Carbon Taxes, U.S. Fiscal Policy and Social Welfare

By

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Association of Environmental and Resource Economists (AERE)

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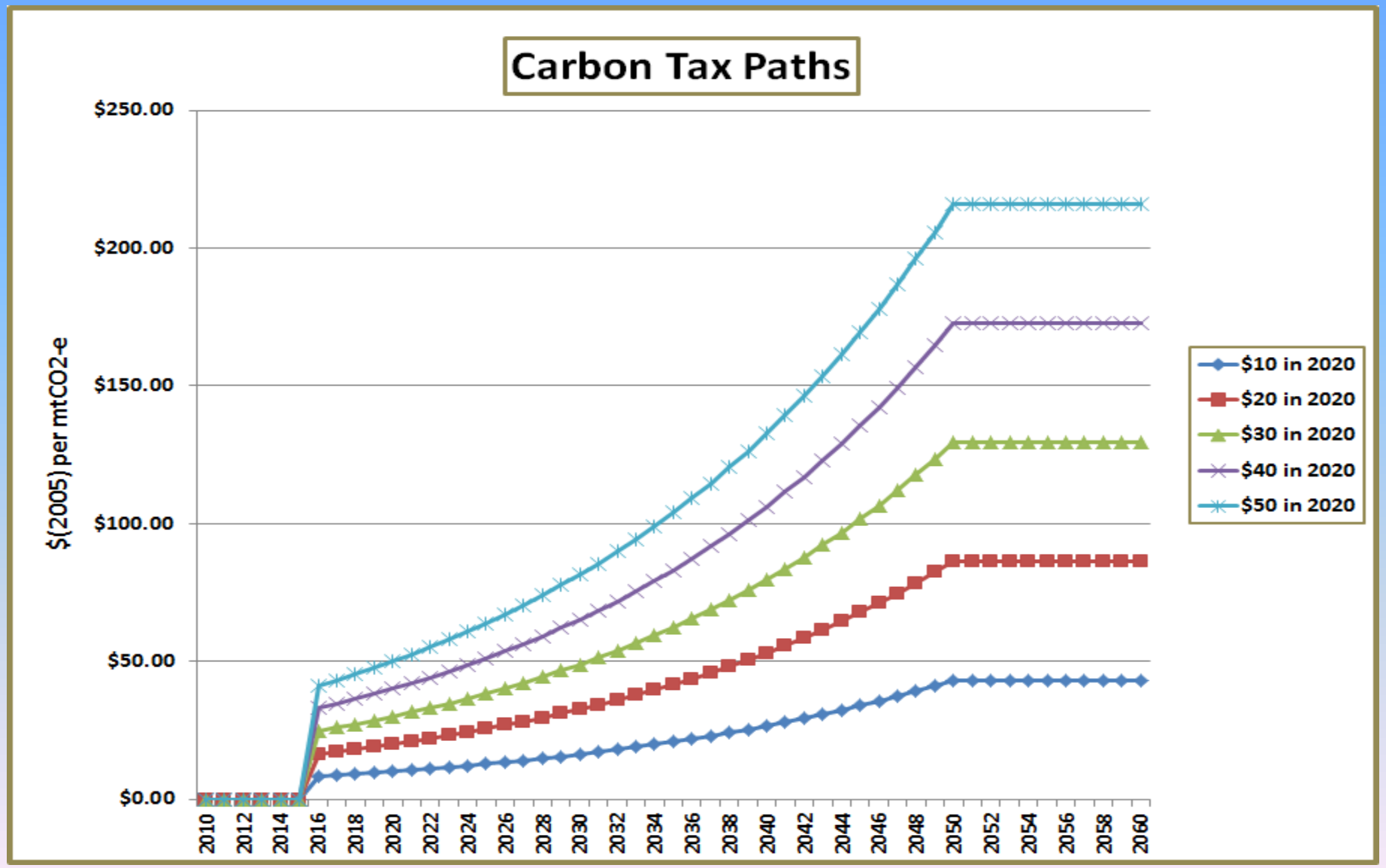
What we did

- Examined the welfare implications
- Of five (5) carbon tax scenarios
  - $10, $20, $30, $40 and $50 in 2020 discounted to 2016 and compounded to 2050 at 5%
- Under seven (7) fiscal treatments
  - Capital tax reduction, capital and labor tax reduction, labor tax reduction, increased government purchasing, deficit reduction, debt reduction and lump-sum redistribution
- Using IGEM, the Intertemporal General Equilibrium Model of Dale Jorgenson Associates (DJA)
  - *http://www.igem.insightworks.com/*
  - *http://www.economics.harvard.edu/faculty/jorgenson*

The Carbon Tax Scenarios



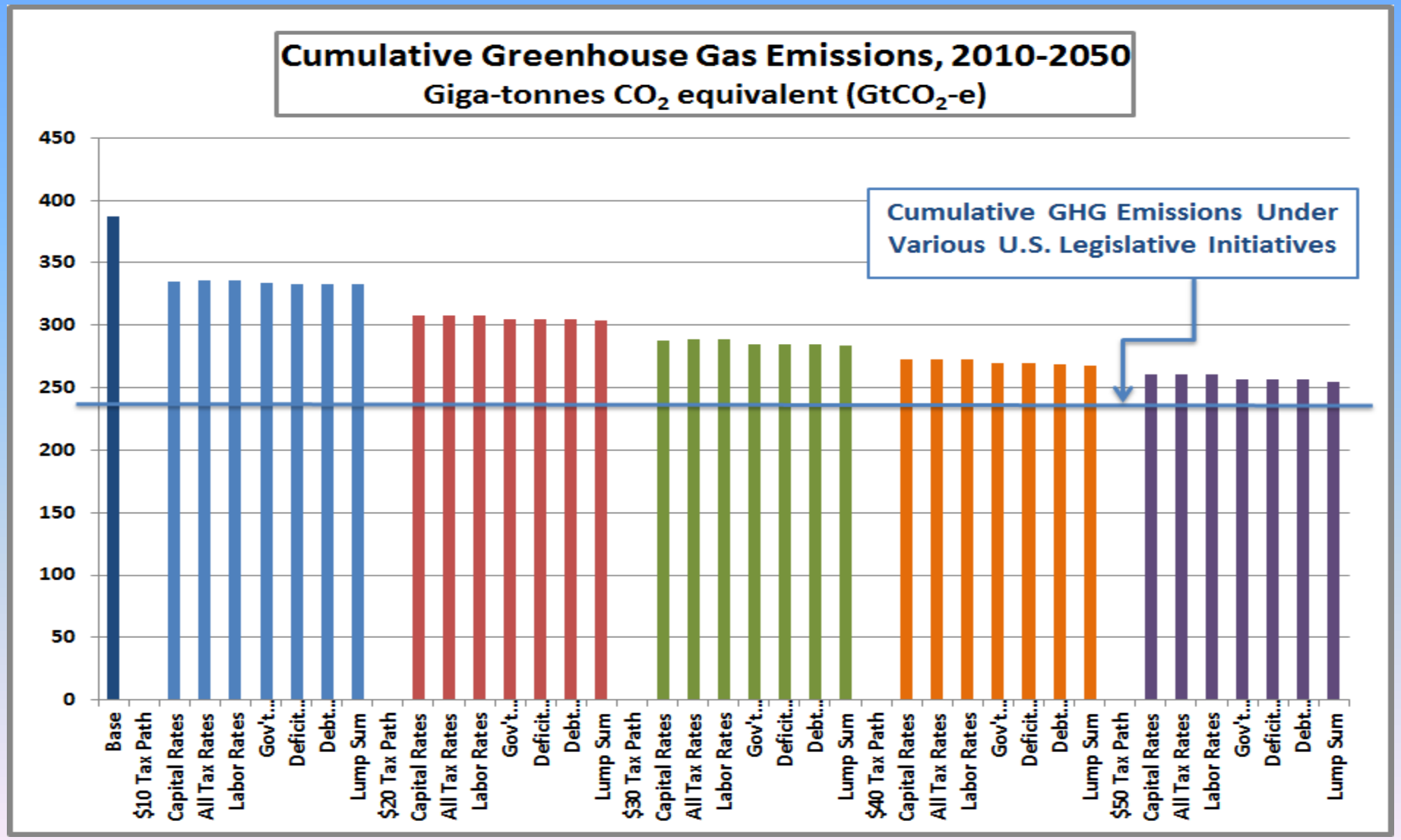
Intertemporal general equilibrium model, IGEM

- Econometrically estimated CGE model of U.S. structure and growth
  - Confidence intervals derived from variance-covariance estimates through delta method
  - Well suited to applications ranging over 30-50 year time horizons
- Unified accounting framework consistent with the *National Income and Product Accounts* and the *Consumer Expenditure Survey*
- Dynamics driven by population trends, capital accumulation, productivity growth in each industry
- Household decisions characterized by perfect foresight
- Supply and demand balances reflect mobility in all product and factor markets
- 35 producing industries generating 35 commodities (5 energy) with 5 final demand sectors (C, I, G, X, and M)
- Producers and consumers substitute among capital, labor and all 35 commodity inputs (models are hierarchical and non-CES)
- Aggregate consumption demand derived through exact aggregation over individual household demands for 244 household types. Each household utility function includes both goods, services and leisure

What we learned

- Robust but ever harder-to-achieve emissions abatement
  - Robust across fiscal treatments with rising marginal abatement costs both within and across carbon tax scenarios
- "Grand bargain" like tax receipts
- Fiscal ranking depends on how performance is measured
- From a welfare perspective
  - Dollar benefits or costs may appear large but the percentage changes are small
  - Capital tax reductions are welfare superior despite their qualified regressivity
  - Labor tax reductions are welfare inferior despite their unqualified progressivity
  - Lump sum redistribution is not necessarily least favorable at either the household or societal levels
- Statistically significant welfare results

Robust but ever harder-to-achieve emissions abatement



“Grand bargain” like tax receipts

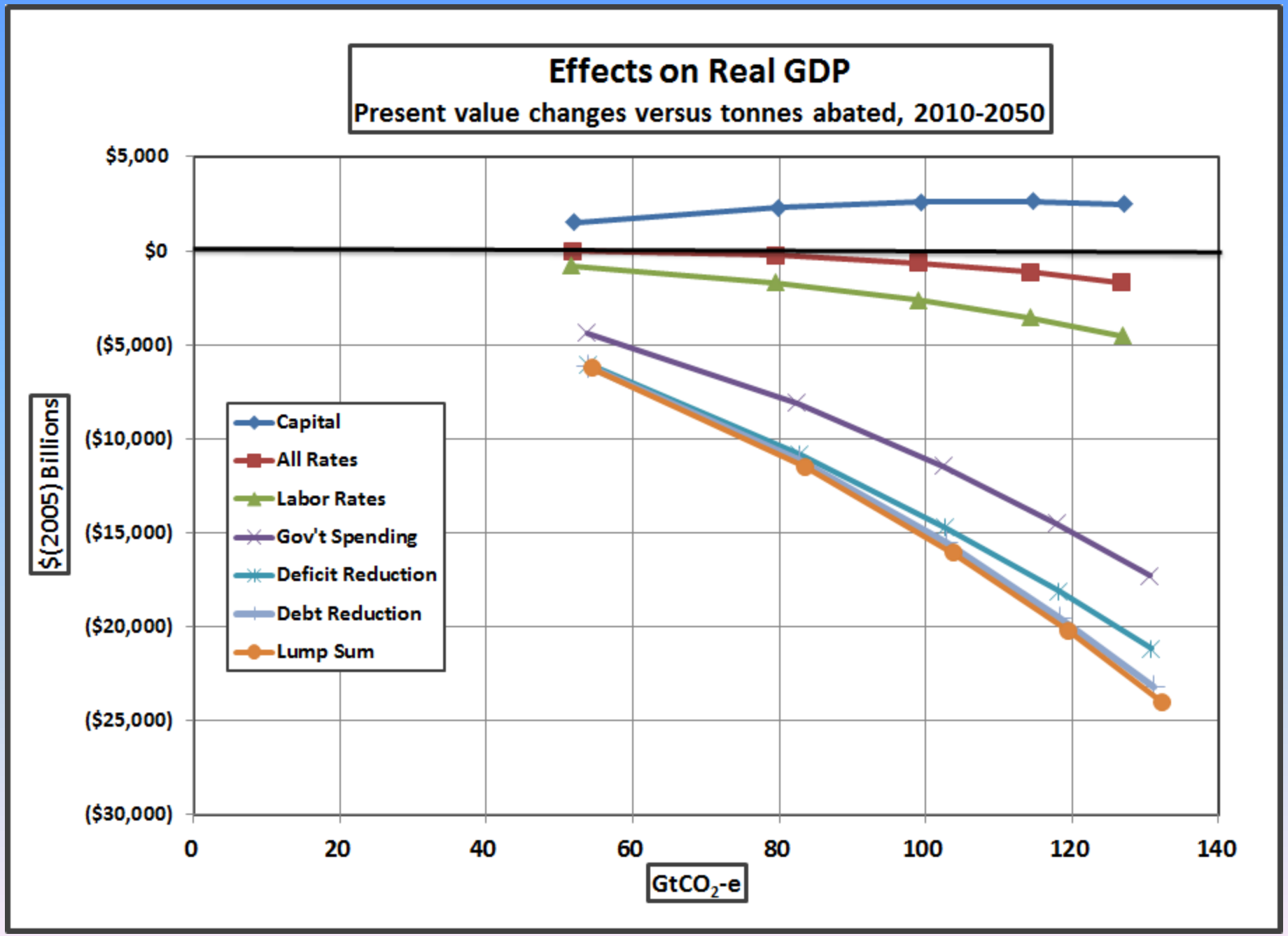
	2016-2025		2026-2050	
	Average	Standard Deviation	Average	Standard Deviation
$10 Tax Path	$890	$3	$6,734	$32
$20 Tax Path	$1,635	$9	$12,019	$91
$30 Tax Path	$2,297	$16	$16,529	$157
$40 Tax Path	$2,899	$24	$20,495	$223
$50 Tax Path	$3,455	$34	$24,044	$286

