Energy Group Introduction

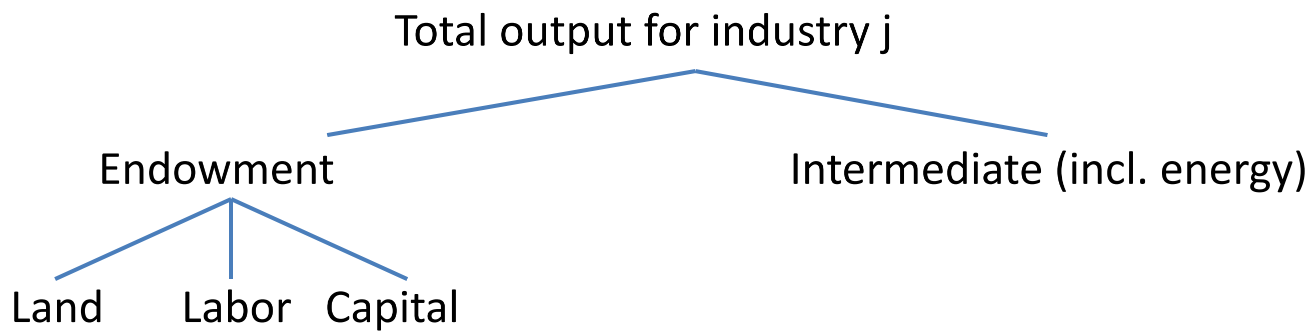
Study Goal & Key Questions

- Goals: (1) To evaluate alternative policy instruments for achieving the Kyoto targets; and (2) to understand the sensitivity of these results to other structural features and the analysis time horizon
- Question 1:What are the welfare impacts of
  - Carbon tax alternative? (Group 1)
  - Changes to existing FF tax rates? (Group 2)
  - Coalition expansion under quota system? (Group 3)
- Question 2: What is the sensitivity of policy results above to assumptions about the elasticity of substitution in electricity production?(Group 4)

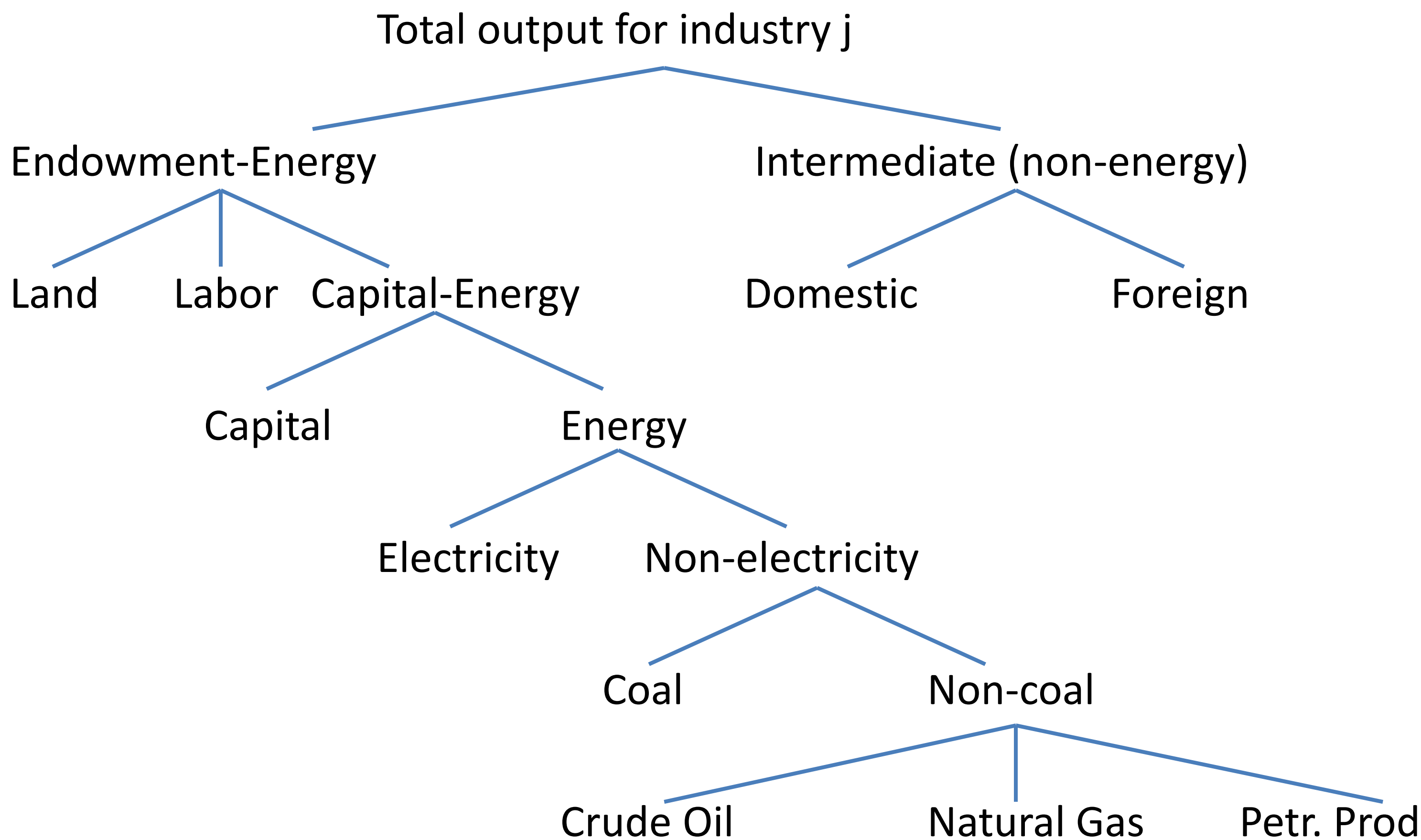
Introduction to the Kyoto Protocol

- A protocol to the UN Framework Convention on Climate Change (UNFCCC); purpose of the latter is to stabilize GHG concentrations in the atmosphere to avoid "dangerous interference" with the climate system
- Industrialized (Annex I) countries who ratified the protocol agreed to adopt specific emissions reduction targets (with a global target benchmarked to 1990 levels)
- In this version of GTAP-E, starting point was global emissions reductions of ~15% relative to 1997, with varying levels of trading

Original GTAP Production Structure



Our Tool: Introduction to GTAP-E



Group 1:
Carbon Tax Extension

Francisco del Pozo and Young Gui Kim

- Background: In Kyoto protocol some countries (Annex1) set binding targets to reduce Greenhouse gas (GHG).

- Simulation results: Kyoto protocol achieves reduction in CO_2 emission by 13.57% and common nominal trading price is $28.78 with worldwide emission trading.

- Problem: Lack of world wide commitment on GHG reduction

- Explore option: Drop on Carbon quota of (some countries)and impose carbon tax (to all countries)

- Questions:

1) How much free riders got benefits from emission trading under Kyoto protocol?

2) If we achieve the same reduction in CO_2 emission with carbon tax, what happens? (Now emission is not a free!)

- Gains from changing quota option by carbon tax (burden sharing) achieving 13.57% of GHG reduction with worldwide emission trading

- Shock *to achieve the same level of reduction*:

Shock NCTAXB("world") = 28.782425;

NCTAXB= nominal carbon tax rate (current USD per ton of carbon)

- Closure :

swap cgdslack = DBALCAR;
swap DBALCAR("row") = cgdslack("row");
swap RCTAXB = NCTAXB;

cgdslack= slack variable for qcgds
qcgds=output of capital goods sector
DBALCAR= change in ratio of current account balance to regional income

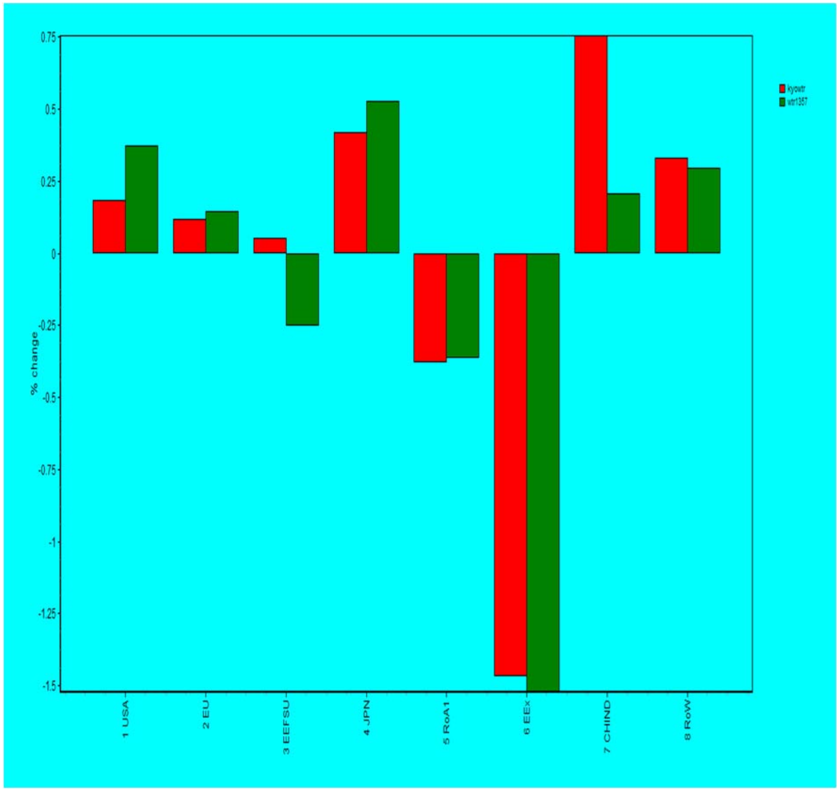
First 2 swap: to allow emissions trading
Last swap: to make NCTAXB to be exogenous

- Results (reduction in CO_2 emission, %)

	Kyoto	Carbon Tax
USA	-12.34	-12.25
EU	-5.88	-5.83
EEFSU	-12.76	-12.92
JPN	-6.37	-6.31
RoA1	-9.20	-9.15
EEX	-7.23	-7.25
CHIND	-32.57	-32.81
RoW	-8.46	-8.48
NCTAXB (USD)	28.78	28.78
World Emission (%)	-13.569	-13.599
World EV (mil USD)	-18987.3	-18500.43

