CBO's Director's Conference
Modeling Climate Change Policy
Allocating Allowances:
Efficiency and Distributional Effects

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Impacts of climate change and climate change policy

- Jobs
  - The mix of businesses, industries and occupations
- Incomes and wealth
  - Employee-shareholders
- Economic welfare
  - Efficiency and equity
- Quality of life
  - Health, habitat and biodiversity

What we've learned: macro impacts

- **More science, more certainty, more ambitious proposals**
  - Previous wave – 20 to 25% reductions in GHG cumulative emissions
  - Current wave – 35 to 60% reductions in GHG cumulative emissions
- **Macroeconomic costs are not large**
  - e.g., impacts 50 years out
    - GDP – 5 to 7% lower, growth slower by 10 to 15 basis points
    - Consumption – 2 to 4% lower, growth slower by 4 to 8 basis points
    - Full Consumption – 0.2 to 0.5% lower, growth slower by 0.4 to 1.0 basis points

What we've learned: meso-micro impacts

- Relatively large impacts on relatively small sectors
  - Coal mining, petroleum refining, electric and gas utilities, primary metals, oil and gas extraction and chemicals
  - The impacts on the coal industry are especially dramatic
- The largest losses are borne by highly visible sectors
  - High technology manufacturing and wholesale and retail trade
- Losses borne by employees and shareholders alike
  - Labor and capital generally experience similar proportional losses
  - There are exceptions – e.g., coal mining, electric utilities and crude oil and gas extraction – where shareholders experience proportionally larger losses than do employees

What we've learned: price/policy-induced technical change

- Overall, ITC reduces the economic costs of climate change policy, especially those incurred by households
- With ITC, the costs in terms of:
  - GDP foregone are 2 to 6% smaller nearer term and 7 to 10% smaller longer term
  - Consumption foregone are 18 to 22% smaller nearer term and over 25% smaller longer term
- Patterns vary by industry
  - Mitigates impacts – electric utilities, crude oil and gas, motor vehicles, chemicals, non-electric machinery
  - Exacerbates impacts – construction, services, trade, primary metals, agriculture
- These results are driven by policy-induced price changes combined with ongoing, but invariant, biases and trends in the outcomes of innovation
  - Product and process innovation here is technology blind

What we've learned: revenue recycling

- At the level of consumption
  - Aggregate capital stock
    - Marginal labor taxes favored over capital taxes favored over lump-sum (average labor) taxes
  - Disaggregated capital stock (corporate, non-corporate and household, short- and long-lived)
    - Personal taxes favored over corporate taxes favored over lump-sum taxes

What we've learned: revenue recycling

- At the level of full consumption
  - Aggregate capital stock
    - Capital taxes favored over lump-sum (average labor) taxes favored over marginal labor taxes
  - Disaggregated capital stock
    - Corporate taxes favored over personal taxes favored over purely lump-sum taxes

What we've learned: revenue recycling

- Leisure matters!!
  - Its inclusion in the measure of economic welfare alters the comparative ranking of recycling alternatives
  - The magnitude of its price-responsiveness influences both the sign and size of the recycling effect
    - In our analyses, the "double dividend" follows from leisure demand and, hence, labor supply being more price-sensitive

Household considerations

- All incomes accrue to the household-employee-shareholder
- Household choices govern general equilibrium outcomes
- Welfare optimizing behavior over
  - Present versus future *full* consumption, that is, inclusive of leisure
  - Leisure demand versus labor supply
  - Consumption versus saving
  - Consumption of goods and services
- IGEM's households
  - A "representative" consumer at the level of present versus future and consumption versus leisure tradeoffs
  - *Rich demographic detail with exact aggregation at the level of consumer goods and services*
    - Infinitely lived
    - 12 expenditure categories, 7 family sizes, 6 ages-of-head groupings, 4 regions, 2 locales, 2 sexes-of-head and 2 races-of-head for a total of 16,128 possible combinations
    - Demographics affect all expenditure decisions but not relative price responsiveness
    - No occupational detail
    - No industry of occupation or ownership

What we've learned: societal distributional impacts

- Individual welfare changes are aggregated and decomposed into efficiency and equity effects
  - Societal views of equality – extremely egalitarian versus extremely utilitarian
- Climate change policy almost unambiguously worsens equality
- This worsening of equality is independent of the recycling mechanism
  - Equity losses dominate the small efficiency losses or gains associated with capital or corporate taxes
  - Equity losses also dominate the relatively larger efficiency gains associated with marginal labor or personal taxes
  - Equity losses reinforce the efficiency losses associated with lump sum redistributions
    - Only in the rarest of cases under the extremely egalitarian view is the equality outcome seen to be welfare improving