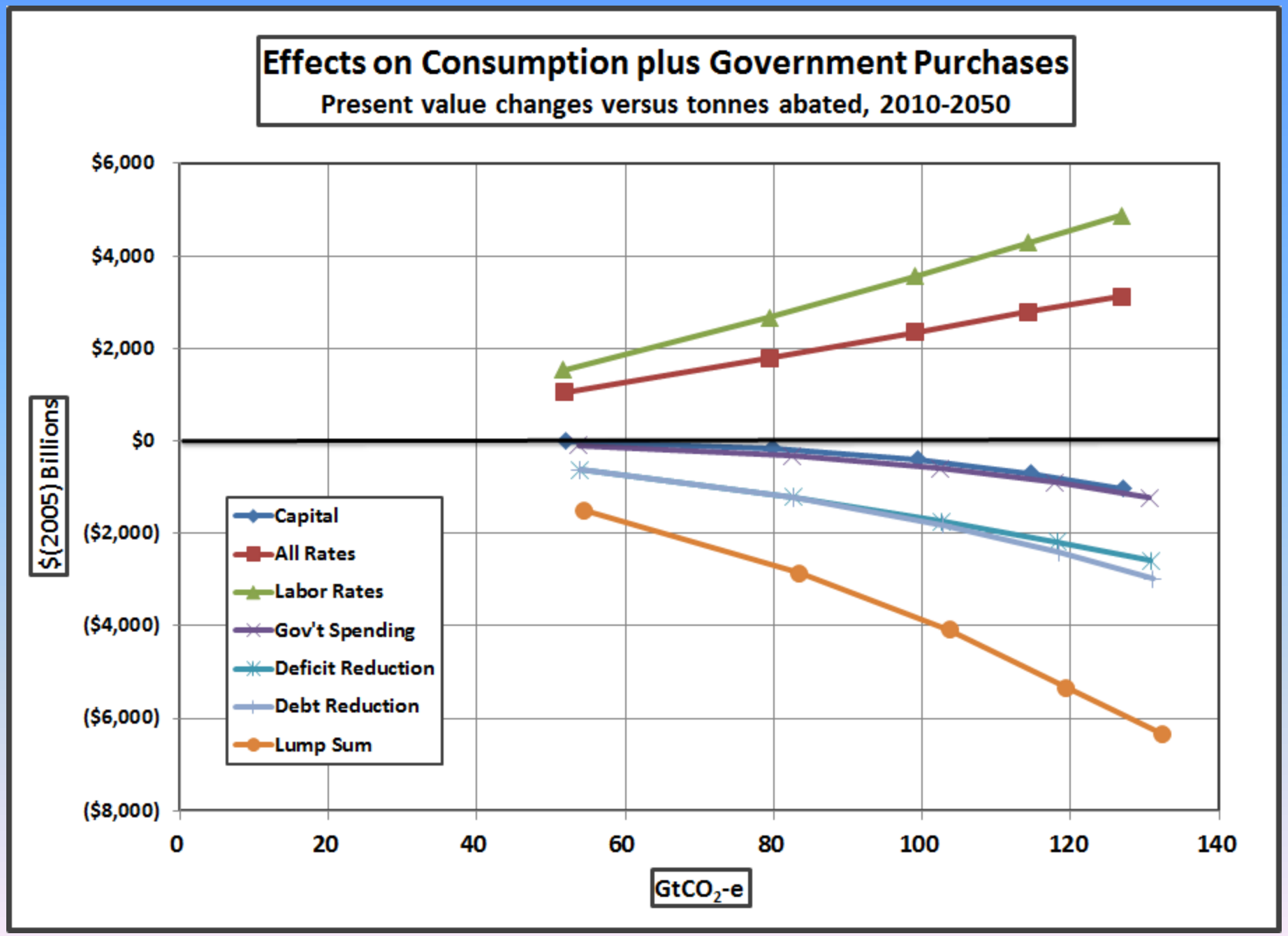
Total tax receipts in $(2013) billions averaged across the seven fiscal treatments

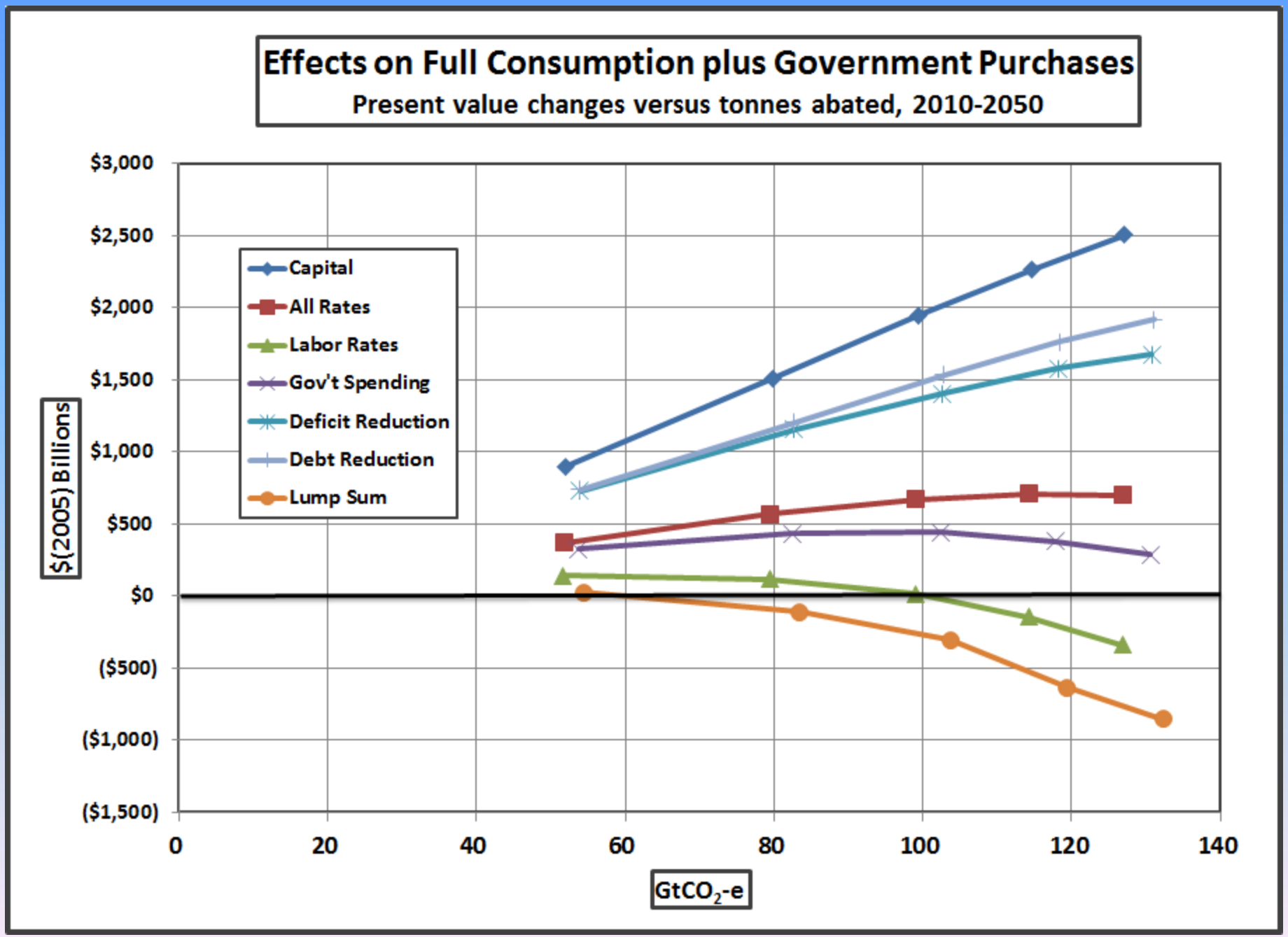
Fiscal ranking depends on how performance is measured

From most to least preferred
in $(2005) billions versus $GtCO_2$-e

- **Real GDP**
  - **capital, combined capital and labor, labor, government, deficit, debt and lump sum**
- **Real Consumption + Government**
  - **labor, combined capital and labor, capital, government, deficit, debt and lump sum**
- **Real Full Consumption + Government**
  - **Capital, debt, deficit, combined capital and labor, government, labor and lump sum**
  - **Leisure-inclusive and the preferred choice**


Effects on Real GDP
Present value changes versus tonnes abated, 2010-2050
$5,000
$0
($5,000)
($10,000)
($15,000)
($20,000)
($25,000)
($30,000)
$(2005) Billions
0
20
40
60
80
100
120
140
GtCO2-e
Capital
All Rates
Labor Rates
Gov't Spending
Deficit Reduction
Debt Reduction
Lump Sum


Effects on Consumption plus Government Purchases
Present value changes versus tonnes abated, 2010-2050
$6,000
$4,000
$2,000
$0
($2,000)
($4,000)
($6,000)
($8,000)
$(2005) Billions
0
20
40
60
80
100
120
140
GtCO2-e
Capital
All Rates
Labor Rates
Gov't Spending
Deficit Reduction
Debt Reduction
Lump Sum


Effects on Full Consumption plus Government Purchases
Present value changes versus tonnes abated, 2010-2050
$3,000
$2,500
$2,000
$1,500
$1,000
$500
$0
($500)
($1,000)
($1,500)
$(2005) Billions
0
20
40
60
80
100
120
140
GtCO2-e
Capital
All Rates
Labor Rates
Gov't Spending
Deficit Reduction
Debt Reduction
Lump Sum

