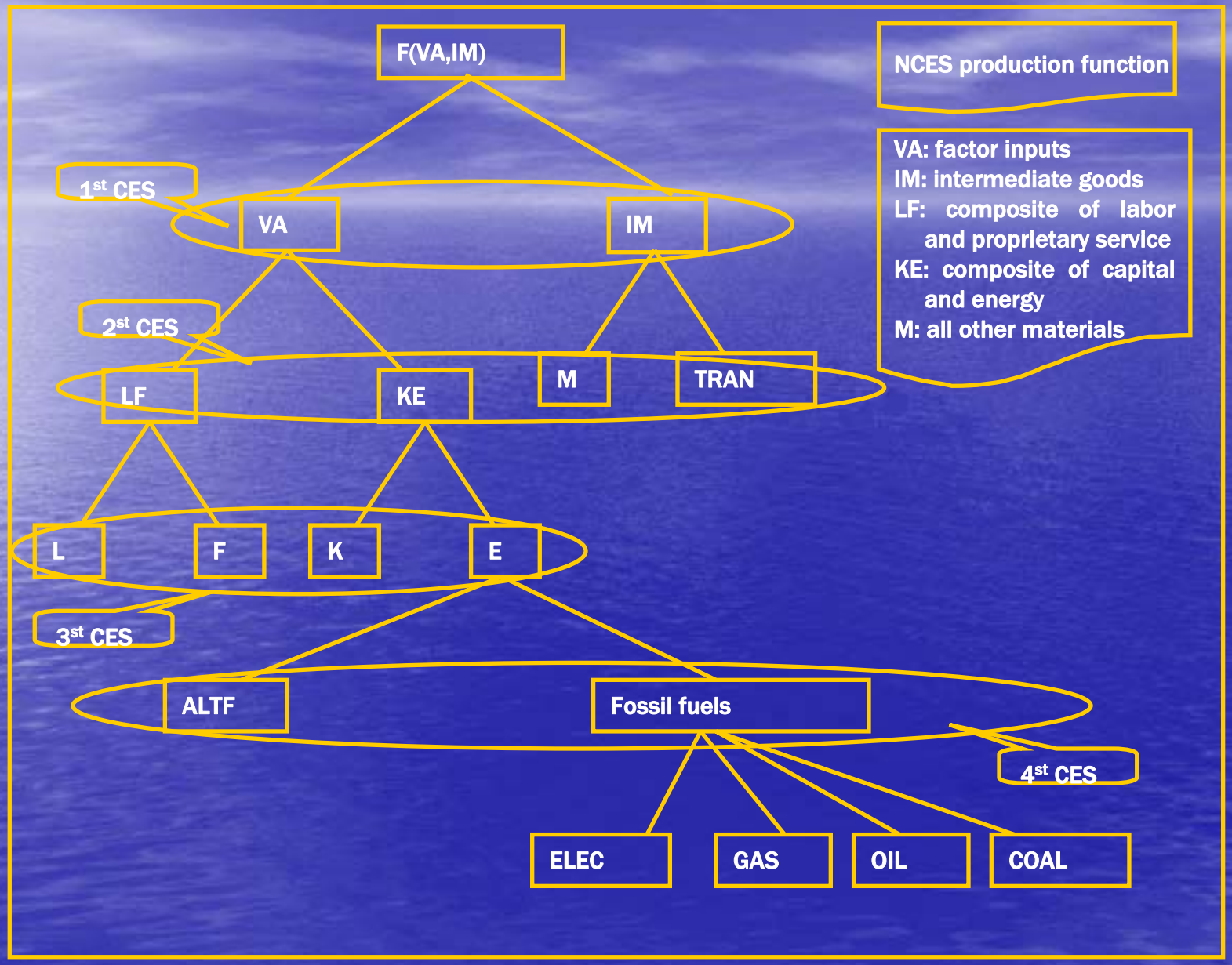
Hybrid SAM for Benchmark Economy

- Mix of economic IO table and energy balance table
- Energy row: unit is quantity (MMTCE)