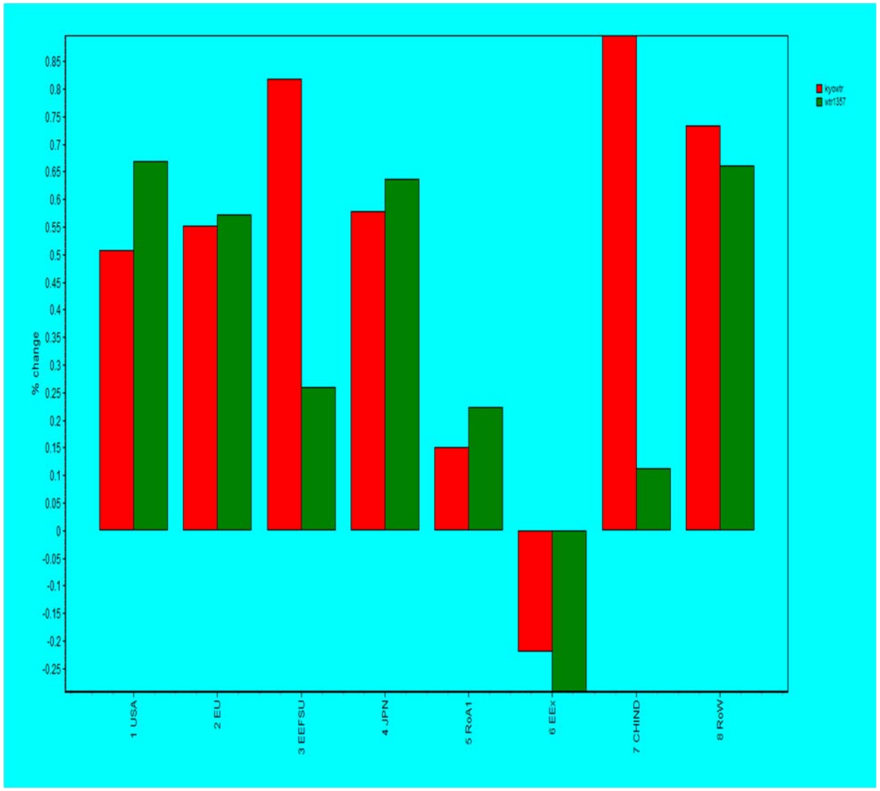
- Results (Welfare decomposition, million USD)

	Kyoto				Carbon Tax			
	Co2 Trade	Alloc-ation	TOT	Total	Co2 Trade	Alloc-ation	TOT	Total
USA	-9993	-2679	1749	-10870	0	-2452	3407	1216
EU	-4311	-1016	2895	-2499	0	-197	3579	3257
EEFSU	5693	-896	109	4910	0	-1391	-681	-2133
JPN	-2456	-1577	1948	-2185	0	-1363	2455	894
RoA1	-1957	-1605	-1826	-5341	0	-1378	-1708	-3088
EEX	1417	-2614	-9881	-11073	0	-2649	-10254	-12909
CHIND	10041	-6619	2145	5441	1	-7091	618	-6494
RoW	1509	-1899	2836	2630	0	-1961	2564	755
Total	-58	-18905	-25	-18987	1	-18483	-20	-18501



- Results (Macroeconomic Effects, %)

	Kyoto			Carbon Tax		
	Welfare	TOT	VGDP	Welfare	TOT	VGDP
USA	-0.151	0.184	0.507	0.017	0.372	0.670
EU	-0.036	0.117	0.553	0.047	0.145	0.572
EEFSU	0.649	0.052	0.818	-0.282	-0.251	0.259
JPN	-0.060	0.421	0.579	0.024	0.528	0.637
RoA1	-0.399	-0.382	0.150	-0.231	-0.363	0.223
EEX	-0.525	-1.469	-0.221	-0.612	-1.523	-0.293
CHIND	0.480	0.755	0.897	-0.573	0.208	0.112
RoW	0.106	0.329	0.733	0.030	0.297	0.662



- Findings:

1) Flat carbon tax can achieve the same objective of Kyoto without considering binding quotas.

3) Also this allows better price (TOT) and gains on welfare and GDP of industrialized countries.

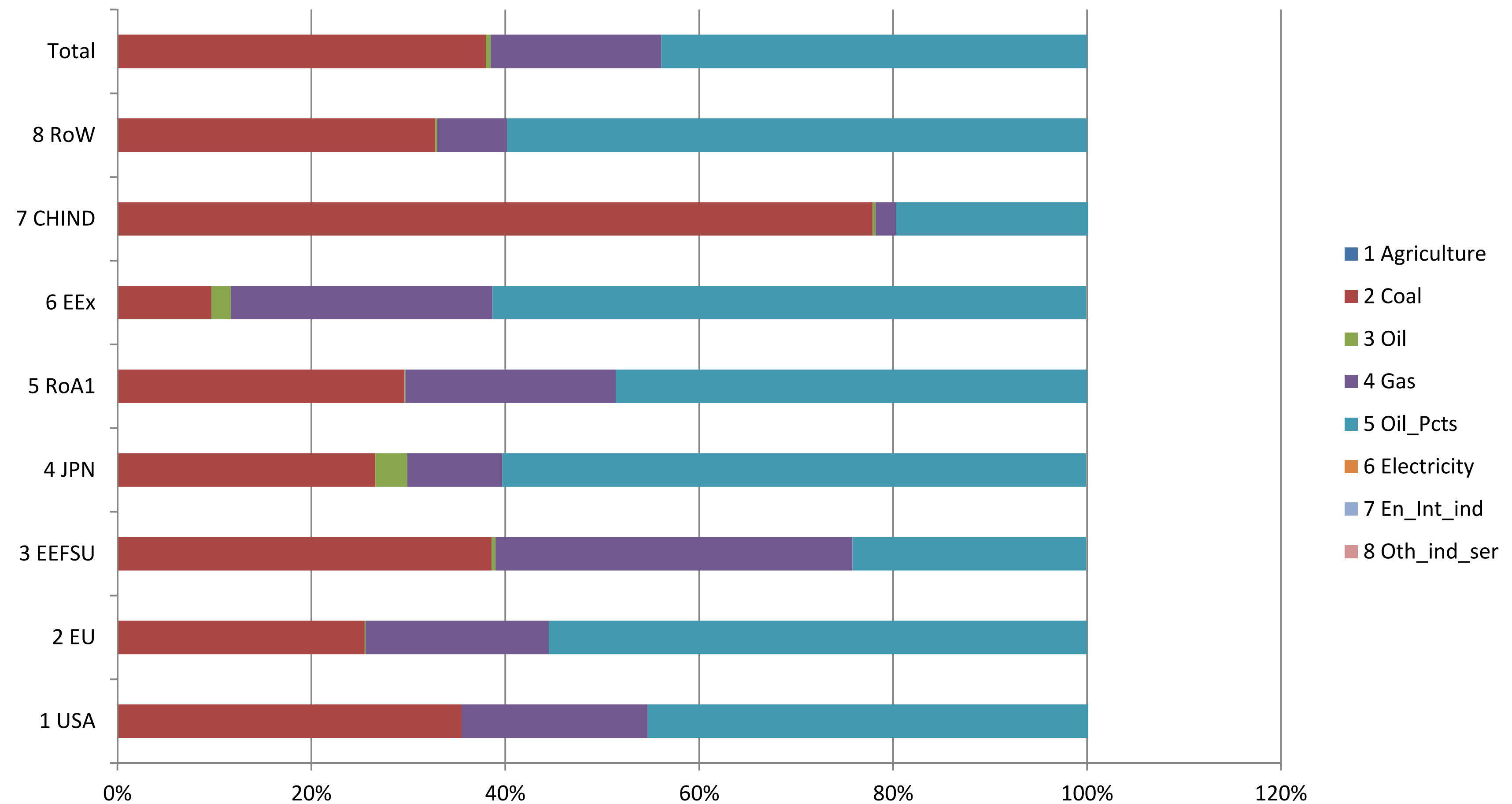
- What happens in TOT(USA) ?

ToT(USA)	0.3724
PSW	0.5952
PDW	0.2228
contribution(oth_ind)	0.8
PFOB(oth_ind)	0.528
PS	0.528
PF(Vaen)	0.3
contribution(Vaen)	0.4608
PF(oth_ind)	0.57
contribution(oth_ind)	0.3167

Group 2:
Examining Fossil Fuel Subsidies

Sangeeta Khorana & Jose Signoret

Global CO2 emissions



Changes to closure

- !   DTBAL exogenous for all regions except one,
- !   and cgdslack exogenous for that one region (which can be any one).
-
- !swap cgdslack = DBALCAR;
- !swap DBALCAR("row") = cgdslack("row");
-
- !swap RCTAXB = NCTAXB;
- !swap pempb("usa")= NCTAXB("usa");
- !swap pempb("eu")= NCTAXB("eu");
- !swap pempb("jpn")= NCTAXB("jpn");
- !swap pempb("roa1")= NCTAXB("roa1");
-
- !swap gco2q("usa") = pemp("usa");

Simulation scenario

- Sectors: "Oil_Pcts", "Oil“, "Coal", "Gas", "Electricity“
- Variables: tpd, tpm, tfd, tfm, tgd, tgm
- Intensity of the shock:

	Shocks EU- Tax Rates		
	Firms	Private	Gov't
2 Coal	3	69	0
3 Oil	0	3	0
4 Gas	9	81	0
5 Oil_Pcts	208	477	0
6 Electricity	4	43	0

Change in CO_2 emissions

	Baseline scenario	Post simulation results	
	CO_2	Ch in CO_2 emissions	Ch% in CO_2emissions
1 USA	1500	-428	-29%
2 EU	911	63	7%
3 EEFSU	777	-93	-12%
4 JPN	337	-66	-20%
5 RoA1	258	-39	-15%
6 EEx	683	-148	-22%
7 CHIND	1081	-110	-10%
8 RoW	623	-166	-27%
Global	6170	-986	-16%