Household Welfare

- *Intra*temporal indirect utility functions (V_d) of prices (p_t), total full wealth expenditures (M_d) and household attributes (A_d)
  - Covering non-durable goods, capital services, consumer services and leisure
  - Attributes – family size (children, adults), race and gender of head, region and location of residence
- *Inter*temporally optimized subject to the lifetime budget constraint on full wealth
  - Full wealth – the present value of future earnings from labor, domestic capital, government debt, net foreign assets plus government transfers and the imputed values of leisure
- Economy-wide full consumption achieved through exact aggregation

$$EV = \Delta W_d = \Omega_d(\{p_t^0\},\{\gamma_t^0\},V_d^1) - \Omega_d(\{p_t^0\},\{\gamma_t^0\},V_d^0)$$

$$\%EV_d = \frac{\Delta W_d}{\Omega_d(\{p_t^0\},\{\gamma_t^0\},V_d^0)}$$

Household Welfare Effects, Reference Households

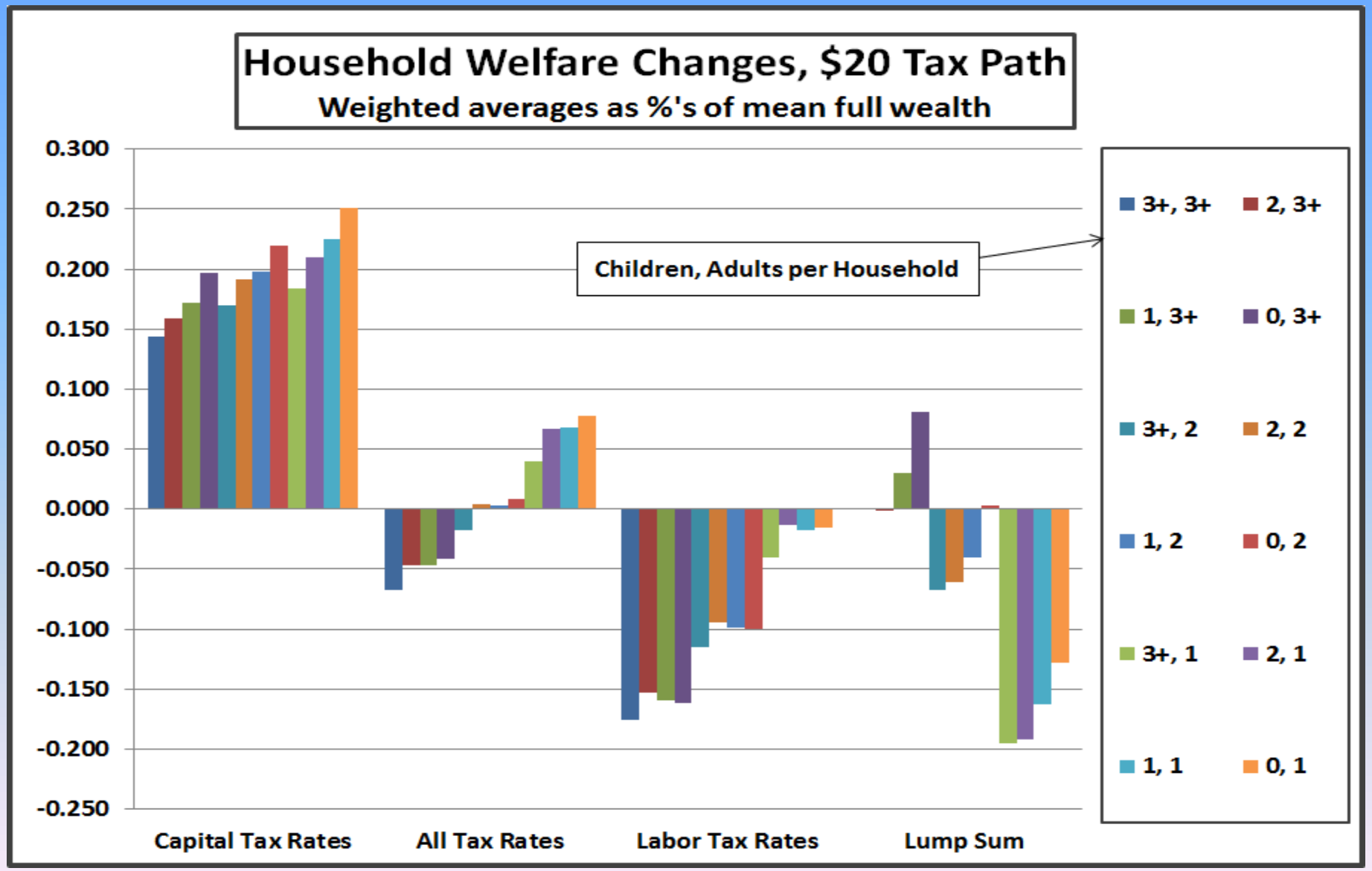
Equivalent Variations in $(2005) and as %'s of full wealth

	Poorest household[1]		Richest household[2]	
	$(2005)	% of wealth	$(2005)	% of wealth
$10 Tax Path				
Capital	$362	0.045	$43,926	0.134
Labor	-$161	-0.020	-$36,133	-0.110
Lump Sum	-$1,296	-0.161	$34,120	0.104
$50 Tax Path				
Capital	-$495	-0.062	$131,852	0.403
Labor	-$2,057	-0.256	-$144,855	-0.442
Lump Sum	-$5,891	-0.734	$99,379	0.303

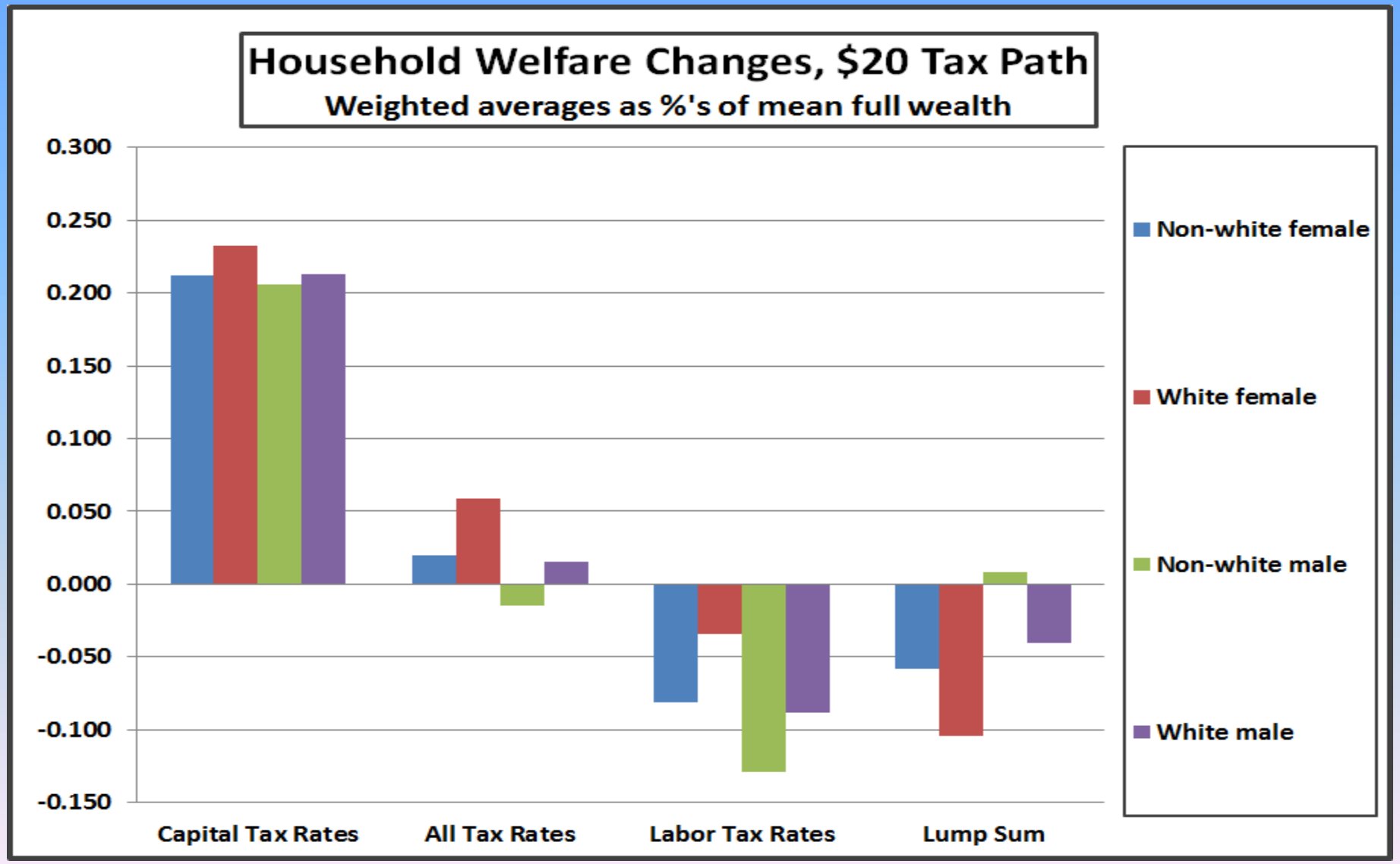
[1] Female headed, non-white household with one child living in the rural South with lifetime full wealth of $0.8 million

[2] Male headed, non-white household with three or more each of adults and children living in the urban West with lifetime full wealth of $32.8 million