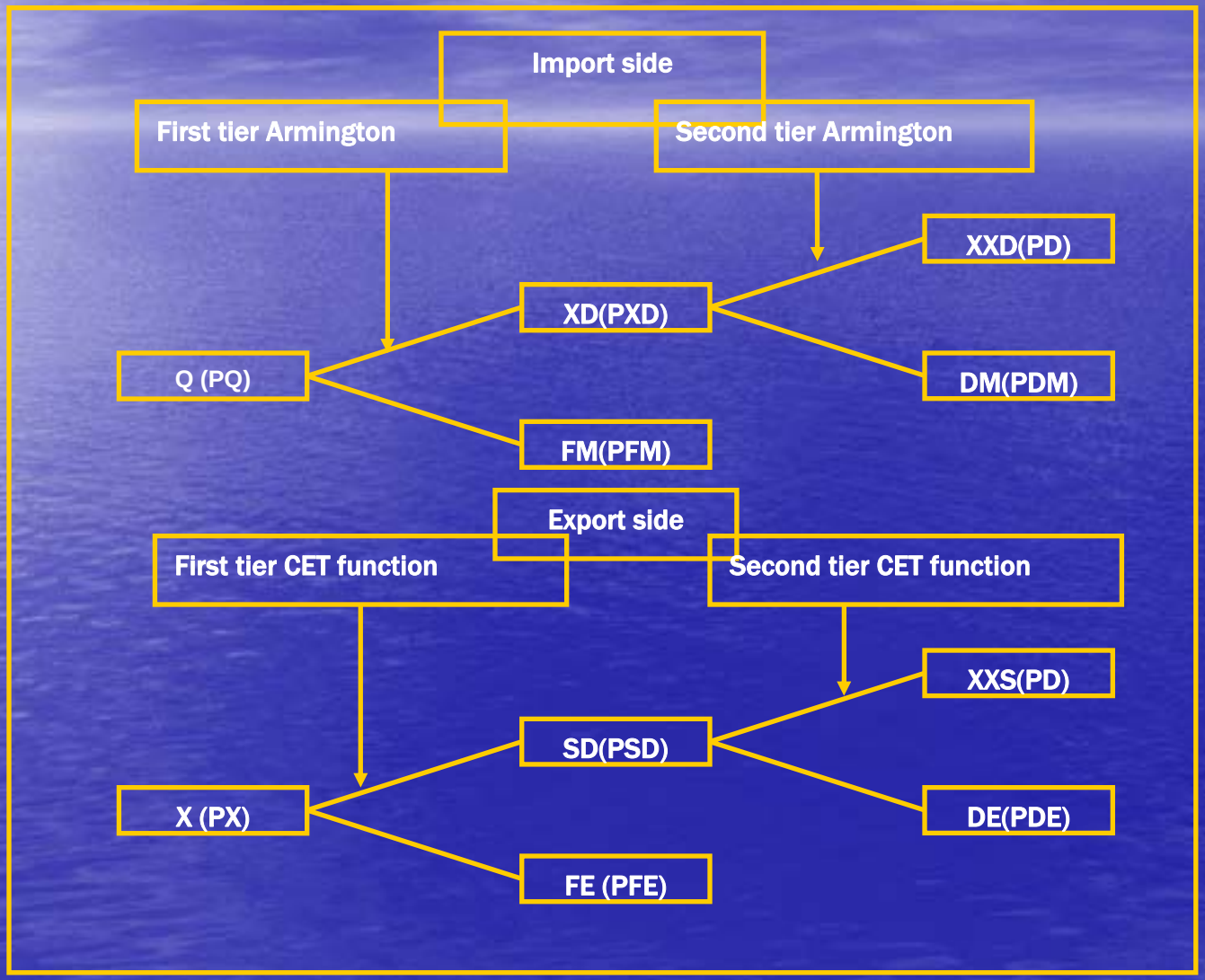
  - Carbon emission by sectors due to the energy consumption
- All other row: unit is a million US Dollar
- A set of prices for all intermediate inputs:

  - rebalancing the hybrid SAM such that the value of output in one sector = the total value of inputs in the sector
- Creation of a new hybrid SAM in value terms