Welfare decomposition

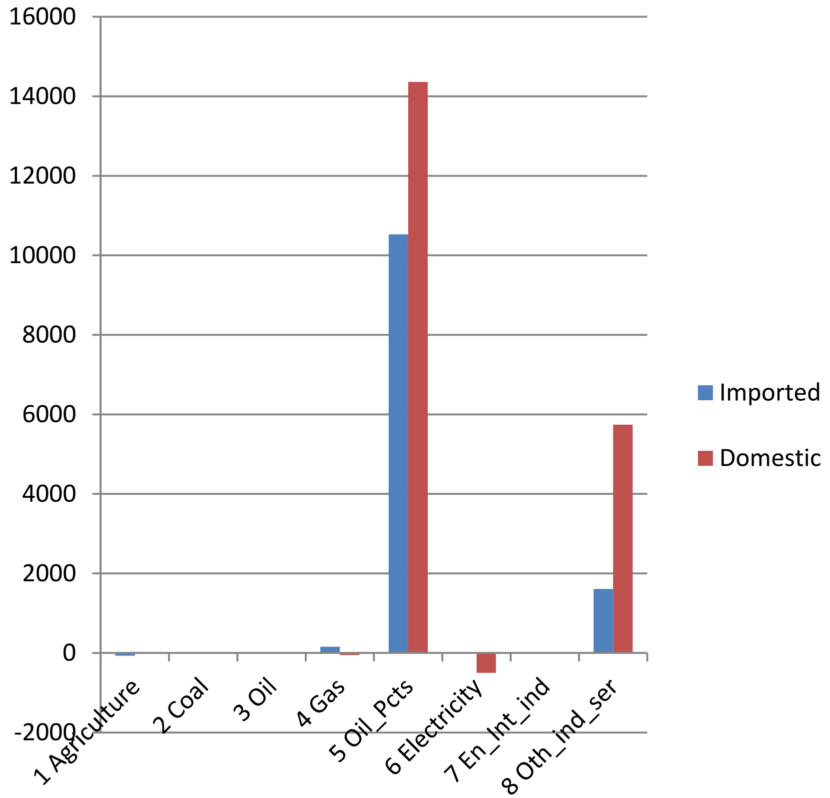
WELFARE	2 alloc_A1	6 tot_E1	7 IS_F1	Total
1 USA	-94098.5	17786.5	1392.9	-74919.1
2 EU	55248.6	32135	-947.3	86436.3
3 EEFSU	-20117	-7337.2	26.6	-27427.6
4 JPN	-41951.3	11862.7	-1167	-31255.6
5 RoA1	-17455.6	-5917.3	-316.5	-23689.4
6 EEx	-50653.3	-58698.6	265.5	-109086
7 CHIND	-35741.9	-2606.2	256.8	-38091.3
8 RoW	-50244.5	12303.4	481.7	-37459.4
Total	-255014	-471.7	-7.2	-255492

Allocative efficiency effect

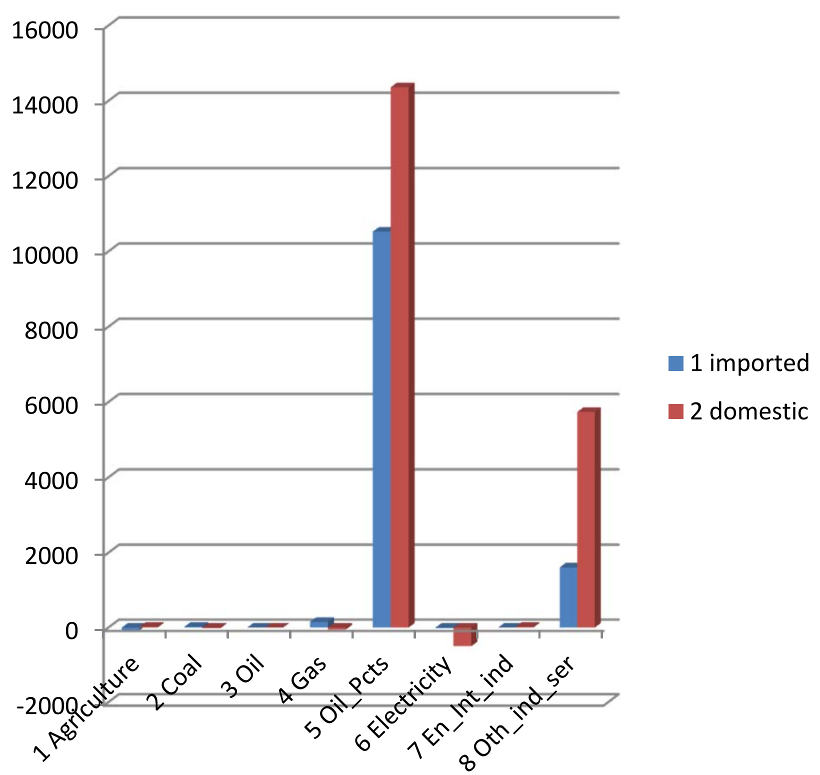
CNTalleffkr	1 pfacttax	2 prodtax	3 inputtax	4 contax	5 govtax	6 xtax	7 mtax	Total
1 USA	-25.7	40.7	**-45669.2**	**-48734.9**	0	7.9	282.7	**-94098.5**
2 EU	601.9	-173.4	**31803.9**	**18578.2**	0	493.1	3944.9	55248.6
3 EEFSU	-29.2	617.2	-12463.4	-6321.7	15	34.3	-1969.3	-20117
4 JPN	-10.7	-2478.5	-20036.9	-20091.4	0.3	-329.3	995.2	-41951.3
5 RoA1	-19.6	-1445.6	-6531	-9309.9	-3.3	119.6	-265.8	-17455.6
6 EEx	-15.6	-553.6	-23798.1	-20858.6	-40.2	723.8	-6111.1	-50653.3
7 CHIND	0	-5565.1	-18058.9	-9677.9	0	418.1	-2858.1	-35741.9
8 RoW	-6.2	-1879.5	-28017.8	-18486.5	1.6	-99.3	-1756.7	-50244.5
Total	494.9	-11437.8	-122772	-114903	-26.6	1368.3	-7738.2	-255014