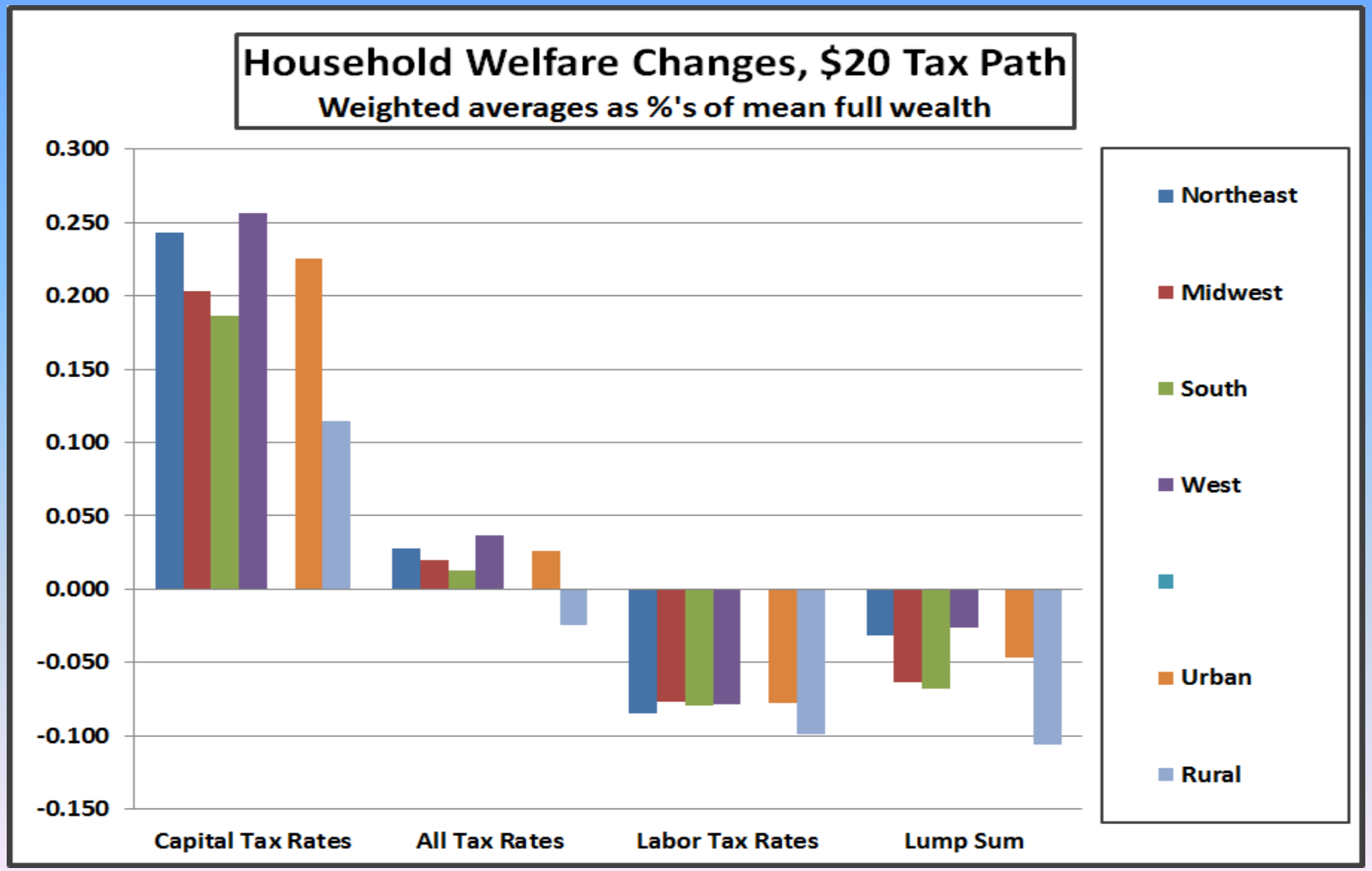
Household Welfare Effects, Family Size



Household Welfare Effects, Race & Gender of Head



Household Welfare Effects, Region & Location



Social Welfare

Jorgenson, Slesnick and Wilcoxen

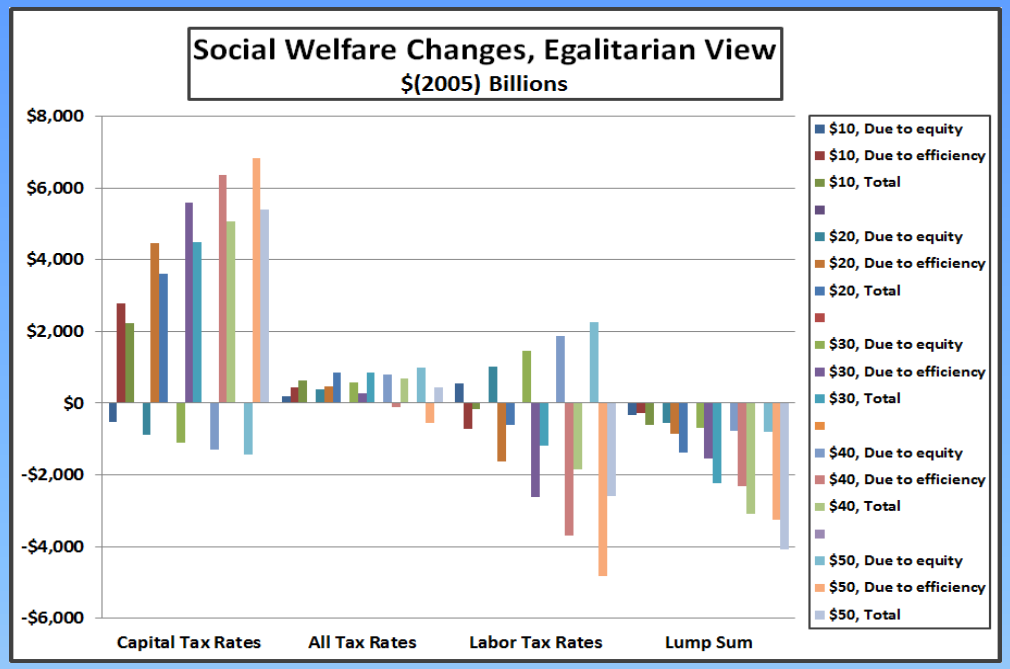
- Pareto-principled, money-metric social welfare function, W
  - Exact aggregation over 244 CEX household types
  - Social welfare increases with increasing household welfare
  - Transfers from richer to poorer households are social welfare improving
  - Parameterizes the range of society's preferences for equality from purely egalitarian to purely utilitarian
- Welfare efficiency, E – maximum social welfare achievable through a reallocation of lifetime expenditure that equalizes household utility
- Welfare equity, EQ – the difference between actual (W) and efficient (E) welfare

$$\Delta W = \Delta E + \Delta EQ$$

$$\Delta W = \Omega(\{p_t^0\},\{\gamma_t^0\},W^1) - \Omega(\{p_t^0\},\{\gamma_t^0\},W^0)$$

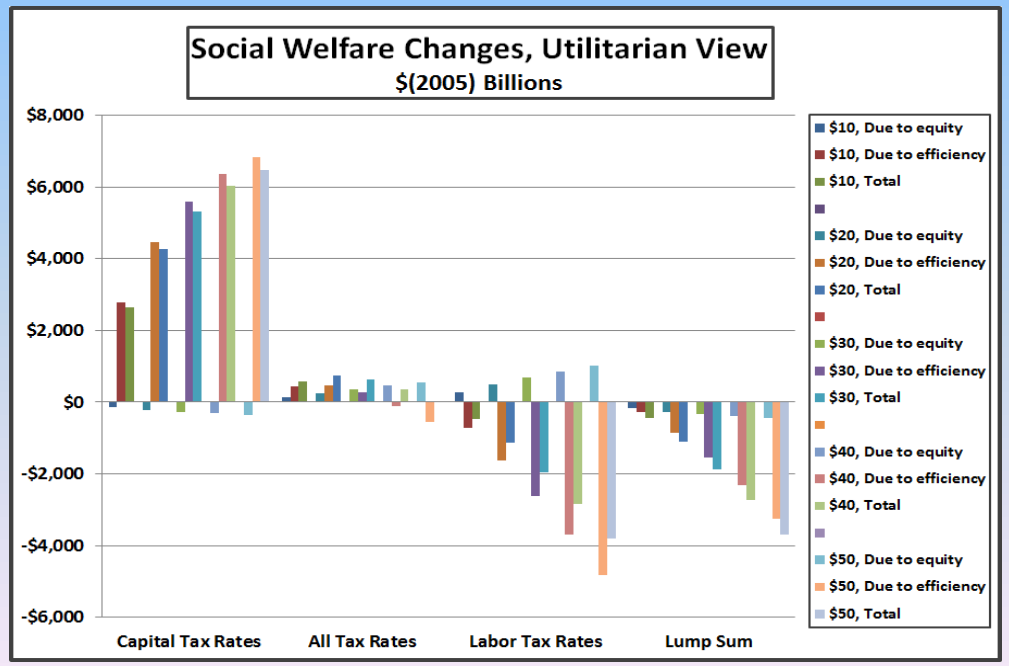
$$\Delta E = \Omega(\{p_t^0\},\{\gamma_t^0\},W_{\max}^1) - \Omega(\{p_t^0\},\{\gamma_t^0\},W_{\max}^0)$$

$$\Delta EQ = [\Omega(\{p_t^0\},\{\gamma_t^0\},W^1) - \Omega(\{p_t^0\},\{\gamma_t^0\},W_{\max}^1)] - [\Omega(\{p_t^0\},\{\gamma_t^0\},W^0) - \Omega(\{p_t^0\},\{\gamma_t^0\},W_{\max}^0)]$$



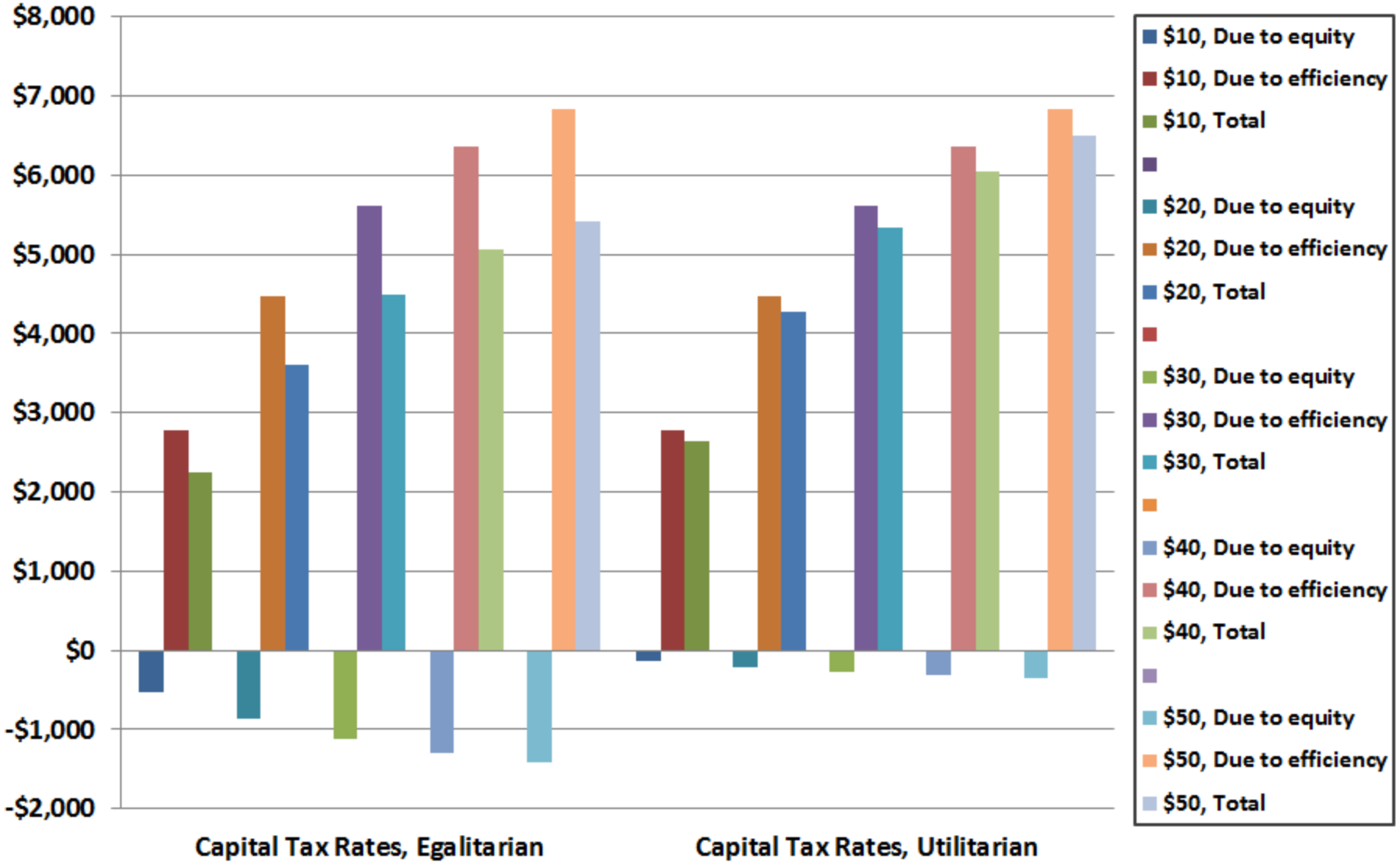
Capital tax reductions are welfare superior despite their qualified regressivity

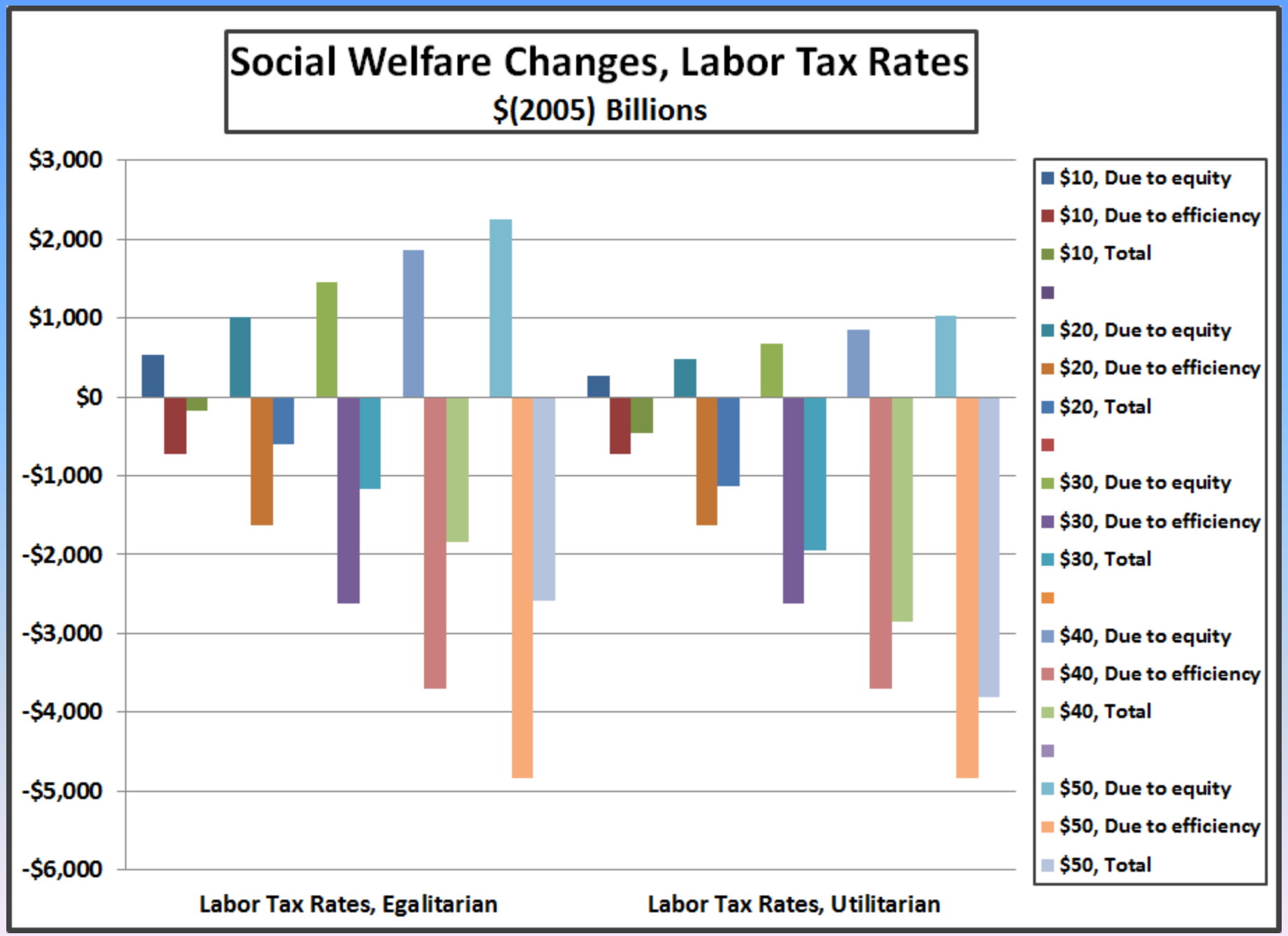
Labor tax reductions are welfare inferior despite their unqualified progressivity