Production System



Trading system



Carbon Tax Design

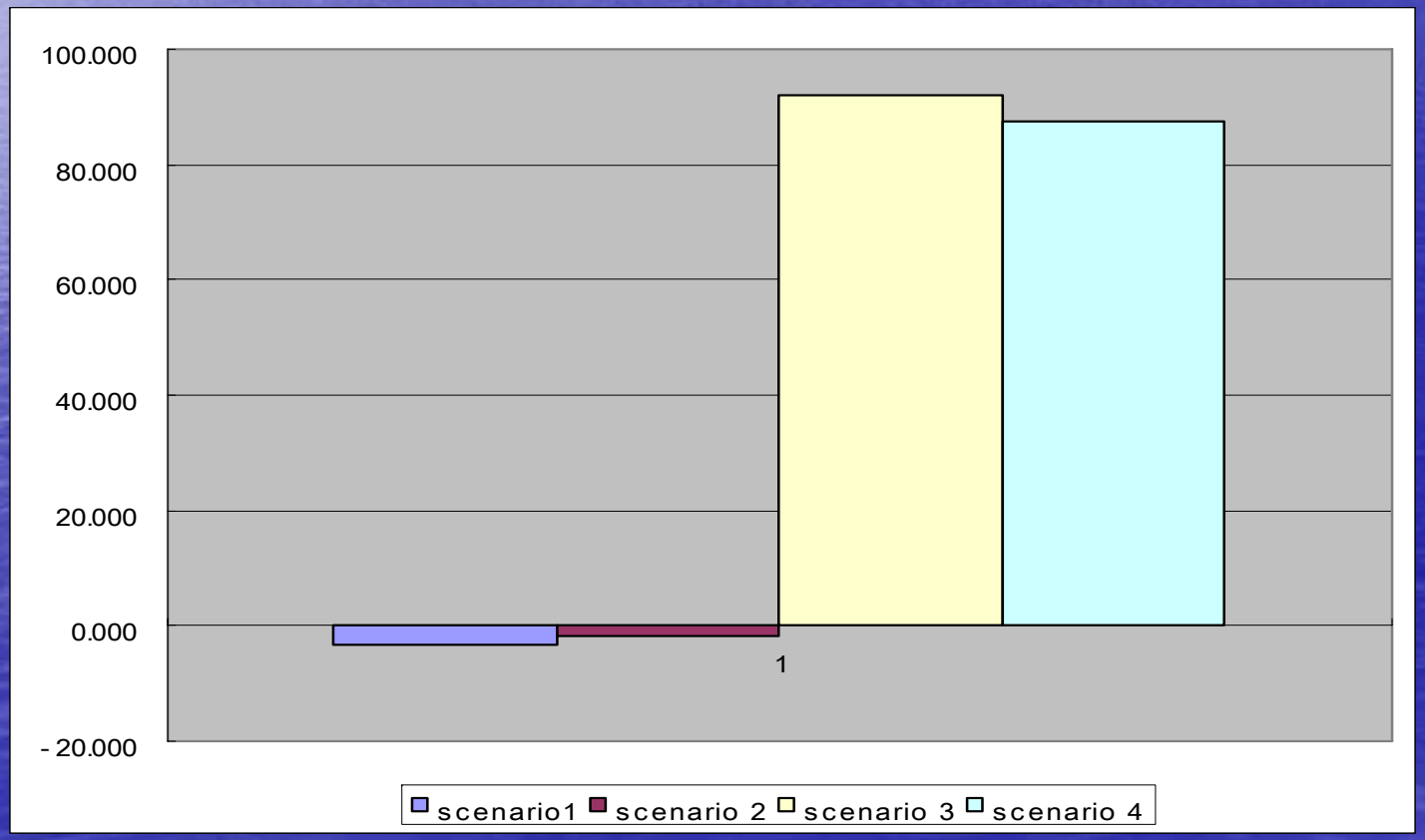
	Equivalent Ad-valorem Fuel Tax			
Carbon Tax ($/Ton)	Coal Tax	Oil Tax	Gas Tax	Electricity Tax
5	0.129	0.015	0.013	0.042
10	0.257	0.030	0.027	0.084
15	0.386	0.045	0.040	0.126