What we've learned:
individual distributional impacts

- Climate change policy is regressive to lifetime expenditure
  - Depending on the recycling mechanism, lower expenditure households experience greater proportional losses or smaller proportional gains than do higher expenditure households
- Policy is more costly or less beneficial to:
  - Farm versus non-farm households
  - Male-headed versus female-headed households
  - Larger-sized versus smaller-sized households
  - Generally, households with heads in their peak-earning years
  - Households in the Midwest and South versus the Northeast and West
  - Households headed by whites versus households headed by non-whites, the exception being under broader capital tax recycling

What we've learned: benefit considerations

- Benefits considered – agriculture, forestry, fisheries, space conditioning, coastal protection, hurricane damages, air quality protection
- Climate change harmful or beneficial to US market economy
  - Comparable magnitudes over the intermediate term but all costs become increasingly larger and any benefits are only temporary (due largely to agriculture)
- When harmful
  - Climate change is regressive – lower expenditure households lose proportionally more than higher expenditure households
  - Costs are proportionally larger for farm, male-headed, larger-sized, peak-earning-year, and non-white-headed households
  - Costs are also proportionally larger for households in the Northeast, the South, the Midwest and the West, respectively
- When beneficial, the climate change is progressive and "costs" become "gains"
- *Timing considerations aside, the equity benefits from damages avoided are directionally opposed to the equity costs of mitigation*

Allocation Schemes

- Policies as written
  - A cap-and-trade system involving both free private distribution and public auction
  - Additional market-based offset opportunities,
    - e.g., non-covered, excluded or exempted sectors and activities, sequestration, international permit trading
  - A complex blend of banking and borrowing covenants, compensatory actions, incentives, transfers, technology assistance and directly funded research
    - Some proactive and defined, occurring at the time of enactment
    - Others reactive and undefined, occurring at the time of implementation or beyond as needs arise
    - Many involving Executive and Legislative Branch coordination

Allocation Schemes

- Policies as modeled
  - Annual permits with no grandfathering or early-action credits
  - Analyses-to-date are all or nothing experiments
    - *Either* all permits are freely distributed with lump-sum payments of permit revenues to employee-shareholders and lump-sum increases in taxes to preserve deficit neutrality (identical to all publicly auctioned with recycling through cuts in average labor tax rates)
    - *Or* all permits are publicly auctioned with deficit neutrality accomplished through revenue recycling (e.g., cuts in average or marginal labor tax rates, overall capital or corporate tax rates, non-energy sales tax rates, etc.)
    - Under lump-sum distributions, *ex post* model outcomes are independent of *ex ante* allocations
  - Allocation analyses involve post-simulation side calculations determining net buyers and sellers. There is nothing to inform within-sector trading

Households revisited: limitations

- Full consumption – the "representative" consumer with no demographic detail
  - No overlapping generations
  - No identifiable occupations or industries of employment or ownership
  - No way to represent distributional tax or allocation policies
  - No distributional detail at the level of full consumption, i.e., consumption of goods, services *and* leisure
- Consumption – representative consumers with demographic detail
  - Policy consequences are national outcomes with each household proportionally affected the same
  - Demographics affect expenditure shares, consumption and welfare – both individual and aggregate – but not relative price sensitivities

Conclusions

- No single methodology provides all of the answers

- Existing models evolve to address an ever-broadening and more complex array of policy features, issues and concerns

- New analytical frameworks appear to fill the gaps in our understanding and capabilities

- Our knowledge base is:
  - Rich and informed
  - Incomplete
  - The former helps justify current action while the latter demands that such actions be multi-faceted, flexible and adaptable

Appendix

Supporting Graphs and Tables

- A national model reflecting market-clearing patterns of demand and supply over time
- Perfect foresight with capital and labor mobility
- Empirically-based, variable substitution possibilities
  - Covering 35 producing sectors, 35 commodities, 5 final demand categories (consumption, investment, government, exports, imports), 3 primary inputs (capital, labor, non-competing imports)
  - At all levels of production and final demand
- Price/policy-induced technical change (ITC)
  - Continuing characteristics and trends
  - Not technology specific or product- or process-related
- Tax structure
  - Detailed enough to consider broad recycling alternatives through adjustments in average marginal rates
- Dominant influence of household sector in model outcomes