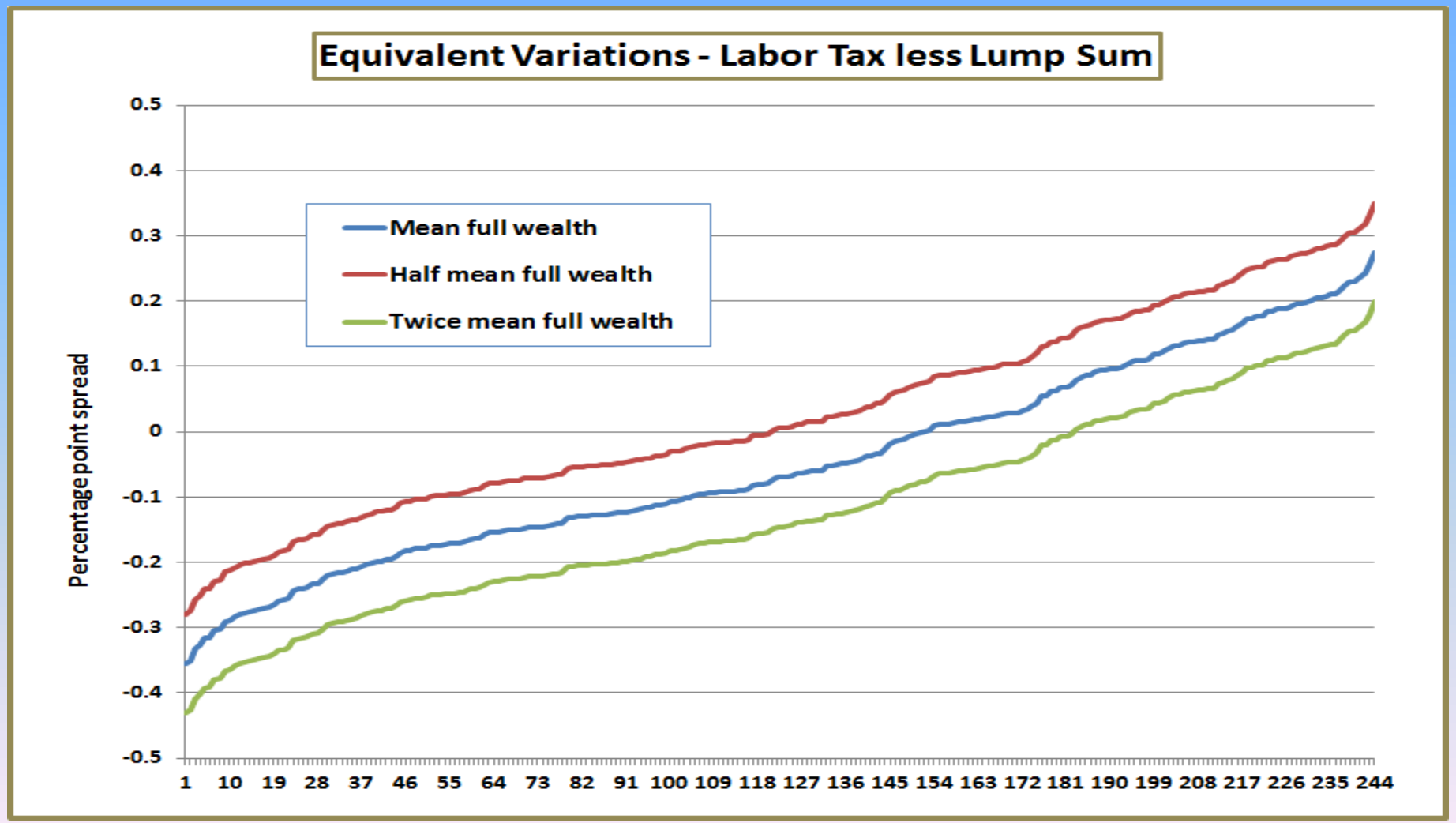
Social Welfare Changes, Capital Tax Rates

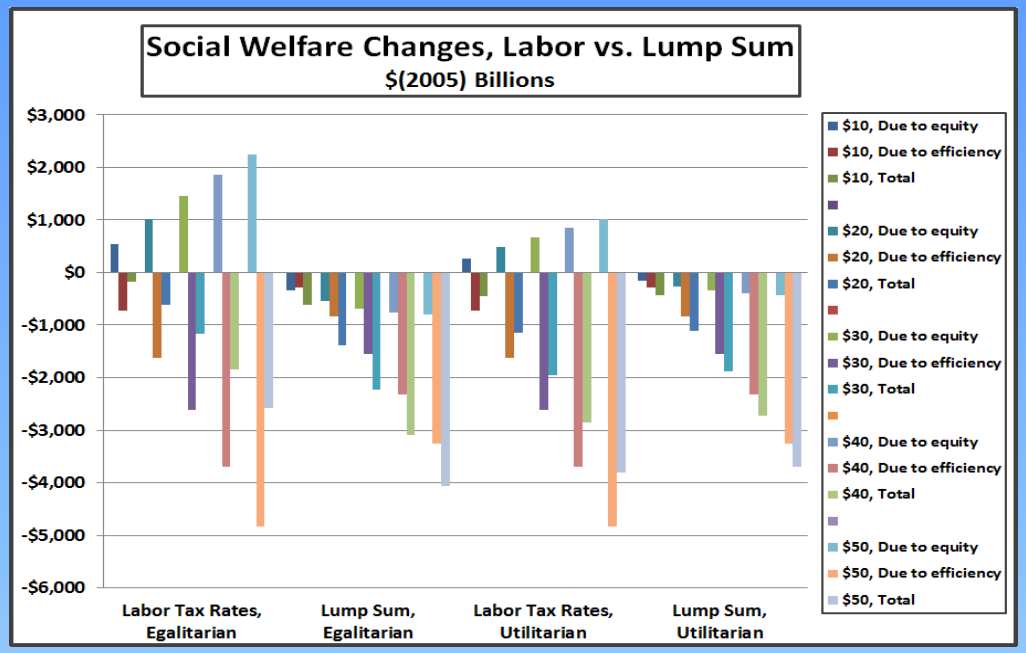
$(2005) Billions



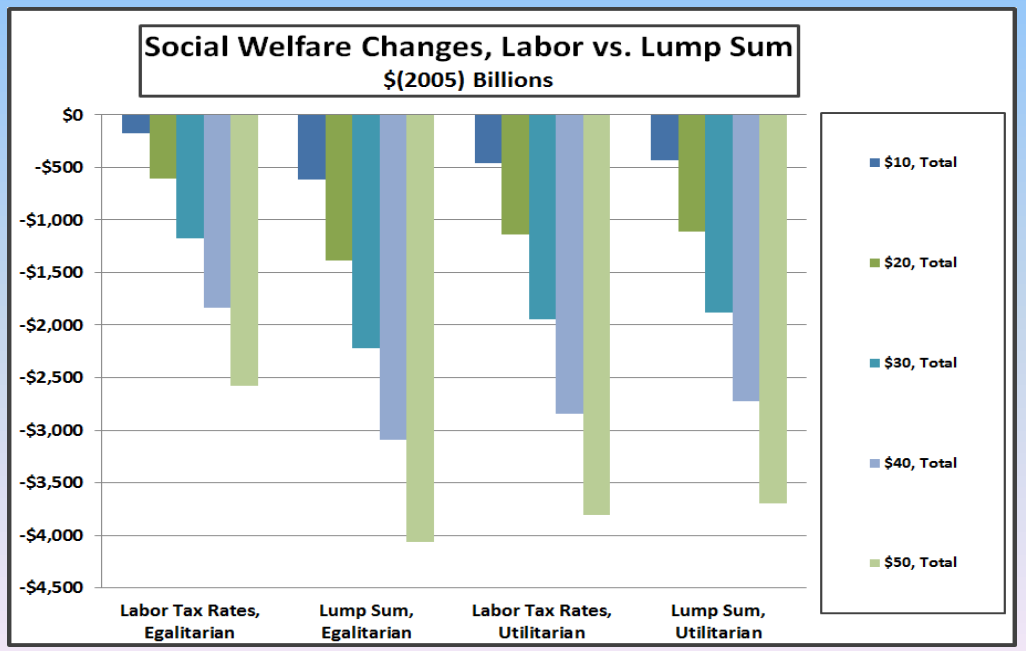

Social Welfare Changes, Labor Tax Rates
$(2005) Billions
$3,000
$2,000
$1,000
$0
-$1,000
-$2,000
-$3,000
-$4,000
-$5,000
-$6,000
Labor Tax Rates, Egalitarian
Labor Tax Rates, Utilitarian
$10, Due to equity
$10, Due to efficiency
$10, Total
$20, Due to equity
$20, Due to efficiency
$20, Total
$30, Due to equity
$30, Due to efficiency
$30, Total
$40, Due to equity
$40, Due to efficiency
$40, Total
$50, Due to equity
$50, Due to efficiency
$50, Total