Input tax effect

EU

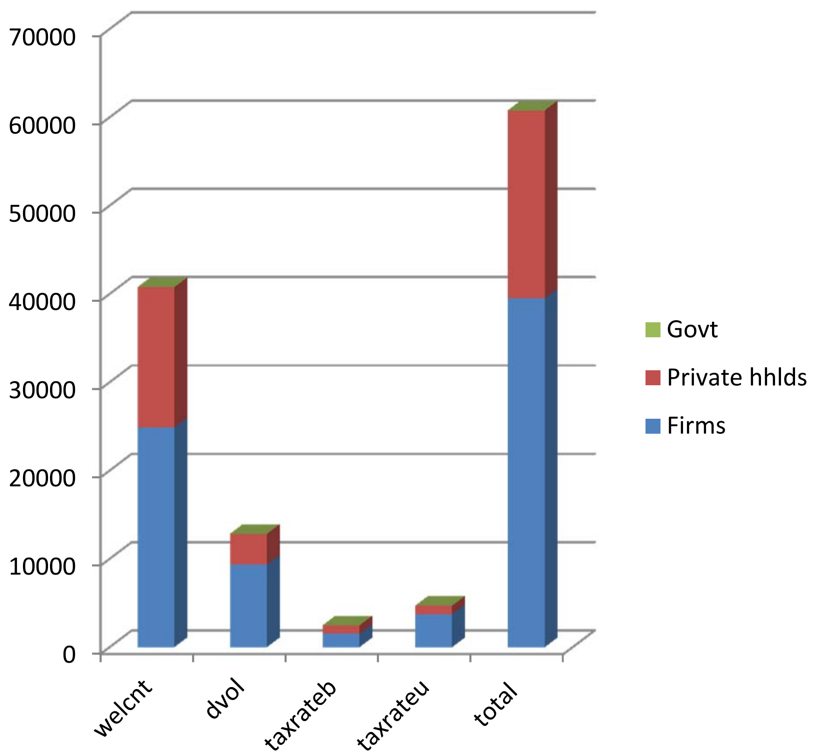


USA

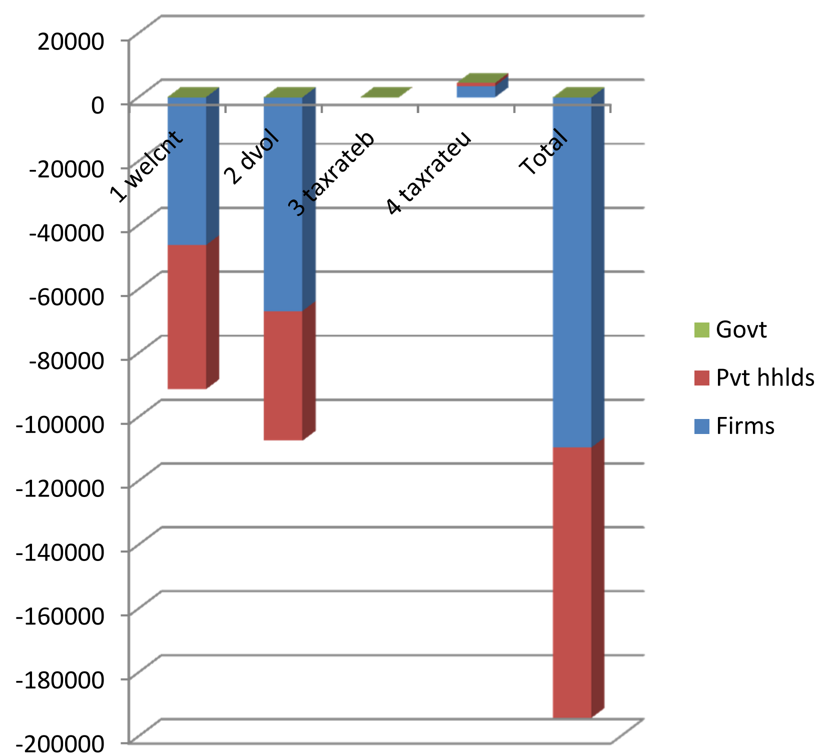


Analysis: Input tax effects

EU

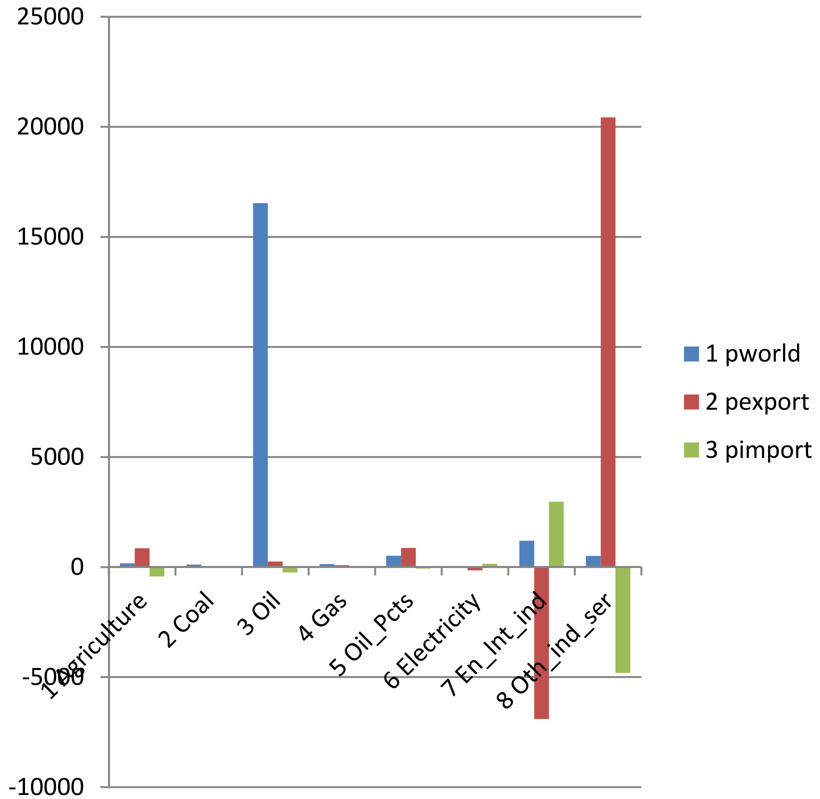


USA

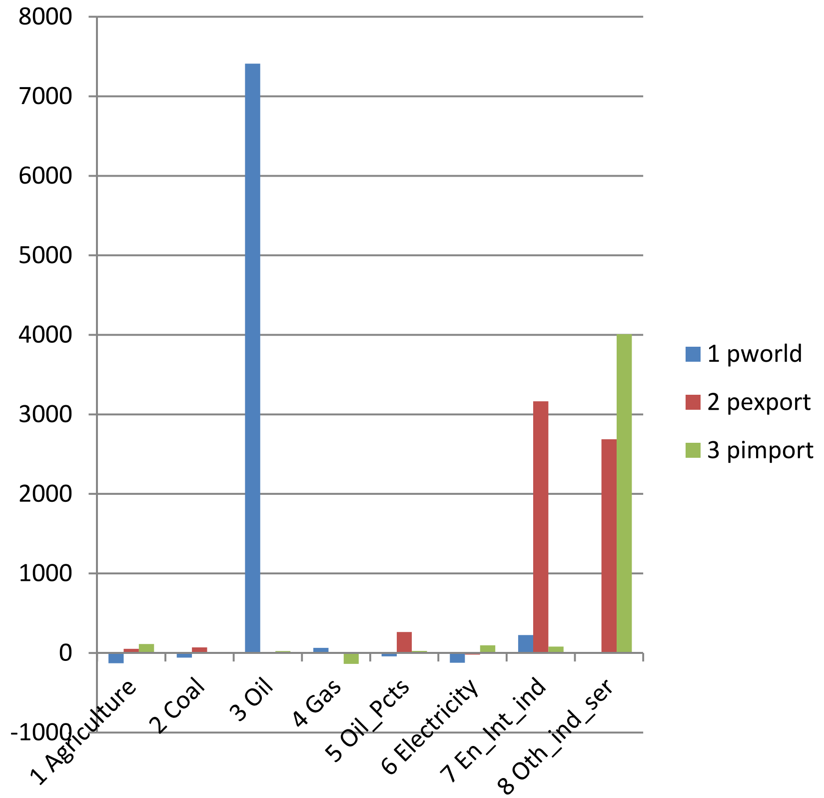


Terms of trade effects

EU



USA



Group 3
Using GTAP-E to analyze emissions reductions through quotas

Bella Tonkonogy & Naiquan Sang

- Original simulation: Kyoto developed country targets with and without trading (implemented on energy-related emissions, in million tons Carbon)
- Extension: “Common but differentiated responsibilities”: add quota for developing countries, leading to 20% global cut in emissions (from 14%)

Extension: Emissions Implications

REGION	SHOCK (% reduction)	EMISSIONS WITHOUT TRADE (% reduction)	EMISSIONS WITH TRADE (% reduction)
USA	-35.6	-35.6	-19.83
EU	-22.4	-22.4	-9.6
EEFSU	-10	-10	-20.41
Jpn	-31.8	-31.8	-10.57
RoA1	-35.7	-35.7	-14.9
Eex	-10	-10	-12.28
ChInd	-10	-10	-43.04
RoW	-10	-10	-13.94
TOTAL EMISSIONS REDUCTION		-20%	-20%

Extension:
Marginal Cost Implications

REGION	SHOCK (% reduction)	Marginal Cost WITHOUT TRADE (USD/ton C)	Marginal Cost WITH TRADE (USD/ton C)
USA	-35.6	128	53
EU	-22.4	150	53
EEFSU	-10	29	53
Jpn	-31.8	230	53
RoA1	-35.7	179	53
Eex	-10	49	53
ChInd	-10	6	52
RoW	-10	43	53
TOTAL EMISSIONS REDUCTION		-20%	-20%