Scenario Design

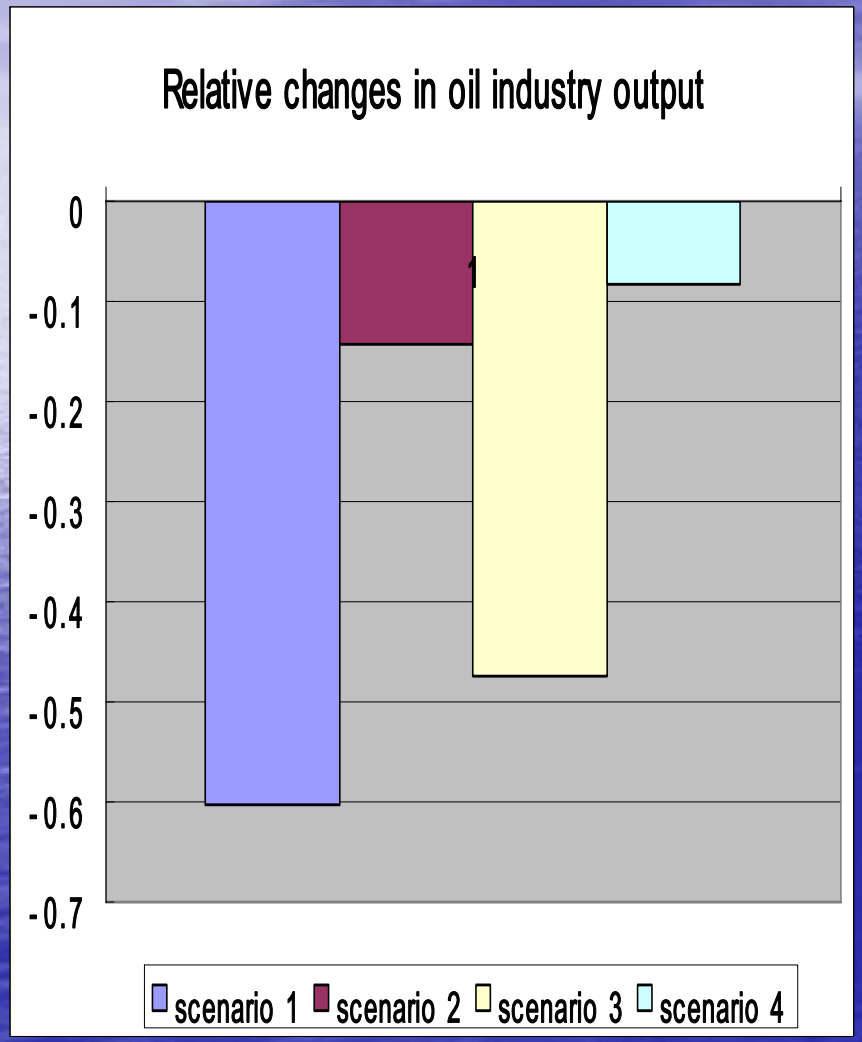
Scenario		Revenue Recycling	Endogenous Labor Migration	Carbon Tax Rate	Wage Elasticity of Migration	Amenity Elasticity of Migration
1	non-DD Policy	No	No	$5/t	0.017	0.025
2		No	Yes	$5/t	0.017	0.025
3	DD Policy	Yes	No	$5/t	0.017	0.025
4		Yes	Yes	$5/t	0.017	0.025
5	Sensitivity for tax rate	No	No	$10/t	0.017	0.025
6		No	No	$15/t	0.017	0.025
7	Sensitivity for elasticity	No	Yes	$5/t	0.01	0.02
8		No	Yes	$5/t	0.02	0.03