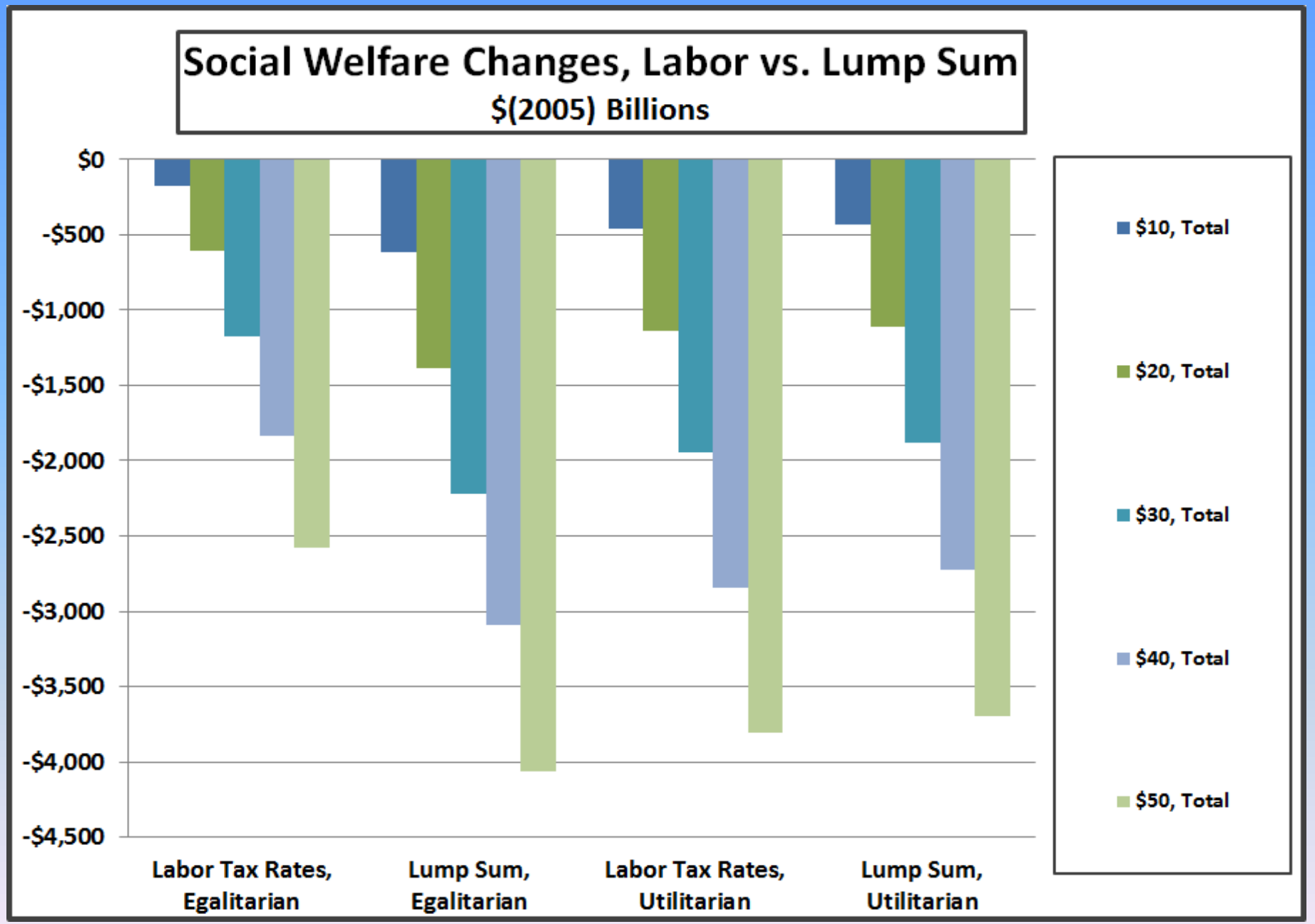
Lump sum redistribution is not necessarily least favorable at the household level





Lump sum redistribution is not necessarily least favorable at the societal level




Social Welfare Changes, Labor vs. Lump Sum
$(2005) Billions
$0
-$500
-$1,000
-$1,500
-$2,000
-$2,500
-$3,000
-$3,500
-$4,000
-$4,500
Labor Tax Rates, Egalitarian
Lump Sum, Egalitarian
Labor Tax Rates, Utilitarian
Lump Sum, Utilitarian
$10, Total
$20, Total
$30, Total
$40, Total
$50, Total

Measures of Equality and Progressivity

Measure of Absolute Equality

$$AEQ(\{p_t^0\},\{\gamma_t^0\},W,W_{\max}) = [\Omega(\{p_t^0\},\{\gamma_t^0\},W)] - \Omega(\{p_t^0\},\{\gamma_t^0\},W_{\max})]$$

Measure of Relative Equality

$$REQ(\{p_t^0\},\{\gamma_t^0\},W,W_{\max}) = \frac{\Omega(\{p_t^0\},\{\gamma_t^0\},W)}{\Omega(\{p_t^0\},\{\gamma_t^0\},W_{\max})}$$

Measure of Absolute Progressivity

$$AP = AEQ(\{p_t^0\},\{\gamma_t^0\},W^1,W_{\max}^1) - AEQ(\{p_t^0\},\{\gamma_t^0\},W^0,W_{\max}^0)$$

Measure of Relative Progressivity

$$RP = REQ(\{p_t^0\},\{\gamma_t^0\},W^1,W_{\max}^1) - REQ(\{p_t^0\},\{\gamma_t^0\},W^0,W_{\max}^0)$$

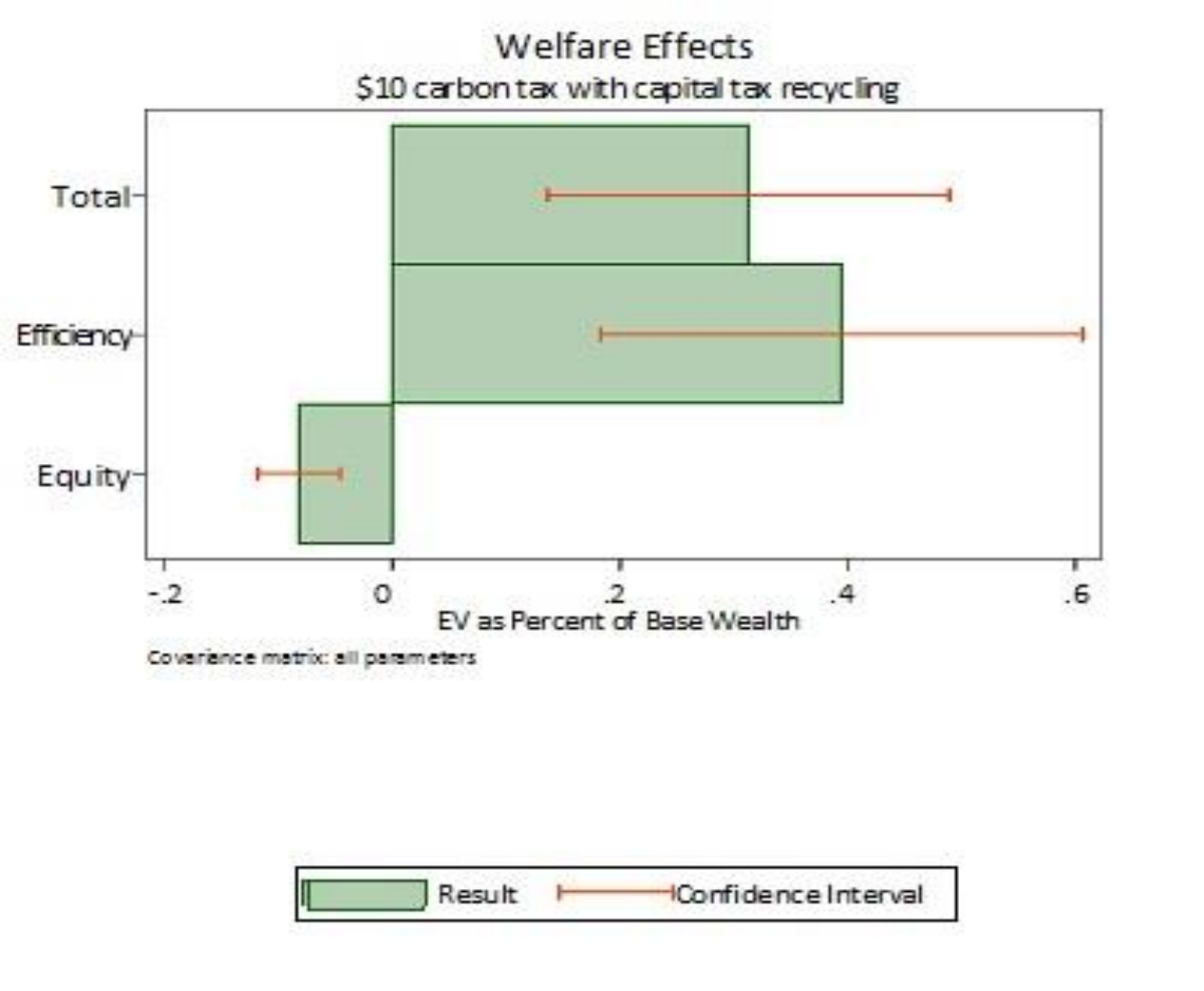
Measures of Progressivity

	Capital Tax Rates	All Tax Rates	Labor Tax Rates	Lump Sum
Absolute	Regressive	Progressive	Progressive	Regressive
Relative	Progressive	Progressive	Progressive	Regressive

Robust across all carbon tax paths and the full range of egalitarian and utilitarian views

Statistically significant welfare results

Tuladhar and Wilcoxen



Appendix

Average Reductions in Tax Rates or Tax Equivalent Redistributions, 2016-2050

	Carbon Tax Path				
	$10	**$20**	**$30**	**$40**	**$50**
Capital	-11.1%	-19.9%	-27.5%	-34.3%	-40.3%
All	-3.5%	-6.4%	-9.0%	-11.3%	-13.4%
Labor	-5.2%	-9.4%	-13.2%	-16.7%	-19.8%
Lump Sum	-3.8%	-6.8%	-9.5%	-11.8%	-13.9%

Household Welfare Effects, Largest and Smallest

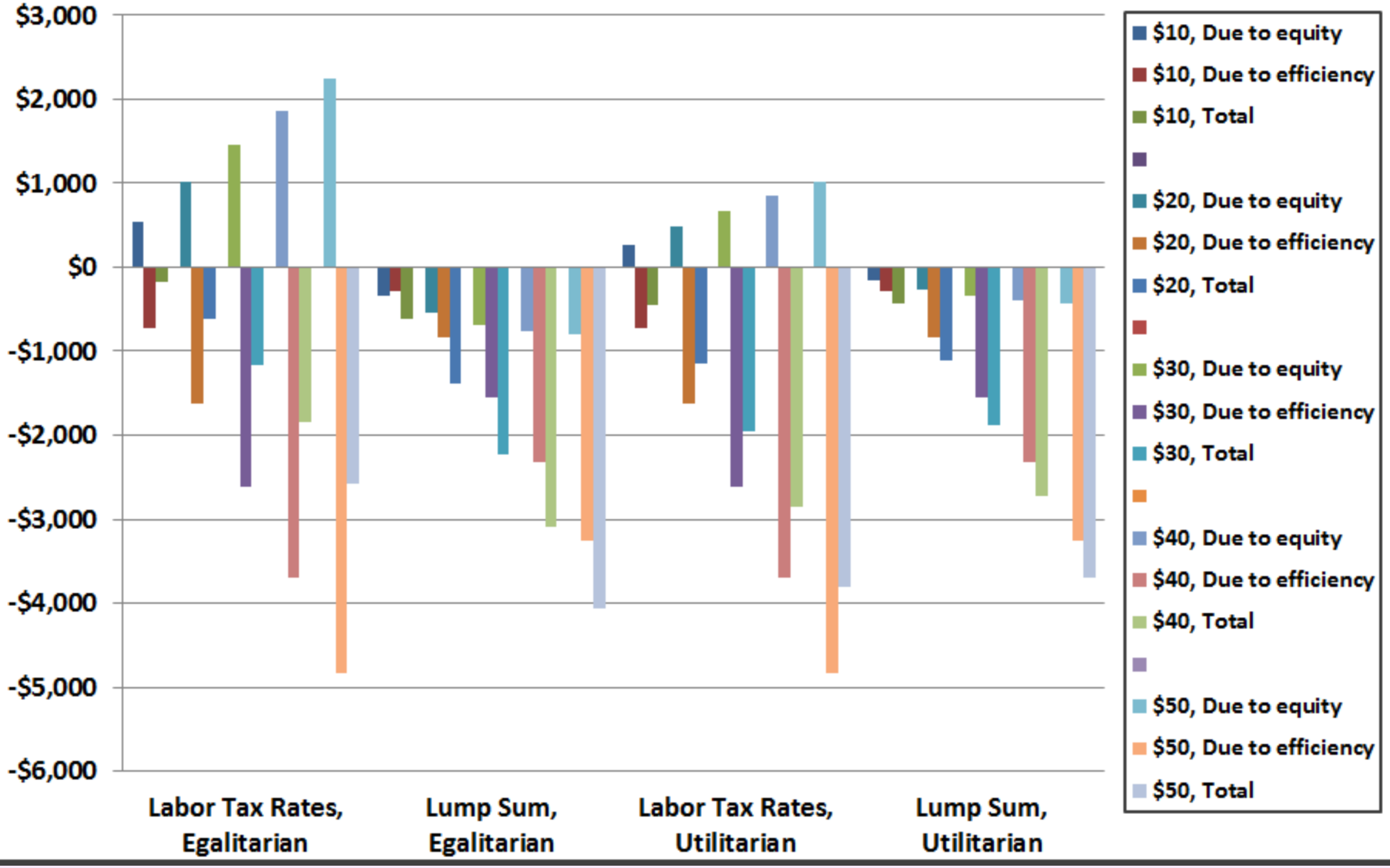
Equivalent Variations in $(2005) and as %'s of full wealth