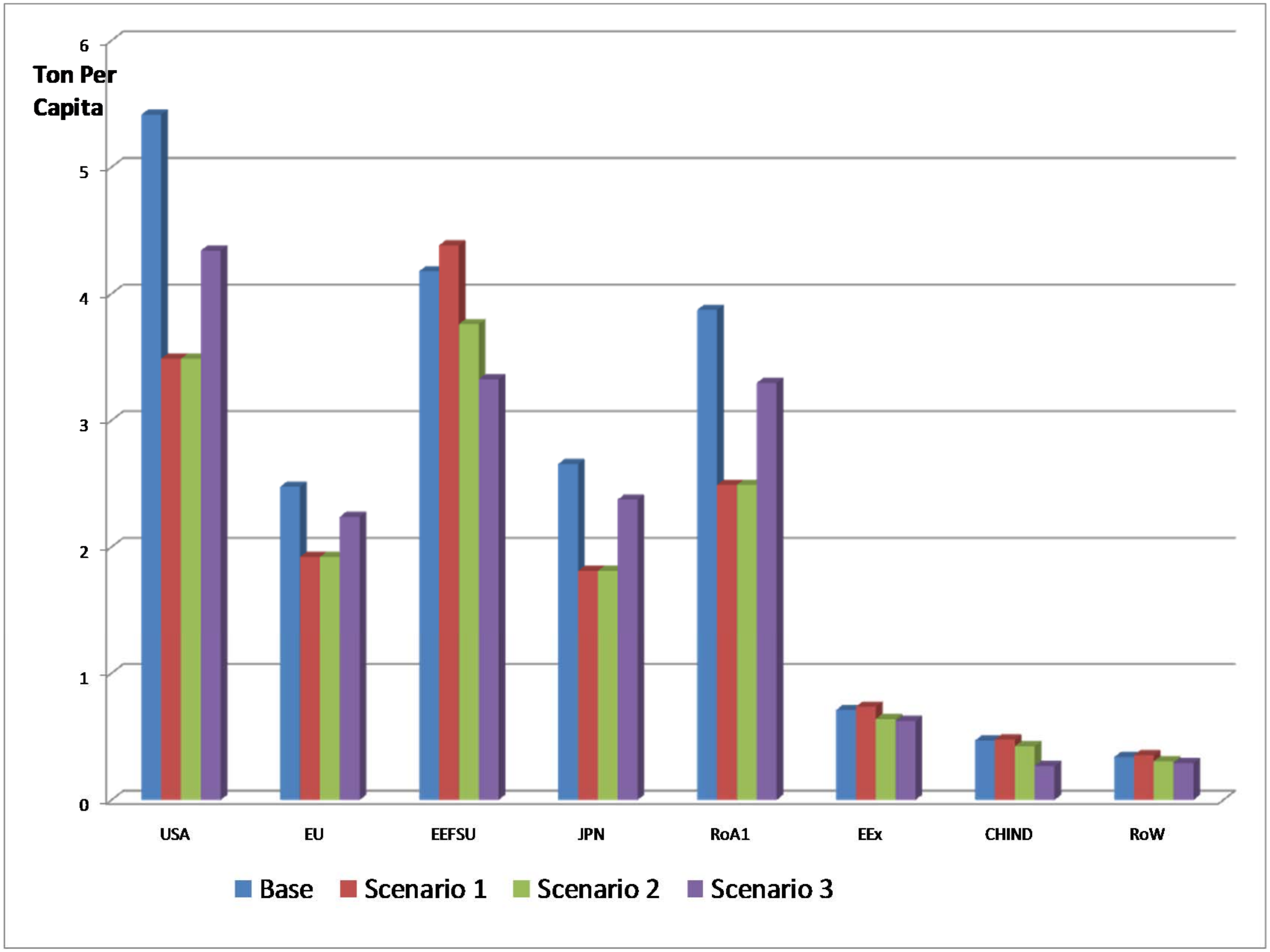
Emissions per Capita

Base:
No Quotas

Scenario 1: Kyoto Targets, no trading

Scenario 2: Kyoto Targets + Developing Country 10% Cut, no trading

Scenario 3: Kyoto Targets + Developing Country 10% Cut, with trading



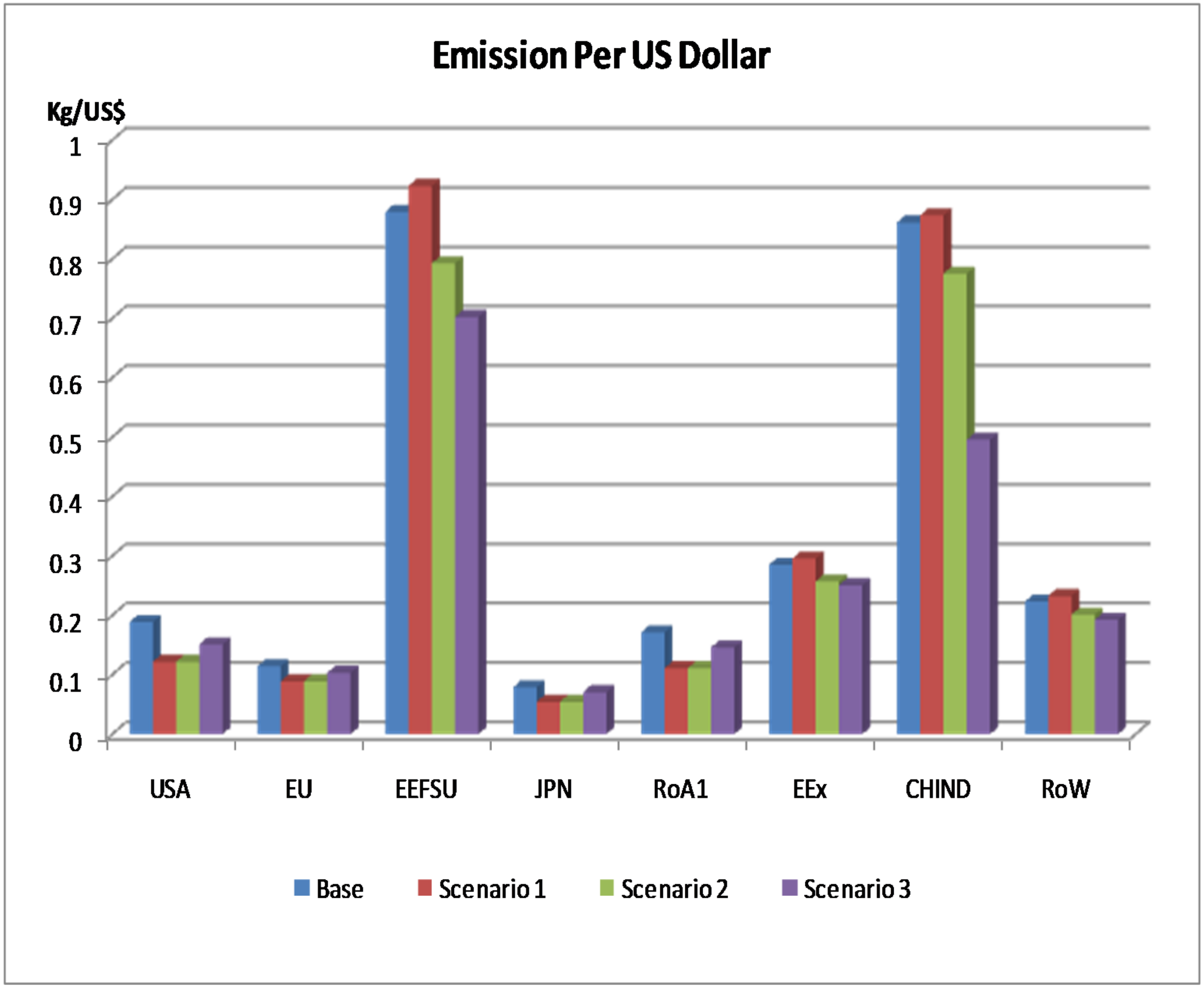
Emissions per GDP (U$)

Base:
No Quotas

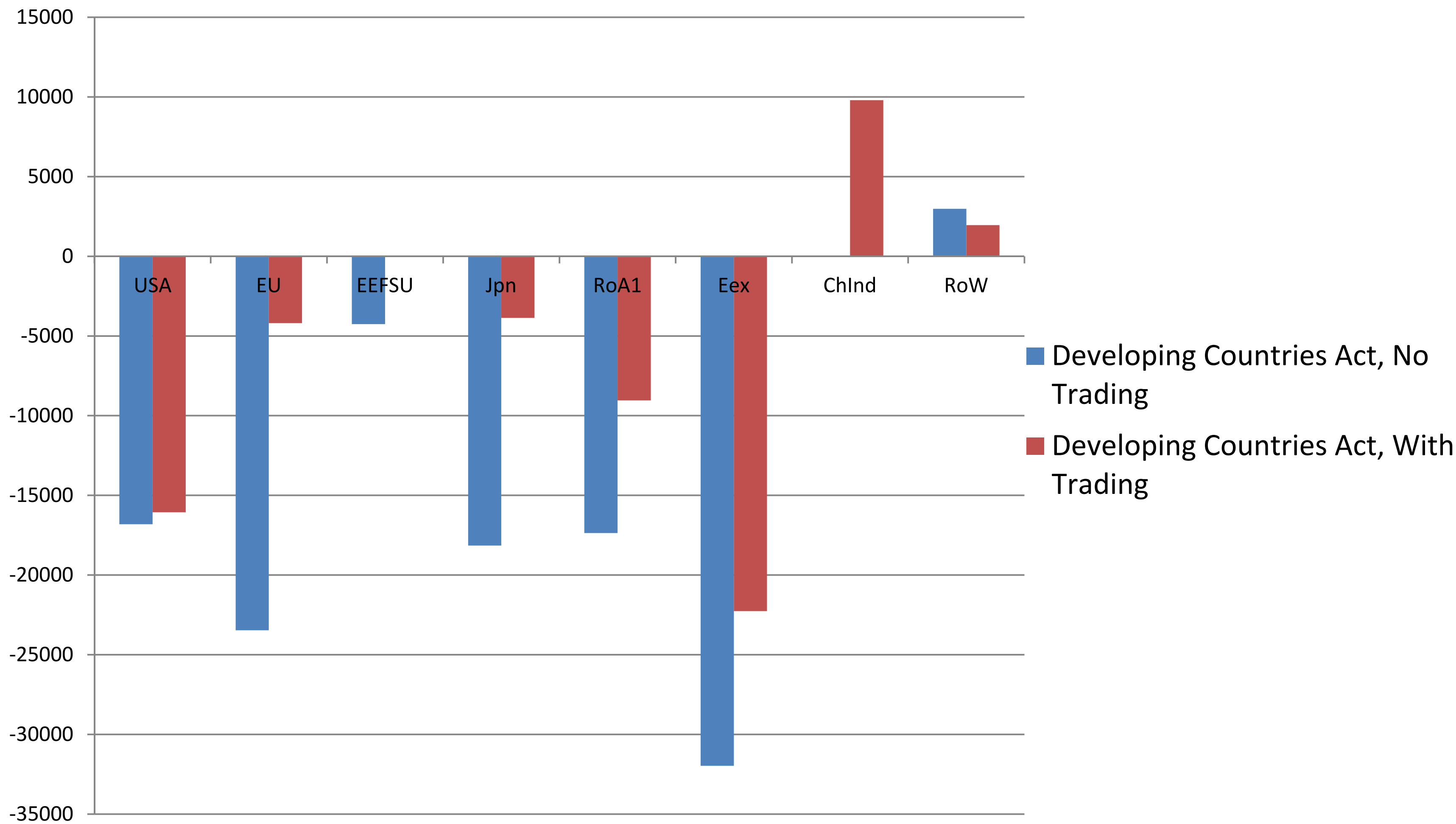
Scenario 1: Kyoto Targets, no trading

Scenario 2: Kyoto Targets + Developing Country 10% Cut, no trading

Scenario 3: Kyoto Targets + Developing Country 10% Cut, with trading



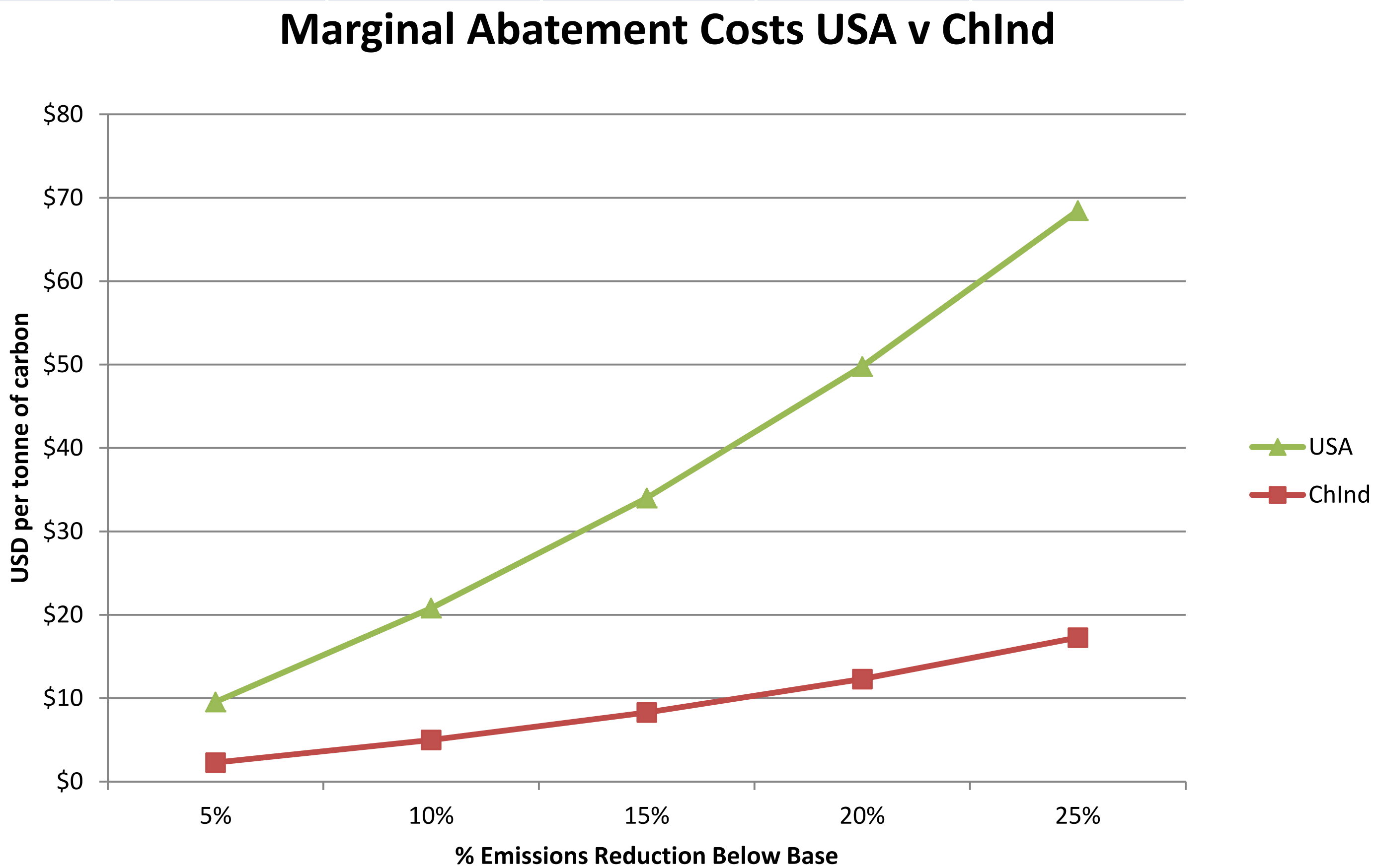
Welfare Implications of Emissions Quotas in all Countries