Output and Price Changes, 2030
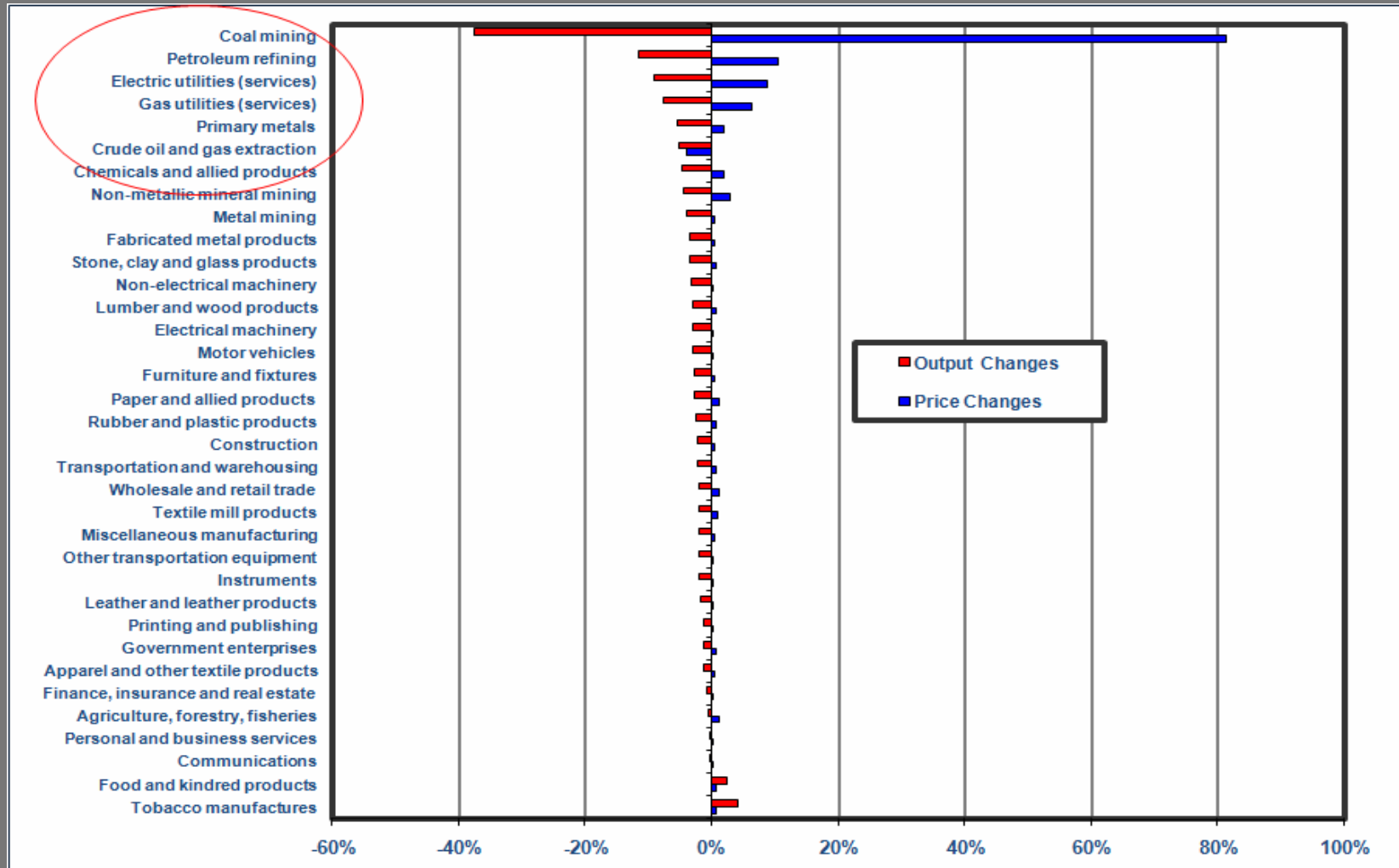
Contributions to Total Output and Total Output Loss, 2030