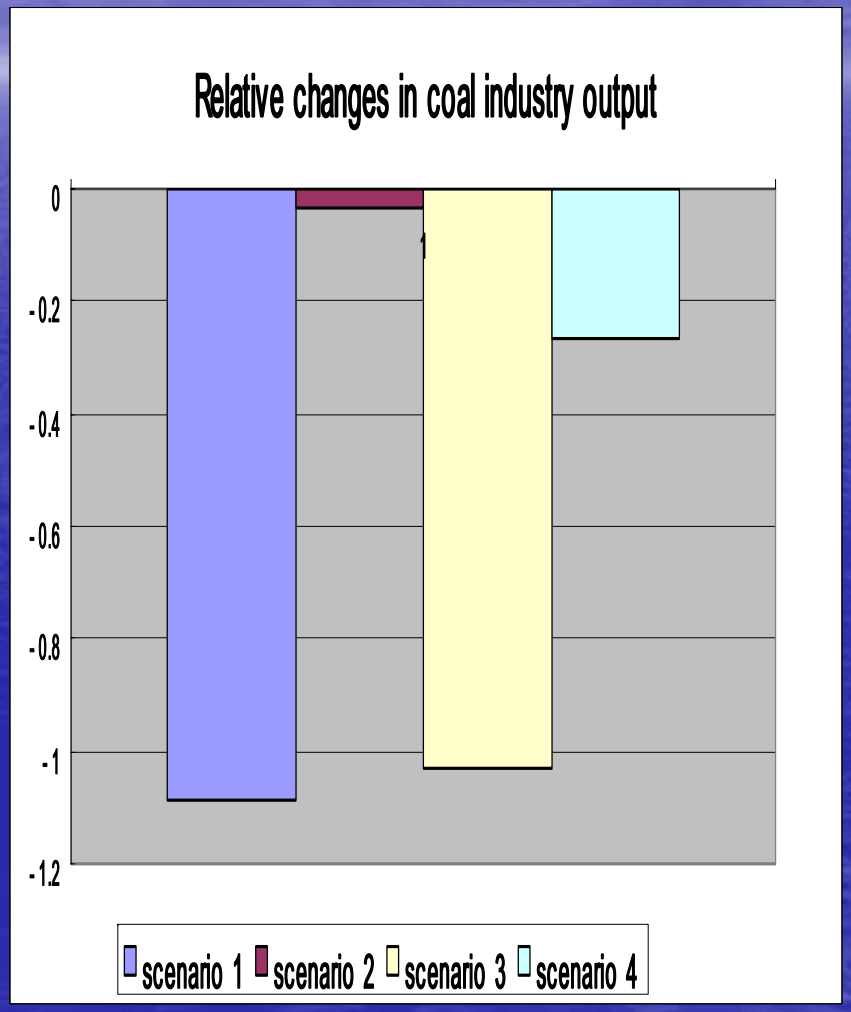
Welfare Changes

- Tax recycling effect > Tax interaction effect –> existence of DD
- Labor in-migration affects welfare negatively