China/India Welfare Decomposition

WELFARE DECOMPOSITION	CO2 Trading	Allocative Efficiency	Terms of Trade	IS	Total	% of Initial Welfare
7 CHIND	18850	-12689	3877	-244	9795	0.9%

Illustration of data behind gains from CO2trading: marginal abatement cost curves



Energy Exporting Countries
Welfare Decomposition

WELFARE DECOMPOSITION	CO2 Trading	Allocative Efficiency	Terms of Trade	IS	Total	% of Initial Welfare
Energy Exporters	830	-5669	-17432	10	-22261	-1.1%

Terms of Trade Decomposition:

• general meaning: export prices declining in relation to import prices

• GTAP calculates ToT based on contributions (world price index, export price index, and import price index)

• World price index largest contributor

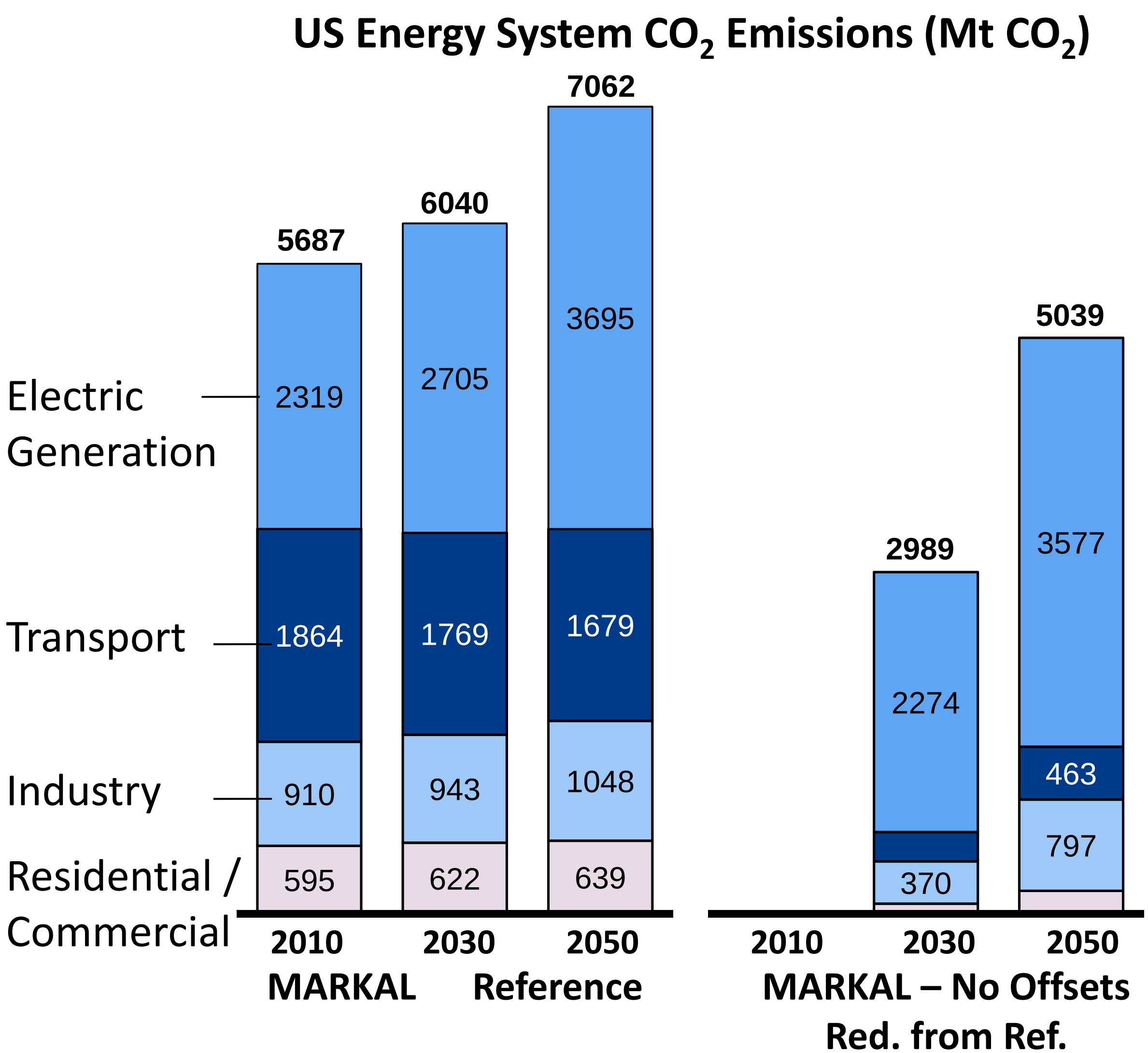
•aggregate share of crude oil exports in total exports from Energy Exporters is 26%

• price of oil declines by greater than 6% in all regions

Group 4
Sensitivity of emissions reduction costs to electricity system substitution elasticity in GTAP-E

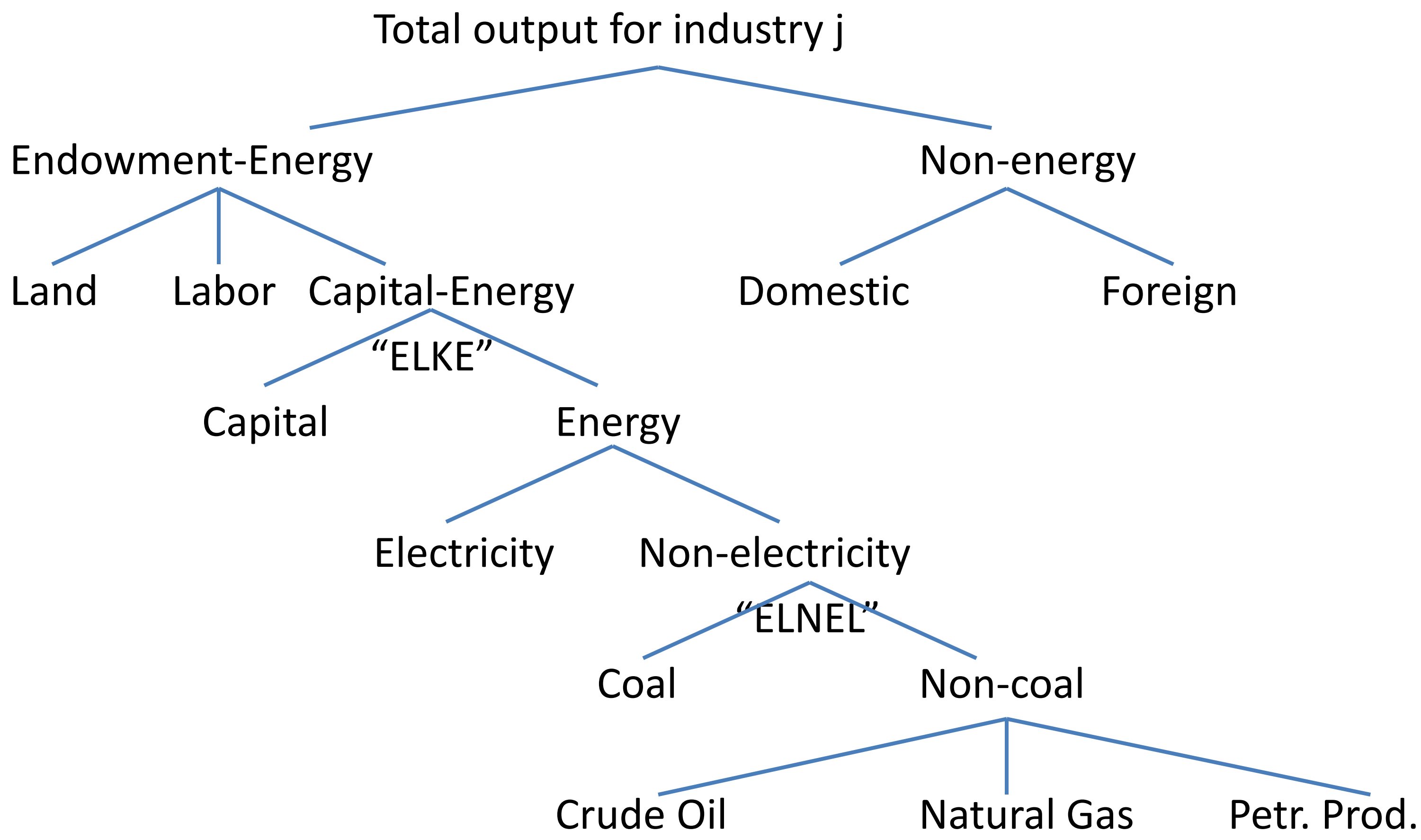
Bryan Mignone & Kemal Sarica

Motivation and Hypothesis



- The electricity sector tends to be quite responsive to price changes in large-scale energy system models
- In GTAP-E, the detailed energy system response is largely parameterized by the substitution elasticities
- Hypothesis: A more flexible energy system or longer time frame of analysis will lower overall compliance cost of policies to mitigate climate change