Output - $(2005) 41.0 Trillion   Loss - $(2005) 0.7 Trillion
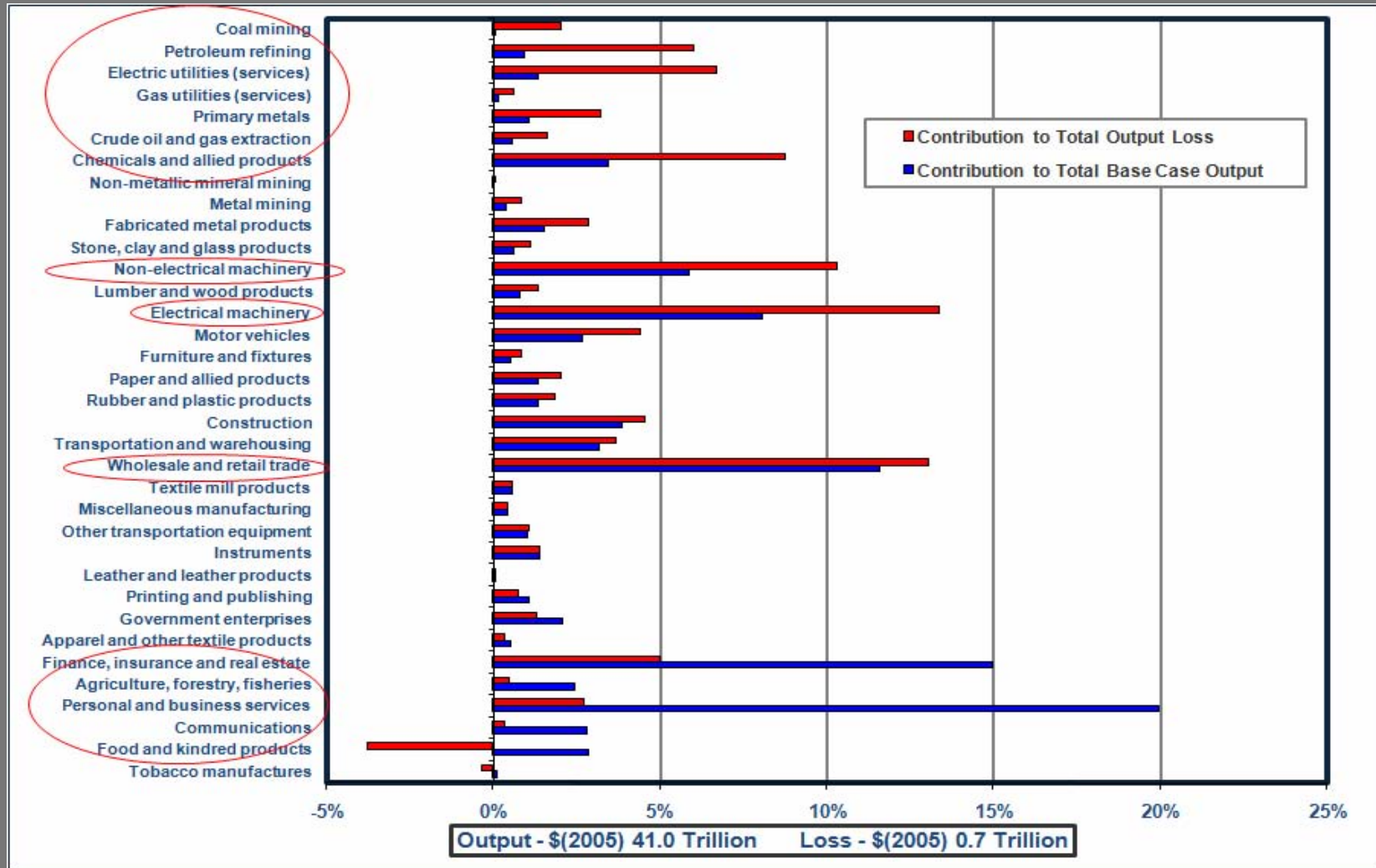