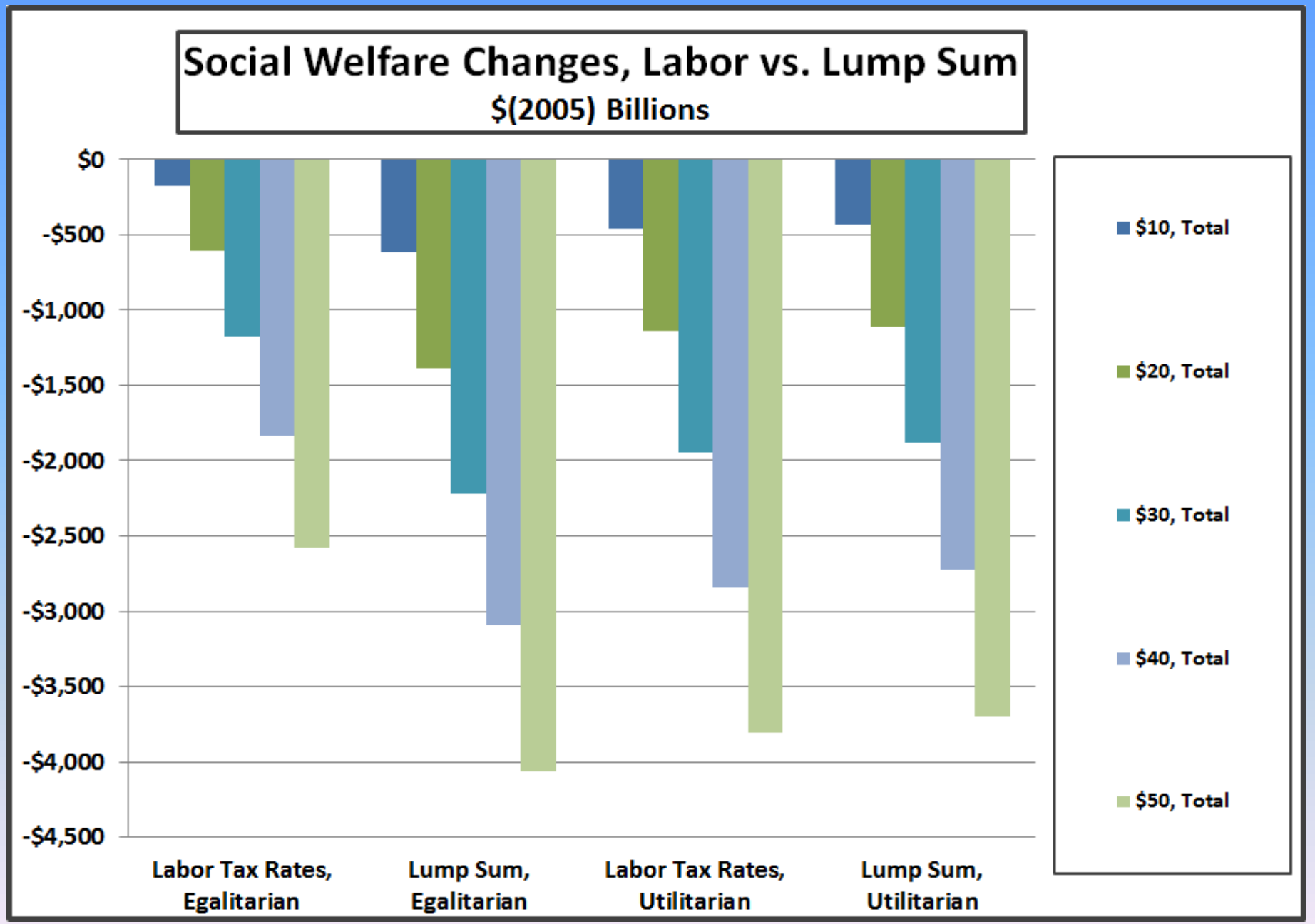
	Impact	$(2005)	% of wealth[1]
$10 Tax Path			
Capital	**Largest**	$45,985	0.204
	Smallest	$111	0.005
Labor	**Largest**	$1,297	0.020
	Smallest	-$36,133	-0.118
Lump Sum	**Largest**	$35,054	0.136
	Smallest	-$6,509	-0.202
$50 Tax Path			
Capital	**Largest**	$139,978	0.574
	Smallest	-$5,740	-0.137
Labor	**Largest**	-$1,733	-0.074
	Smallest	-$144,855	-0.515
Lump Sum	**Largest**	$110,314	0.429
	Smallest	-$36,554	-0.893

[1] **Household characteristics often do not correspond to those represented in the adjacent $(2005) column**

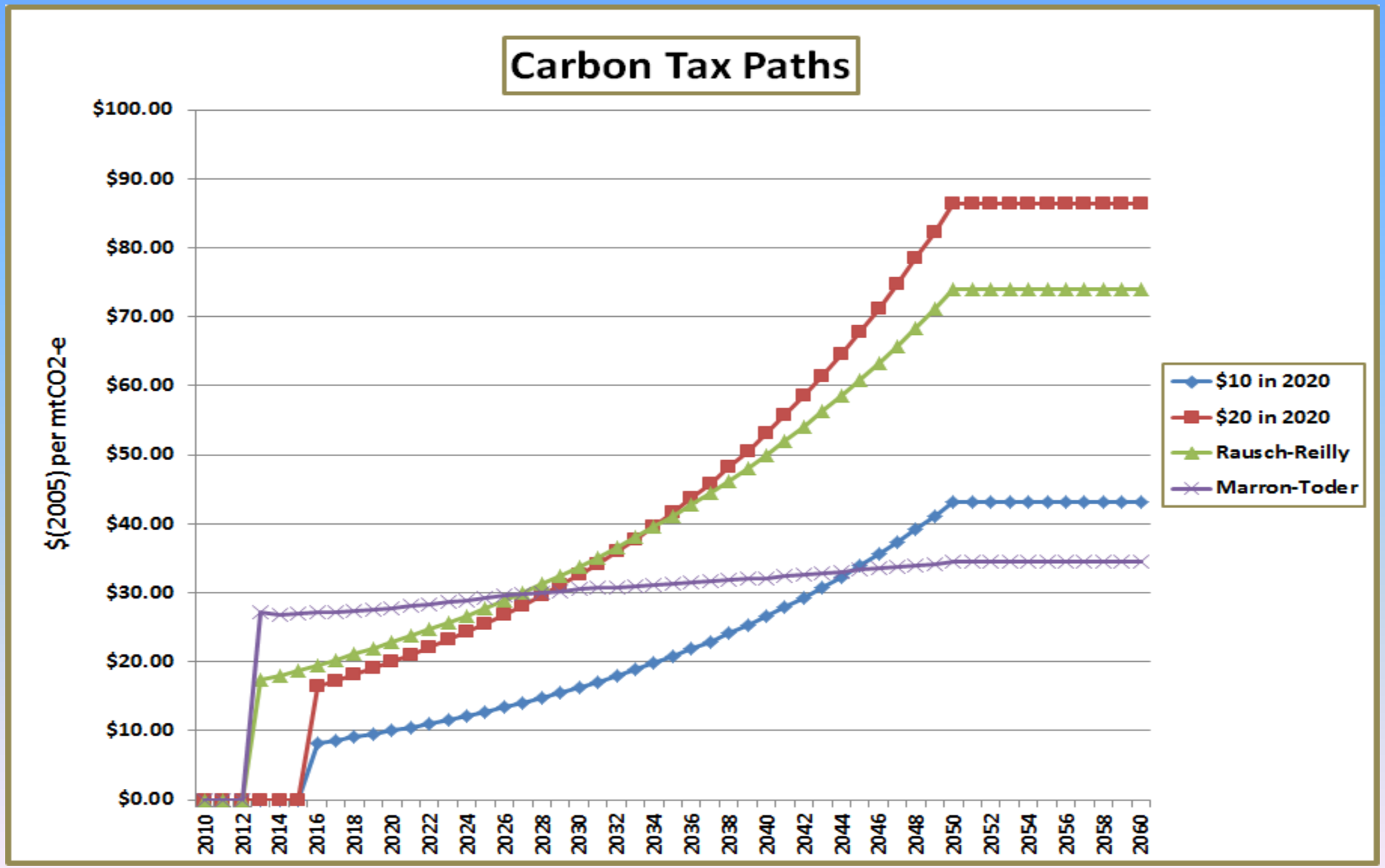
Social Welfare Changes, Labor vs. Lump Sum

$(2005) Billions

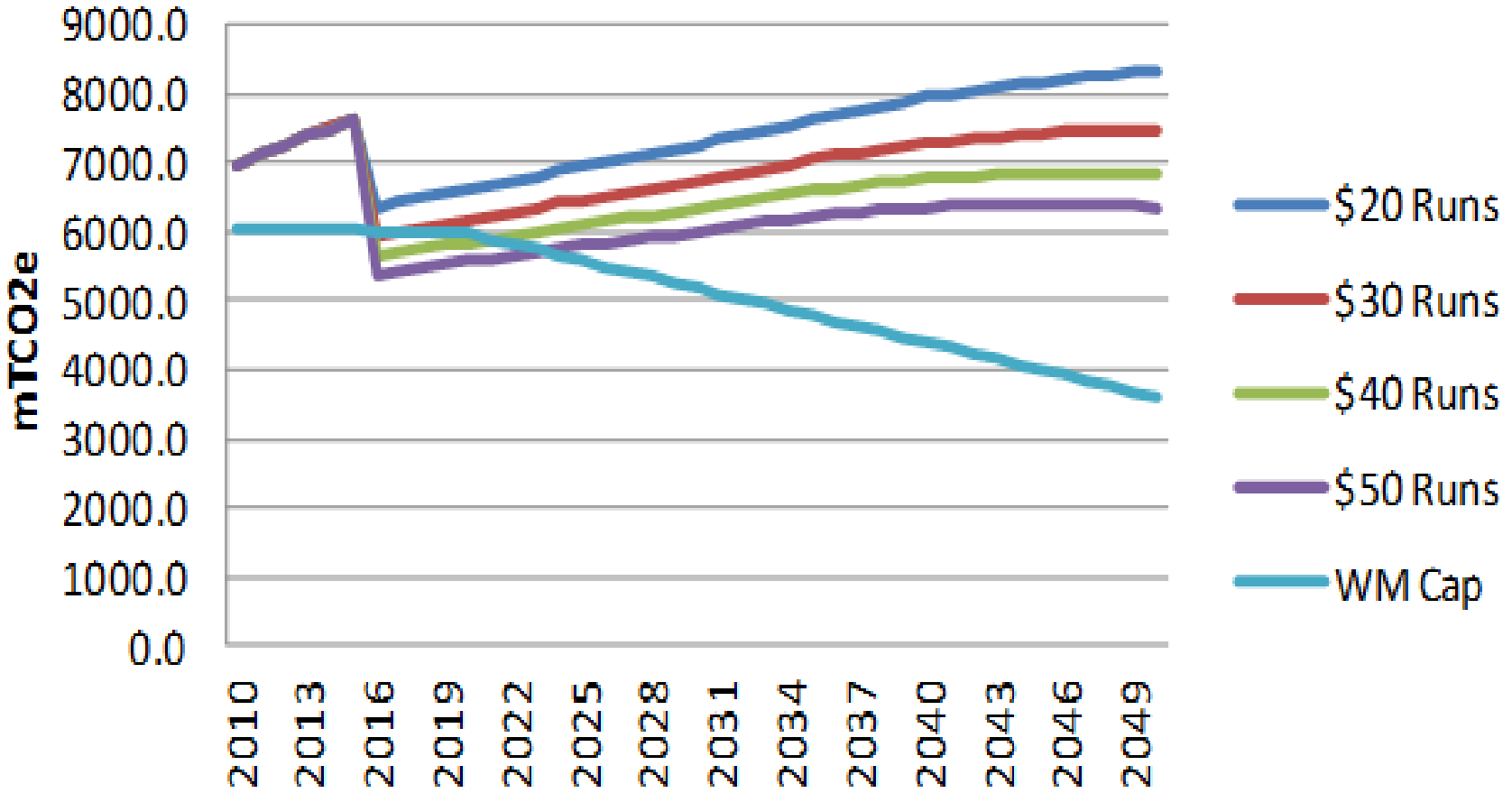



Social Welfare Changes, Labor vs. Lump Sum
$(2005) Billions
$0
-$500
-$1,000
-$1,500
-$2,000
-$2,500
-$3,000
-$3,500
-$4,000
-$4,500
Labor Tax Rates, Egalitarian
Lump Sum, Egalitarian
Labor Tax Rates, Utilitarian
Lump Sum, Utilitarian
$10, Total
$20, Total
$30, Total
$40, Total
$50, Total