GTAP-E Production Structure



Study Design

j=ELECTRICITY, r=ALL REGIONS	Short-run elasticity	Default elasticity	Long-run elasticity
"ELKE" (K—E composite)	0.0	0.5	1.0
"ELNEL" (coal – non-coal composite)	0.0	0.5	1.0

Interpretation

- Change of ELKE represents the possibility of more flexible capital-energy substitution in electricity production (i.e. electricity with lower fossil fuel inputs relative to capital)
- Change of ELNEL represents the possibility of more flexible coal-to-gas substitution in electricity generation

Policy Objective/Shock

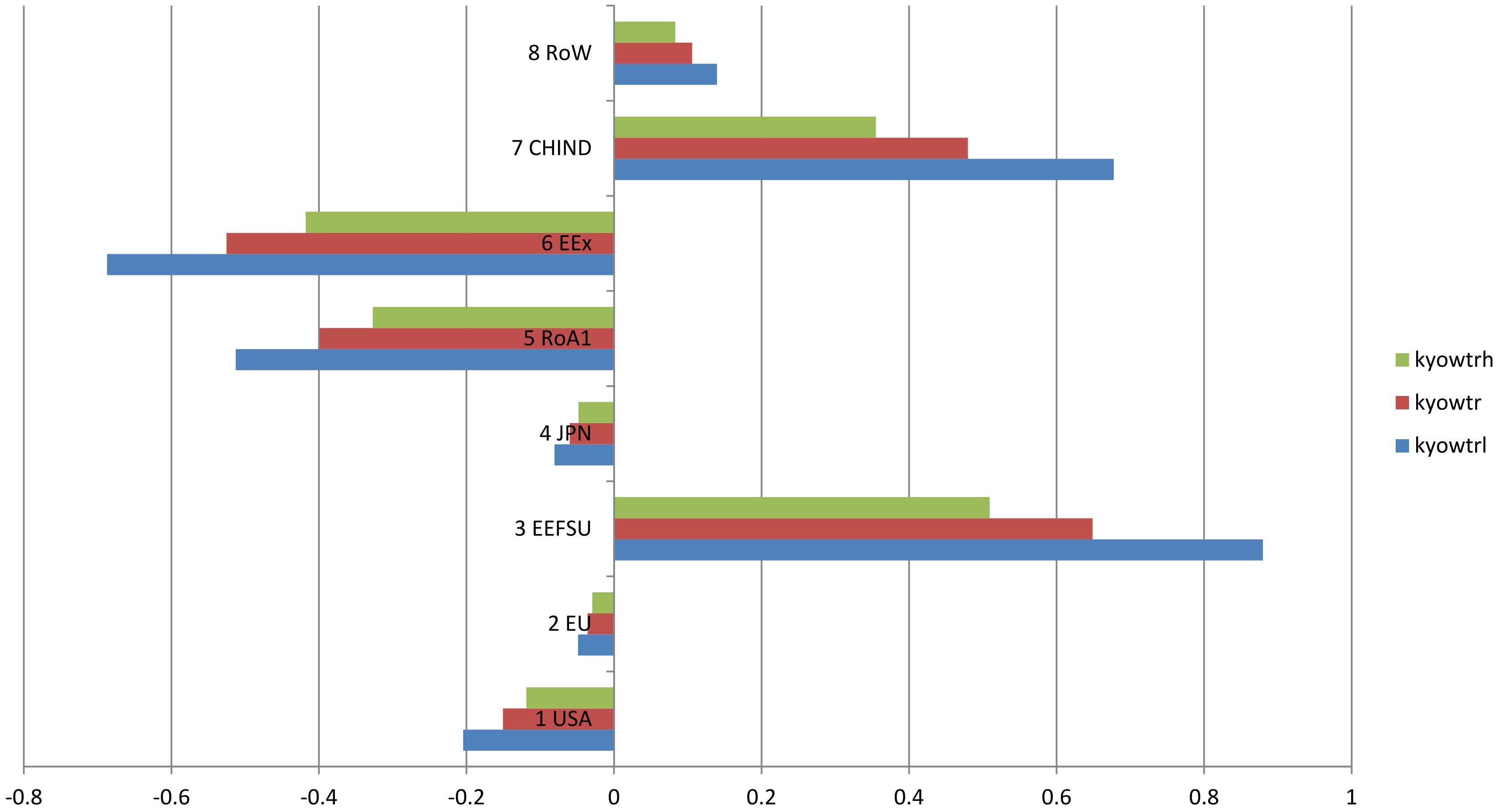
- Shock: Pre-loaded Kyoto experiment (~15% global reduction in CO_2) with trading among all regions
- Objective: Evaluate the sensitivity of the energy system and time horizon of analysis on cost of achieving the Kyoto emissions reduction targets

Abatement Costs

$/tonC	Short-run response	Default response	Long-run response
USA	38.54	28.63	22.49
EU	38.54	28.63	22.49
EEFSU	38.29	28.49	22.41
JAPAN	38.53	28.62	22.48
Rest Annex I	38.61	28.67	22.52
E Exporters	38.65	28.69	22.53
China/India	38.14	28.41	22.37
ROW	38.46	28.53	22.46

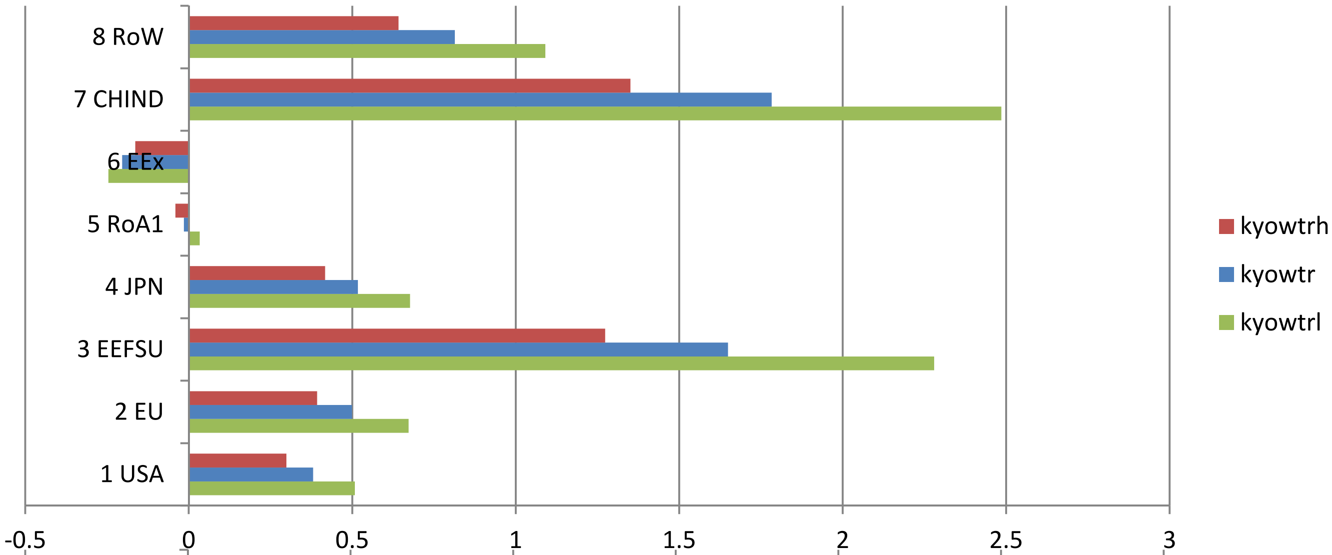
- Global emissions trading harmonizes the resulting carbon price
- In all scenarios, total quantity of emissions reduction is identical