Capital and Labor Income Changes, 2030
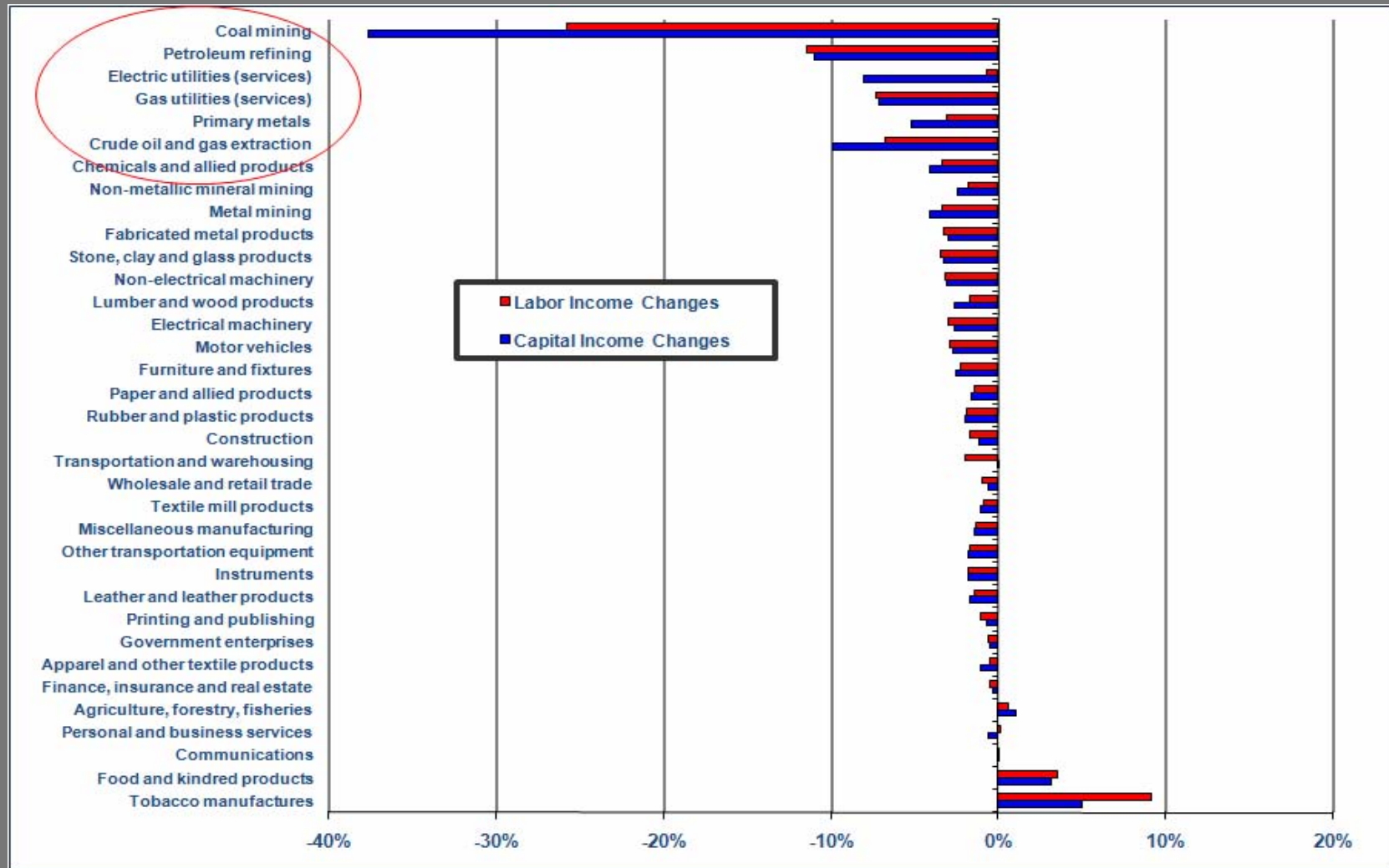
Price-Induced Technical Change:
Contributions to Annual Effect, 2020
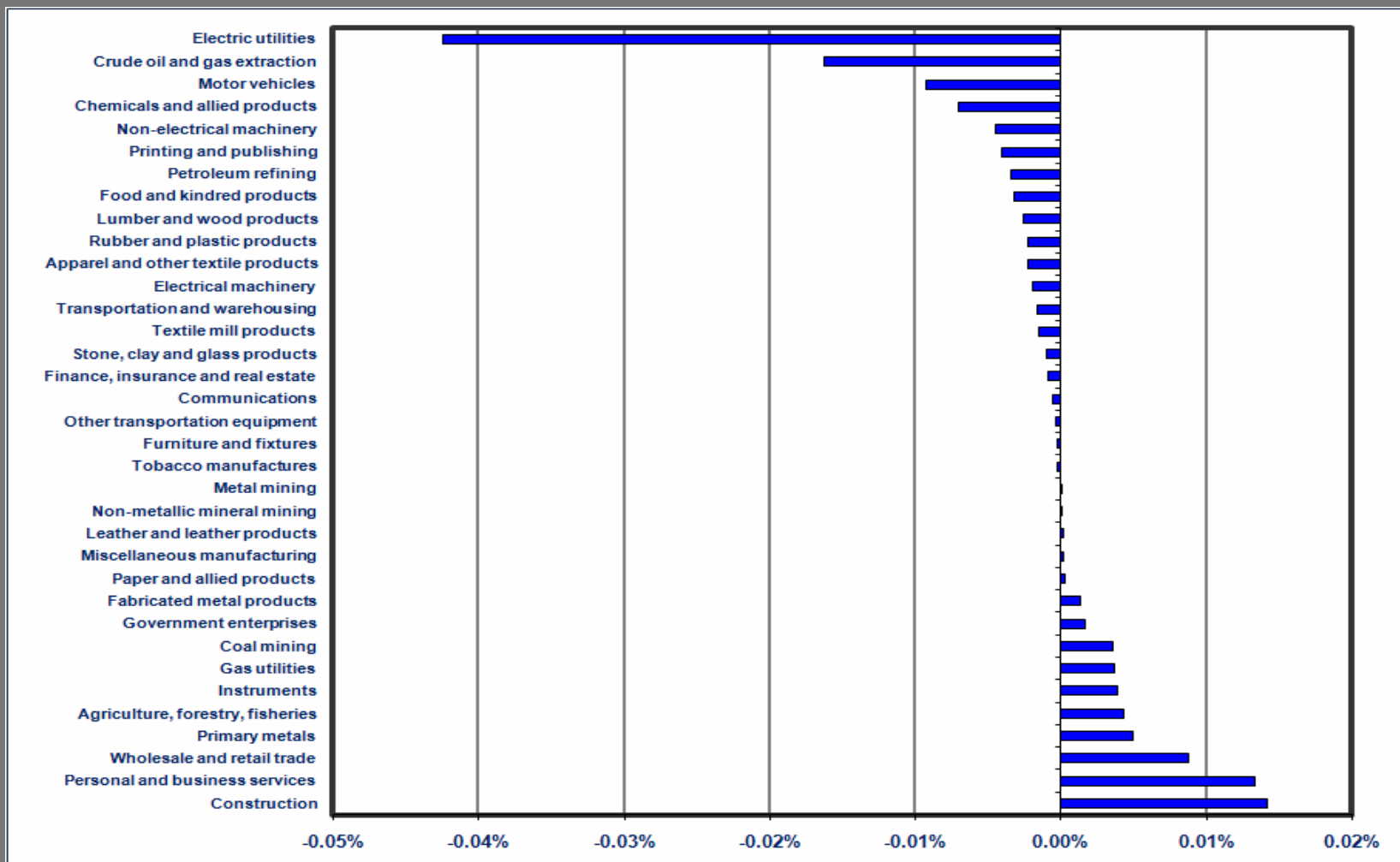
Welfare Effects