Comparative Carbon Tax Scenarios



GHG Emissions under IGEM runs and Waxman-Markey Cap



Household Welfare

Indirect utility function of prices (p_t) and total full wealth expenditures (M_d) and attributes (A_d)

$$\ln V_{dt} = \alpha_p' \ln p_t + \tfrac{1}{2} \ln p_t' B_{pp} \ln p_t - D(p) \ln \frac{M_{dt}}{N_{dt}} \quad \text{where}$$

$$\ln N_{dt} = \frac{1}{D(p_t)} \ln p_t' B_A A_d \quad \text{and} \quad D(p_t) = -1 + \iota' B_{pp} \ln p_t$$

$$\max_{F_{kt}} U_k = E_t \{ \sum_{t=1}^{T} (1+\rho)^{-(t-1)} \ln V_{kt} \}$$

$$\text{s.t.} \quad \sum_{t=0}^{\infty} \gamma_t M_{dt}(p_t, V_{dt}, A_d) = \Omega_d \quad \text{where} \quad \gamma_t = \prod_{s=0}^{t} \frac{1}{1+r_s}$$

$$EV = \Delta W_d = \Omega_d(\{p_t^0\}, \{\gamma_t^0\}, V_d^1) - \Omega_d(\{p_t^0\}, \{\gamma_t^0\}, V_d^0)$$

$$\%EV_d = \frac{\Delta W_d}{\Omega_d(\{p_t^0\}, \{\gamma_t^0\}, V_d^0)}$$

Social Welfare

$$W(u,x)=\bar{V}-\eta\left[\sum_{d=1}^{D}a_d\left|V_d-\bar{V}\right|^{-\mu}\right]^{-1/\mu} \qquad -\infty<\mu<-1$$

Utilitarian < μ < Egalitarian

where $\bar{V}=\sum_{d=1}^{D}a_dV_d$ and $a_d=\dfrac{\exp\left\{\sum_t\delta^tD_t\ln N_{dt}/S\right\}}{\sum_{l=1}^{D}\exp\left\{\sum_t\delta^tD_t\ln N_{lt}/S\right\}}$

$$\Omega_d^*=a_d\Omega \qquad W_{\max}=S\ln R-S\ln\Omega+S\ln N+\sum_{t=0}^{\infty}\delta^tD_t\ln\left(\frac{D_0\gamma_tP_t}{\delta^tD_tP_0}\right)$$

$$\Delta W=\Delta E+\Delta EQ$$

$$\Delta W=\Omega(\{p_t^0\},\{\gamma_t^0\},W^1)-\Omega(\{p_t^0\},\{\gamma_t^0\},W^0)$$

$$\Delta E=\Omega(\{p_t^0\},\{\gamma_t^0\},W_{\max}^1)-\Omega(\{p_t^0\},\{\gamma_t^0\},W_{\max}^0)$$

$$\Delta EQ=[\Omega(\{p_t^0\},\{\gamma_t^0\},W^1)-\Omega(\{p_t^0\},\{\gamma_t^0\},W_{\max}^1)]$$
$$-[\Omega(\{p_t^0\},\{\gamma_t^0\},W^0)-\Omega(\{p_t^0\},\{\gamma_t^0\},W_{\max}^0)]$$

Tier Structure of Household Demand

Full consumption = U (Nondurables, Capital services, Services, Leisure)

Nondurables = U (Energy, Food, Consumer Goods)

Energy = U (Gasoline, Coal & Fuel Oil, Electricity, Gas)

Household Full Consumption Model

Demographic Groups

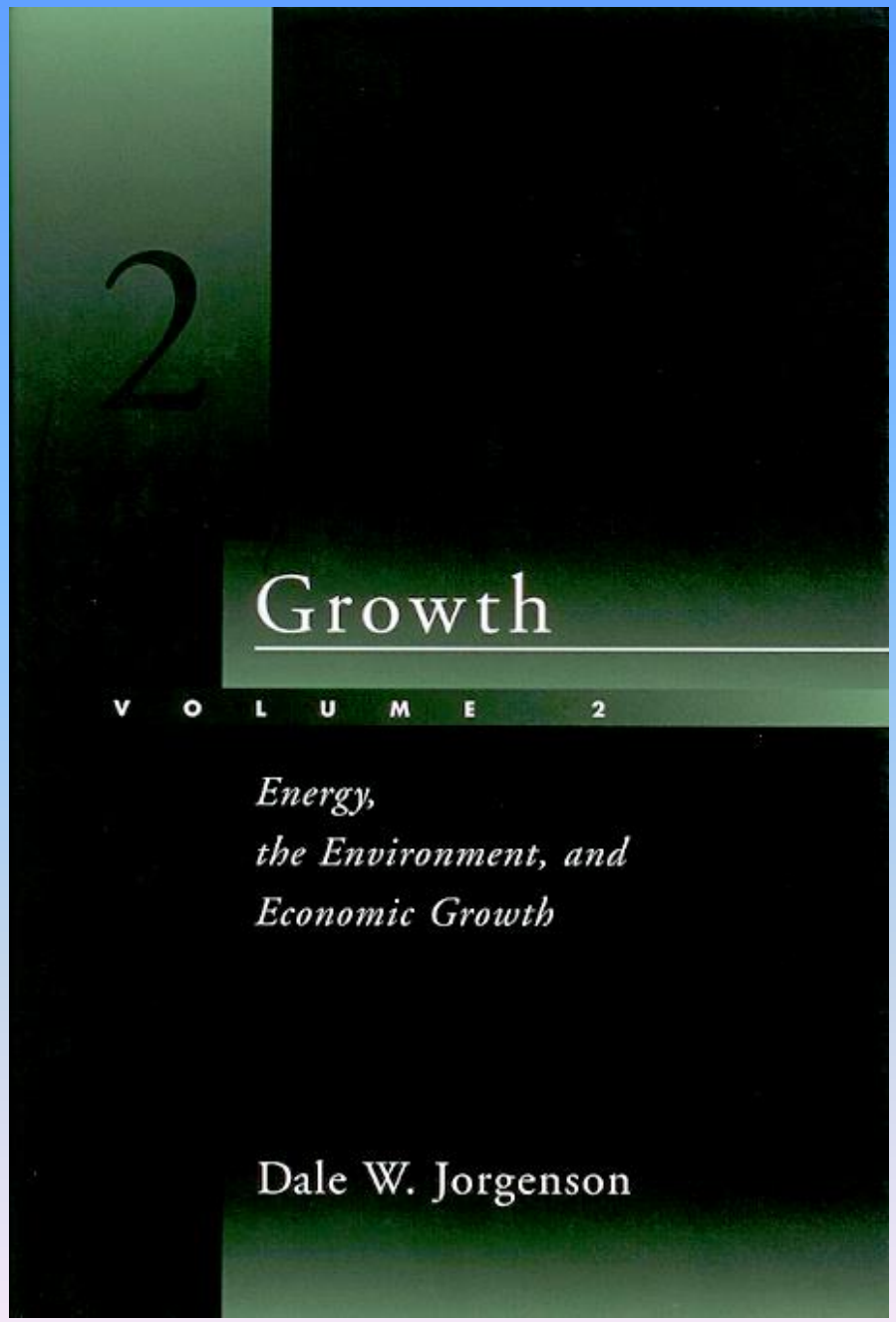
Number of children	0,1,2, 3 or more
Number of adults	1,2, 3 or more
Region	Northeast, Midwest, South, West
Location	Urban, Rural
Race of head	Non-white, White
Gender of head	Female, Male

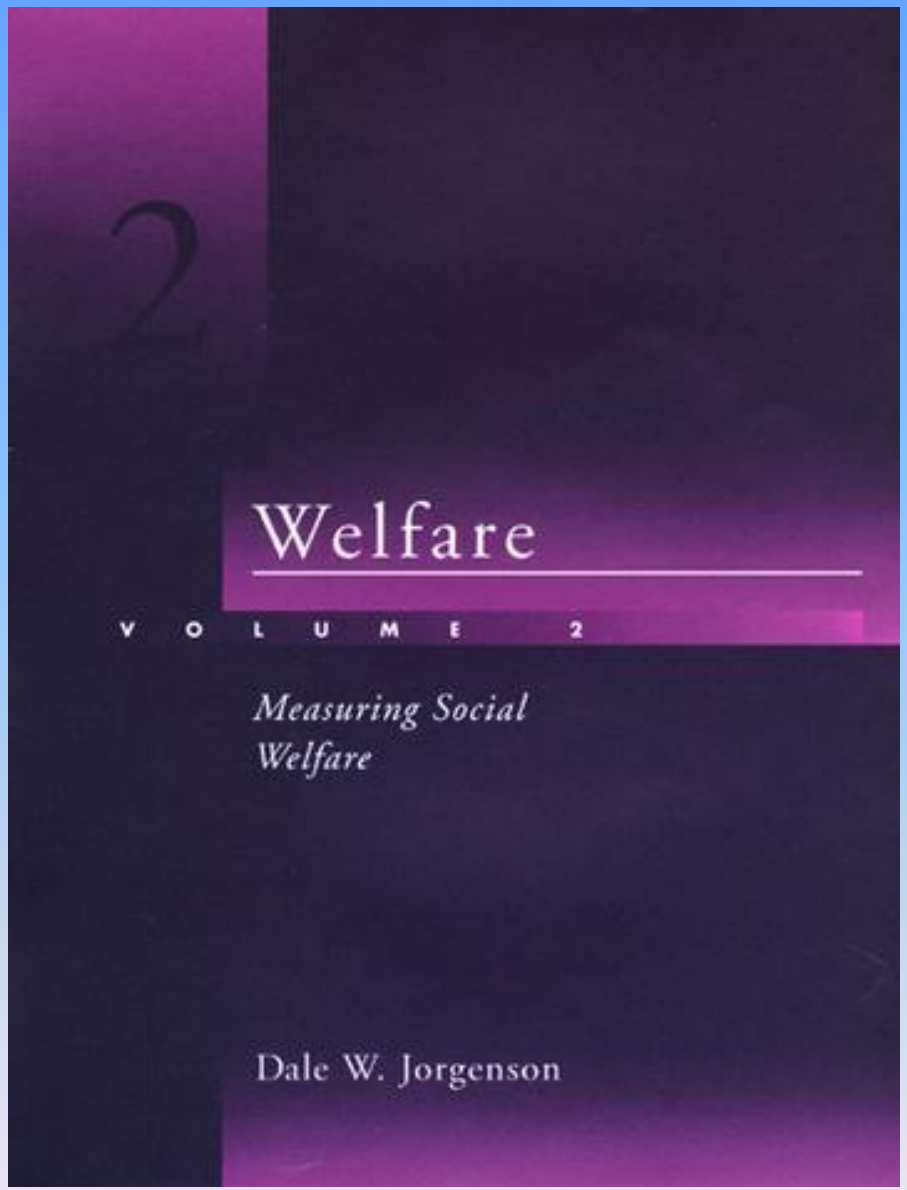
Full Expenditure and Household Budget Shares

Full Expenditures	Nondurables	Capital	Services	Leisure
$7,500	0.208	0.151	0.055	0.586
$25,000	0.164	0.137	0.060	0.626
$75,000	0.123	0.124	0.065	0.693
$150,000	0.098	0.116	0.068	0.713
$275,000	0.075	0.108	0.071	0.718
$350,000	0.066	0.106	0.072	0.716

Price and income elasticities

	Uncompensated Price Elasticity	Compensated Price Elasticity	Expenditure Elasticity
Nondurables	-0.727	-0.651	0.673
Capital Services	-1.192	-1.084	0.902
Consumer Services	-0.561	-0.49	1.067
Leisure	0.014	-0.305	1.063
Labor Supply	-0.032	0.713	-2.486


2
Growth
VOLUME 2
Energy,
the Environment, and
Economic Growth
Dale W. Jorgenson


2
Welfare
VOLUME 2
Measuring Social Welfare
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