Welfare
Utility change by region

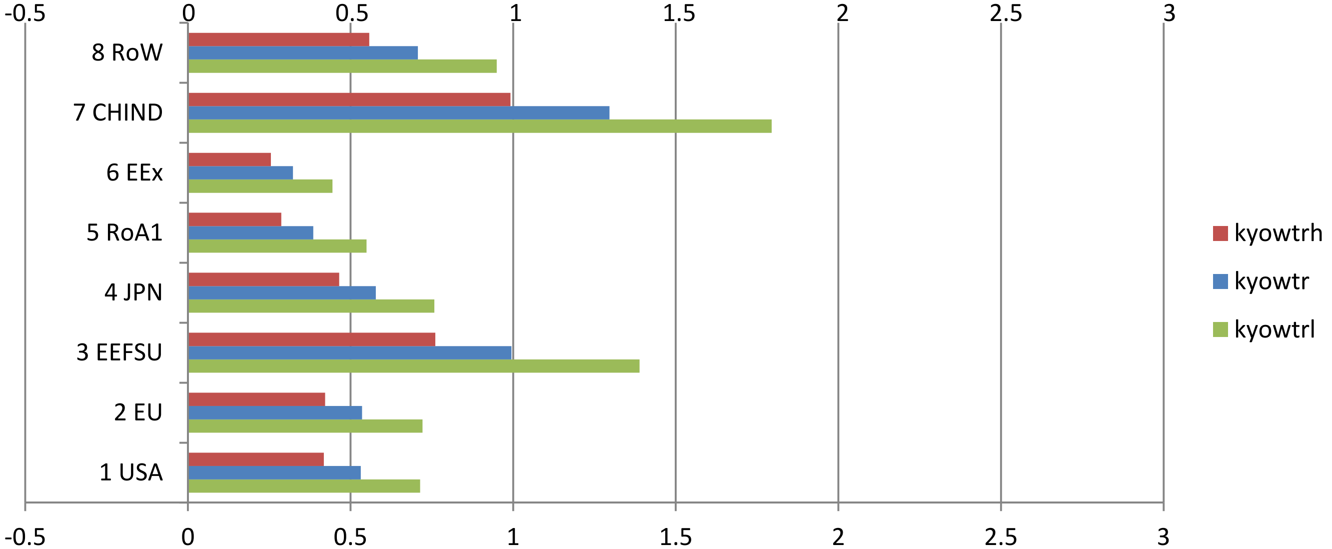


Welfare
Utility change by region

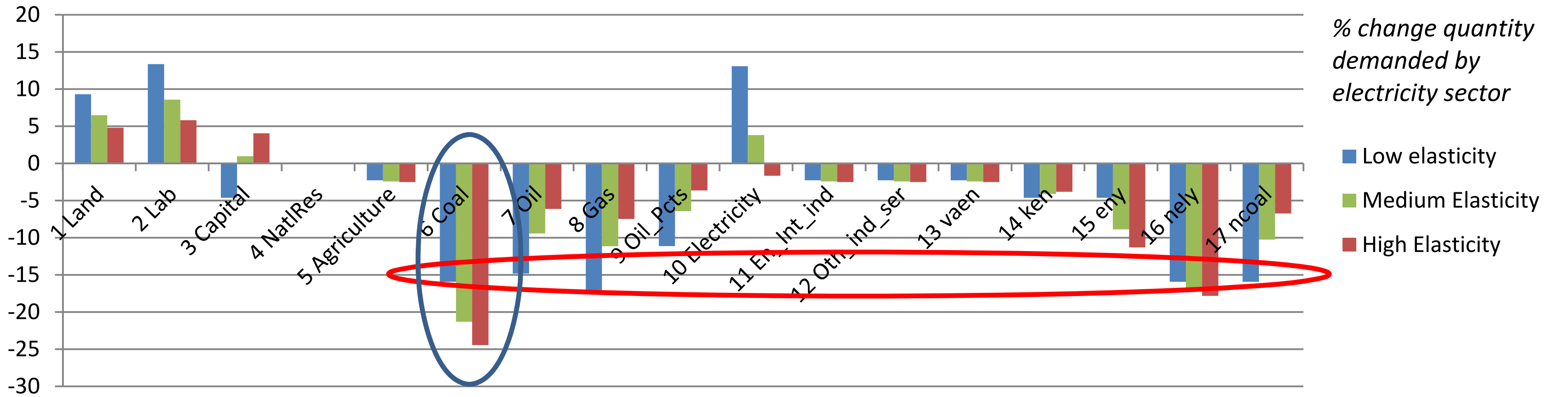
Regional income y(r)

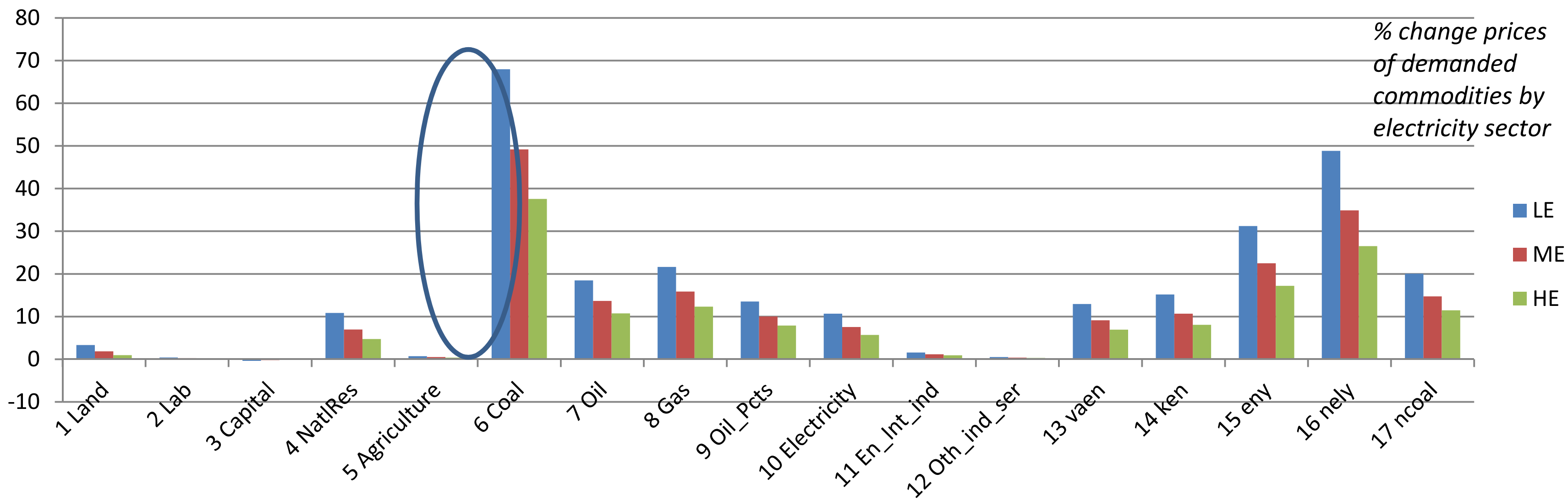


Price index p(r)

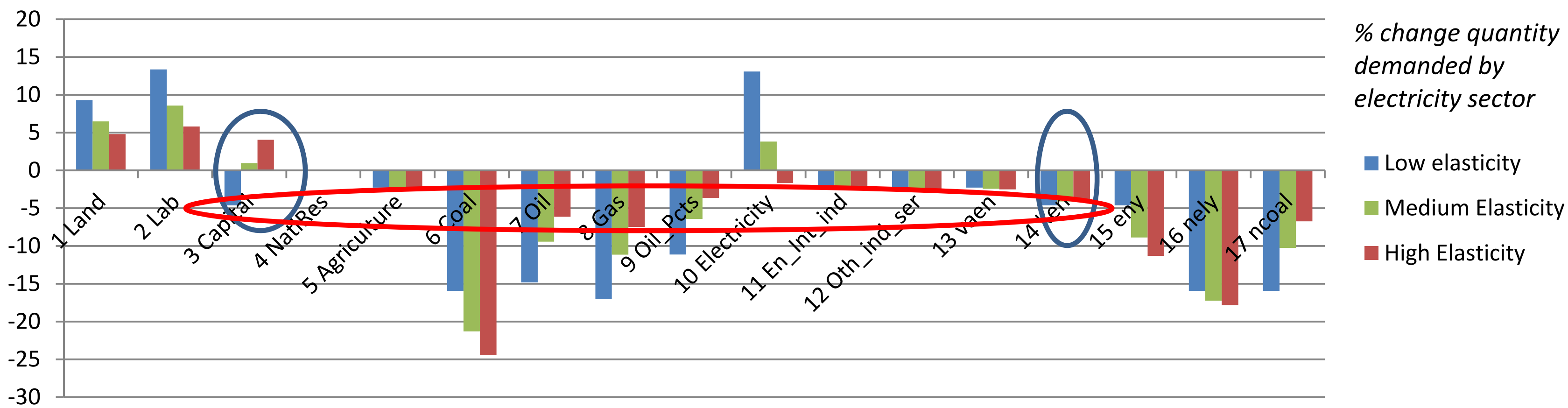


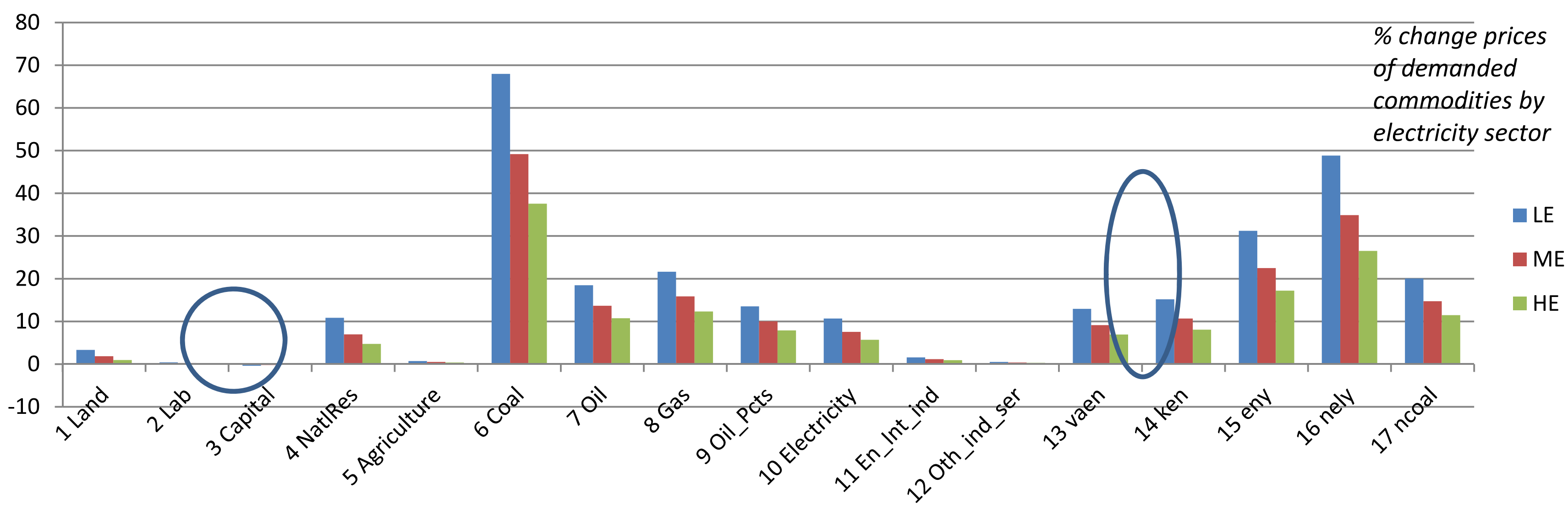
Effects of Nest at Coal – Non-coal Composite





Effects of Nest at Energy -Capital





Conclusions

- GTAP-E is a global energy model, which modifies standard GTAP to include an energy-capital substitution nest
- We used GTAP-E to evaluate several climate policy instruments
  - Carbon taxes
  - Changes to fossil fuel subsidies/taxes
  - Carbon permits/quotas
- These policy instruments can be applied to the world or selectively among both individual regions and user-defined trading blocs (such as “Annex I” countries in the Kyoto Protocol).
- Key outputs of GTAP-E are emissions reductions (regional and global), costs per ton emissions reduced, and implications for welfare of individual regions.
- However, GTAP-E is limited by its structure.
  - Most abatement comes from substitution
  - Few technology options
  - Static model