Recycling Option	Consumption Goods and Services	Full Consumption Goods, Services and Leisure
Social Cost Energy Pricing and Revenue Recycling		
Capital	-0.14%	0.09%
Average Labor	-4.19%	-0.67%
Marginal Labor	0.22%	-0.91%
Carbon Mitigation, Permit Trading and Revenue Recycling		
Corporate	-0.21%	-0.04%
Average Labor	-0.75%	-0.10%
Personal	0.67%	-0.07%

Percentages of lifetime expenditure for the "representative" consumer.

Average Labor and Lump Sum recycling are equivalent.

Welfare Effects, Revenue Recycling and the Consumption-Leisure Tradeoff
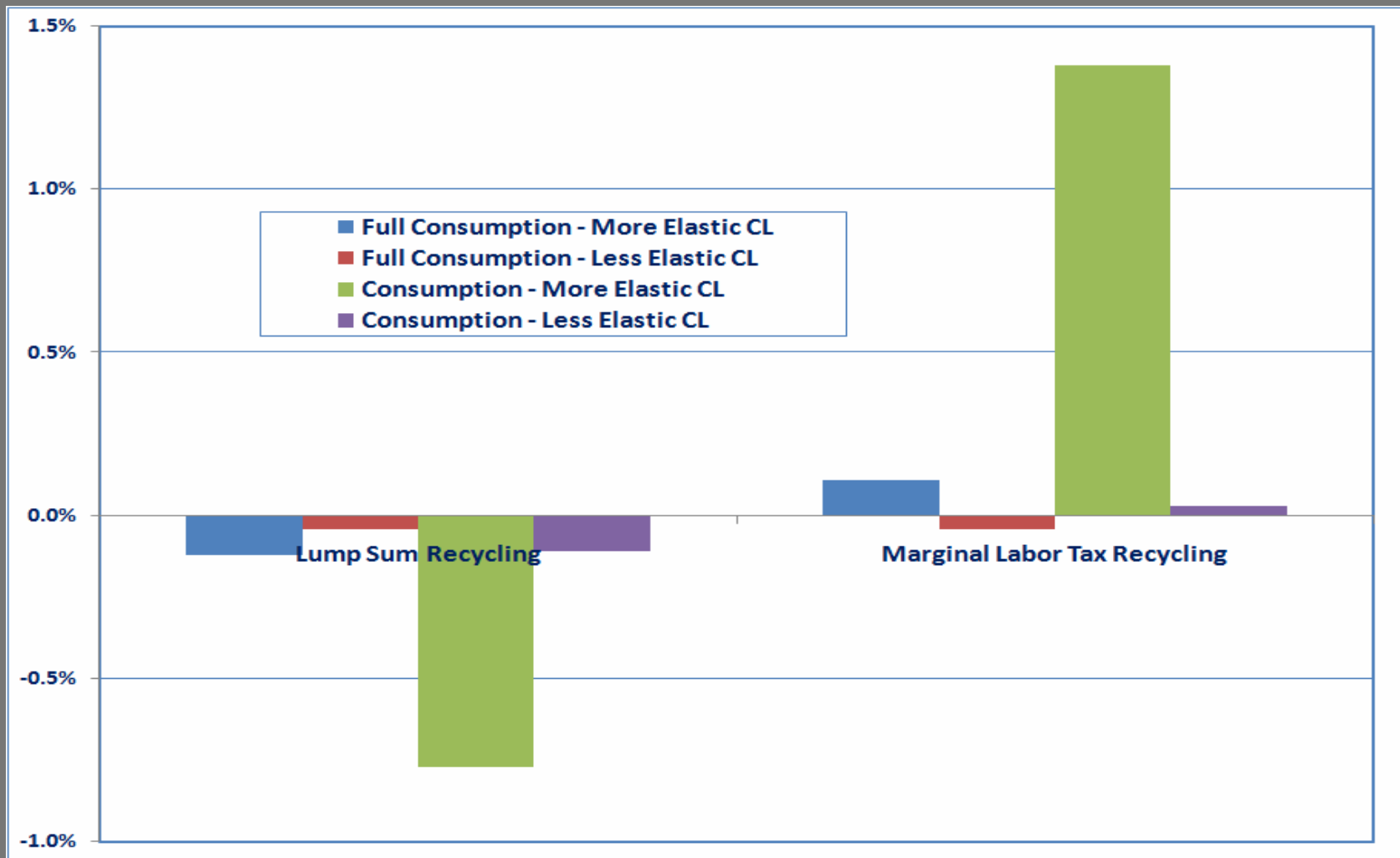
Welfare Effects

Recycling Option	Societal Effects			Individual Effects	
	Efficiency Only	Combined Efficiency & Equity			
	Maximum Efficient Welfare	Aversion to Inequality: Egalitarian View	Aversion to Inequality: Utilitarian View	Maximum Individual Welfare Change	Minimum Individual Welfare Change
Social Cost Energy Pricing and Revenue Recycling					
Capital	-0.50%	-1.21%	-1.46%	1.09%	-4.08%
Average Labor	-2.96%	-2.64%	-3.50%	-2.89%	-6.08%
Marginal Labor	1.56%	-0.22%	-0.14%	1.81%	-1.59%
Carbon Mitigation, Permit Trading and Revenue Recycling					
Corporate	0.02%	-0.23%	-0.27%	0.06%	-0.66%
Average Labor	-0.53%	-0.59%	-0.74%	-0.53%	-1.25%
Personal	1.01%	0.40%	0.55%	1.09%	0.35%
Percentages of lifetime expenditure with demographic weightings.					
Average Labor and Lump Sum recycling are equivalent.					