Changes in Energy Mix





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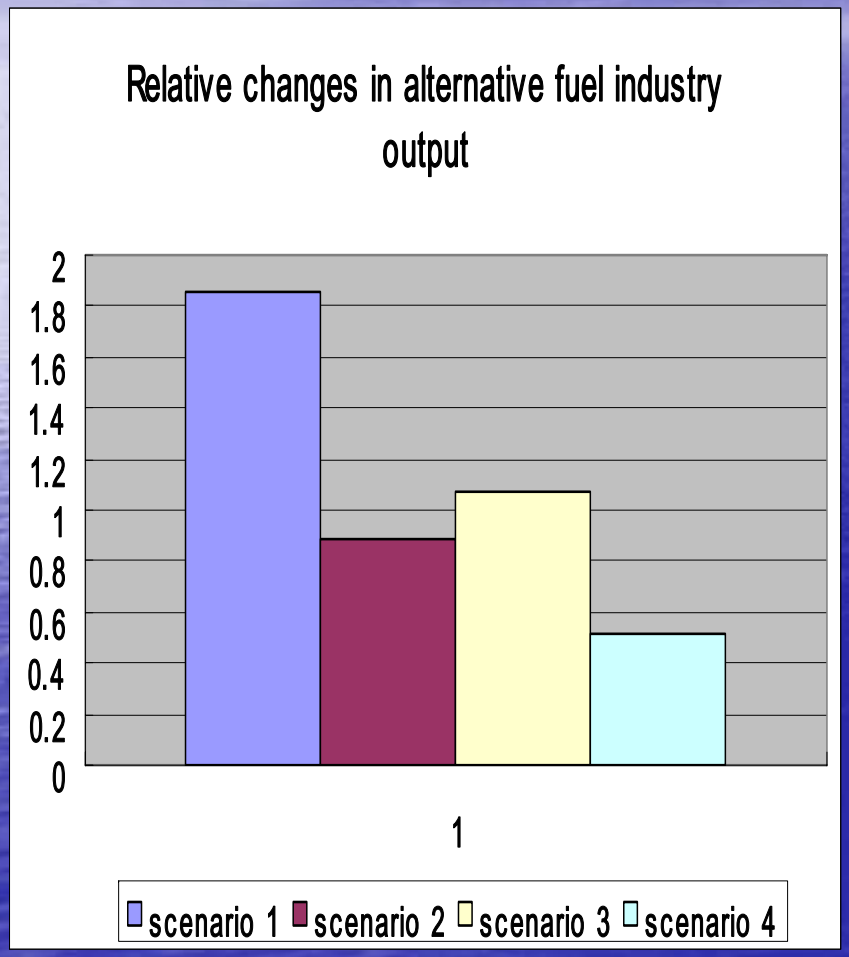
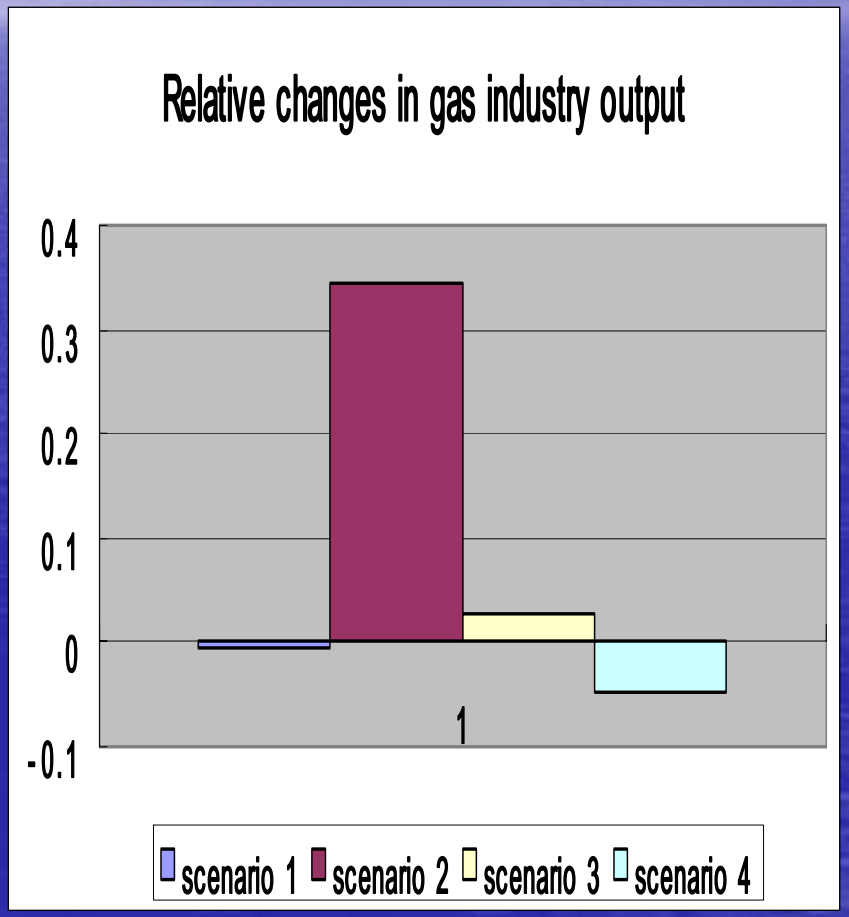
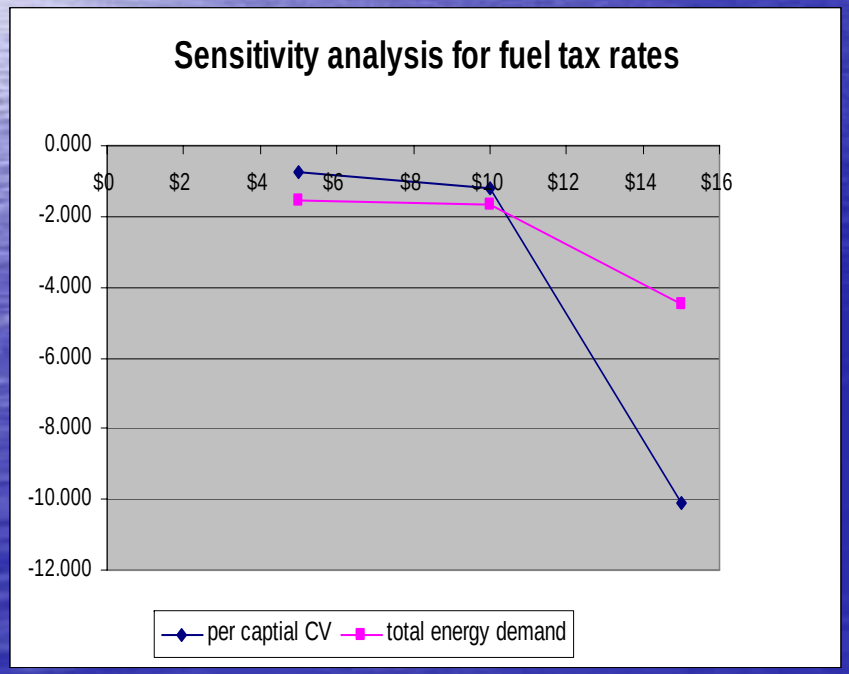
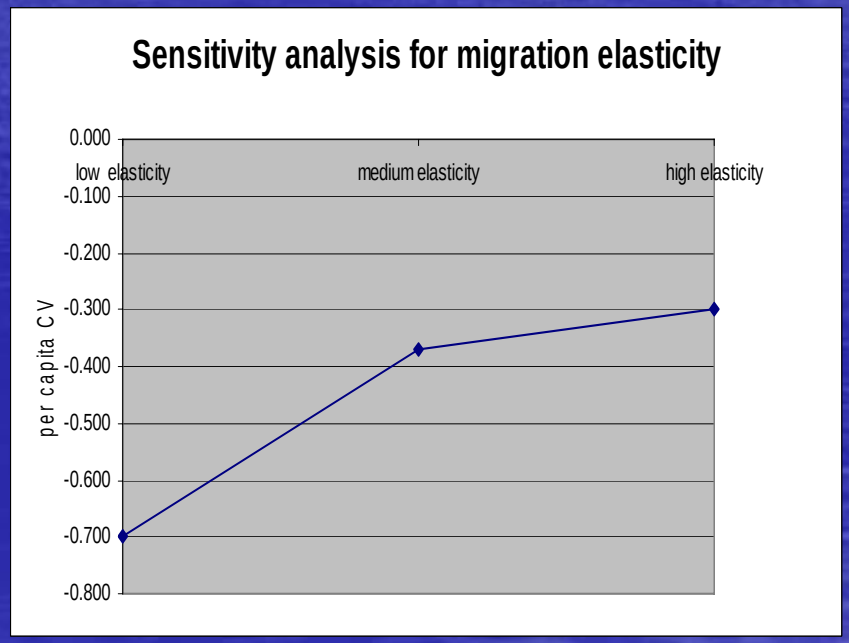




Sensitivity for tax rate and mig. elasticity

- As the carbon tax rate increases, welfare and total energy demand decline in non-linear way
- As the elasticity of migration increases, welfare increases non-linearly





Policy Implication

- Policy instrument with carbon tax and reduction in labor income tax: positive to the welfare of PA (existence of DD)
- With the endogenous labor migration: Complicated effects exist since the effect of inmigration is negative for DD policy, but higher elasticity of migration leads to less welfare loss for non-DD policy
- Energy mix transfers from carbon-based energy to climate friendly-energy (alternative fuels, natural gas)

Issues in the study

- More sophisticated model is required to consider labor / capital mobility in the DD hypothesis analysis: negative effects of in-migration on environment for example
- More works on co-benefit assumption: each fossil fuel has different components in emission gas, so different emission coefficients as well as different emission components are required for each fossil fuel consumption

Future Approach: Stochastic CGE modeling

- From static to dynamic CGE model
- Recursive Model: no expectation for the future

  - No inter-temporal equilibrium block
- Ramsey Model: perfect foresight (certainty)

  - Inter-temporal equilibrium block
- Stochastic Model: uncertainty on the development of new technology

  - Appropriate for realistic world

  - Imperfect information, uncertainty on the future technology (ex: clean and renewable energy)