Distributional Impacts of Social Cost Energy Pricing and Revenue Recycling

Welfare changes measured in terms of lifetime expenditure on goods and services (i.e., consumption)
Ranked from the least severe (or most beneficial) to the most severe (or least beneficial)

Recycling Option	Path of Lifetime Expenditure				Locale			Sex of Head	
	Least		Most		Least	Most		Least	Most
Capital	High	Medium	Low		NonFarm	Farm		Female	Male
Average Labor	High	Medium	Low		NonFarm	Farm		Female	Male
Marginal Labor	High	Medium	Low		NonFarm	Farm		Female	Male

Recycling Option	Family Size						
	Least						Most
Capital	1	2	3	4	5	6	7+
Average Labor	1	2	3	4	6	5	7+
Marginal Labor	1	2	3	4	6	5	7+

Recycling Option	Age of Head					
	Least					Most
Capital	16-24	25-34	35-44	65+	45-54	55-64
Average Labor	65+	35-44	16-24	25-34	45-54	55-64
Marginal Labor	65+	35-44	25-34	16-24	45-54	55-64

Recycling Option	Region				Race of Head	
	Least			Most	Least	Most
Capital	West	NE	Midwest	South	White	NonWhite
Average Labor	West	NE	South	Midwest	NonWhite	White
Marginal Labor	West	NE	South	Midwest	NonWhite	White

Reference Household: *Family of four, living in a nonfarm setting in the Northeast, headed by a white male aged 35-44.*

Path of Lifetime Expenditure: *Medium is the average for all households. Low is half the average. High is twice the average.*

Average Labor and Lump Sum recycling are equivalent.

Distributional Impacts of Carbon Mitigation, Permit Trading and Revenue Recycling

Welfare changes measured in terms of lifetime expenditure on goods and services (i.e., consumption)
Ranked from the least severe (or most beneficial) to the most severe (or least beneficial)

Recycling Option	Path of Lifetime Expenditure				Locale				Sex of Head	
	Least		Most		Least	Most			Least	Most
Corporate	High	Medium	Low		NonFarm	Farm			Female	Male
Average Labor	High	Medium	Low		NonFarm	Farm			Female	Male
Personal	High	Medium	Low		NonFarm	Farm			Female	Male

Recycling Option	Family Size						
	Least						Most
Corporate	1	2	3	4	6	5	7+
Average Labor	1	2	3	4	6	5	7+
Personal	1	2	4	6	3	7+	5

Recycling Option	Age of Head					
	Least					Most
Corporate	65+	35-44	16-24	25-34	45-54	55-64
Average Labor	16-24	35-44	65+	25-34	45-54	55-64
Personal	65+	35-44	25-34	45-54	55-64	16-24

Recycling Option	Region				Race of Head	
	Least			Most	Least	Most
Corporate	West	NE	South	Midwest	NonWhite	White
Average Labor	West	NE	Midwest	South	NonWhite	White
Personal	West	NE	South	Midwest	NonWhite	White

Reference Household: *Family of four, living in a nonfarm setting in the Northeast, headed by a white male aged 35-44.*

Path of Lifetime Expenditure: *Medium is the average for all households. Low is half the average. High is twice the average.*

Average Labor and Lump Sum recycling are equivalent.

Distributional Impacts of Climate Change

Welfare changes measured in terms of lifetime expenditure on goods and services (i.e., consumption)
Ranked from the least severe (or most beneficial) to the most severe (or least beneficial)

Climate Change	Path of Lifetime Expenditure		
	Least		Most
Beneficial	Low	Medium	High
Harmful	High	Medium	Low

Climate Change	Locale	
	Least	Most
Beneficial	No Difference	
Harmful	NonFarm	Farm

Climate Change	Sex of Head	
	Least	Most
Beneficial	Male	Female
Harmful	Female	Male

Climate Change	Family Size						
	Least						Most
Beneficial	7+	6	5	4	3	2	1
Harmful	1	2	3	4	6	5	7+

Climate Change	Age of Head					
	Least					Most
Beneficial	45-54	55-64	35-44	65+	25-34	16-24
Harmful	16-24	25-34	65+	35-44	55-64	45-54

Climate Change	Region			
	Least			Most
Beneficial	NE	South	Midwest	West
Harmful	West	Midwest	South	NE

Climate Change	Race of Head	
	Least	Most
Beneficial	NonWhite	White
Harmful	White	NonWhite

Reference Household: *Family of four, living in a nonfarm setting in the Northeast, headed by a white male aged 35-44.*
Path of Lifetime Expenditure: *Medium is the average for all households. Low is half the average. High is twice the average.*