

**Can the cost burden of Kyoto be relieved through trade liberalization with non-Kyoto countries?**

**If so, what are the CO<sub>2</sub> emissions and economic implications?**

# Methodology - Decomposition

- $KP \text{ and } TL = KP + TL + KP*TL$ 
  - KP = Kyoto Annex 1 with emissions trading
  - TL = Annex 1 trade liberalization with non-Annex 1

$$KP*TL = (KP \text{ and } TL) - KP - TL$$

- Hypothesis: carbon leakage to non-Kyoto countries through foreign production of non-CO<sub>2</sub> taxed products
- Products are taxed at point of demand (i.e. includes imports)
- US firms' share of total demand
  - Coal (1.0), oil (1.0), gas (0.9), oil products (0.7), electricity (0.8)

# Experiment

- Shock: elimination of US import tariffs on non-CO<sub>2</sub> taxed tradables from non-Kyoto countries
  - Agriculture, Energy Intensive Industries, Other Industries and Services
- CO<sub>2</sub> emitting products: coal, oil, gas, oil products, and electricity
- **Summary Results**
  - Global emissions rise (319 MMTCO<sub>2</sub>)
  - Market price of CO<sub>2</sub> falls
    - Most Kyoto participants benefit from decline in average cost of emissions—not EEFSU
  - Increase in energy intensive imports from non-Kyoto regions

# Results – KP \* TL Interaction

| Welfare | KP & TL  | KP       | TL      | KP * TL |
|---------|----------|----------|---------|---------|
| 1 USA   | -25036.4 | -18814.2 | -6307.2 | 85.1    |
| 2 EU    | -21225.0 | -19048.0 | -2304.3 | 127.4   |
| 3 EEFSU | 20556.6  | 20855.4  | -130.4  | -168.4  |
| 4 JPN   | -10695.0 | -9731.0  | -1032.2 | 68.1    |
| 5 RoA1  | -12770.4 | -11451.0 | -1362.4 | 42.9    |
| 6 EEx   | -13532.9 | -15329.7 | 1652.8  | 144.0   |
| 7 CHIND | 4914.8   | 611.2    | 4318.1  | -14.6   |
| 8 RoW   | 10548.4  | 3330.8   | 7306.8  | -89.2   |
| Total   | -47239.8 | -49576.4 | 2141.3  | 195.3   |

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## Import Shares

|             | IMP shr | EEx   | CHIND | Row   |
|-------------|---------|-------|-------|-------|
| Agriculture | 0.082   | 0.030 | 0.004 | 0.024 |
| En_int_ind  | 0.141   | 0.010 | 0.006 | 0.013 |
| Others      | 0.064   | 0.025 | 0.002 | 0.007 |

## Import Tariffs (%)

|             | EEx   | CHIND | RoW   |
|-------------|-------|-------|-------|
| Agriculture | 12.53 | 10.25 | 12.48 |
| En_int_ind  | 1.39  | 4.18  | 3.05  |
| Others      | 1.70  | 5.75  | 4.21  |

# Conclusions

- Trade liberalization benefits can be moderated or enhanced by Kyoto
- However, CO<sub>2</sub> leakage can result—increased global emissions
- Interaction effects seem to exist and to depend on import shares and tariff magnitudes
- Interaction effects concerning the US are small
- Social welfare vs. GTAP welfare
- Future research opportunities

# The GTAP- E Model

## The 8 regions are:

United States  
European Union  
Eastern Europe and FSU  
Japan  
Oth. Annex 1 countries  
Net Energy Exporters  
China and India  
Rest of the World

## The 8 sectors are:

Agriculture  
Coal Mining  
Crude oil  
Natural gas extraction  
Refined oil products  
Electricity  
Energy intensive industries  
Other industries and  
services

Special is the Production Nest for Energy Inputs!

# Core Experiments

- Kyoto without emissions trading
- Kyoto with emissions trading

## Shock: Reduce Carbon Emissions

|          |        |
|----------|--------|
| US       | -36%   |
| EU       | -22.4% |
| Japan    | -31.8% |
| RoAnnex1 | -35.7% |

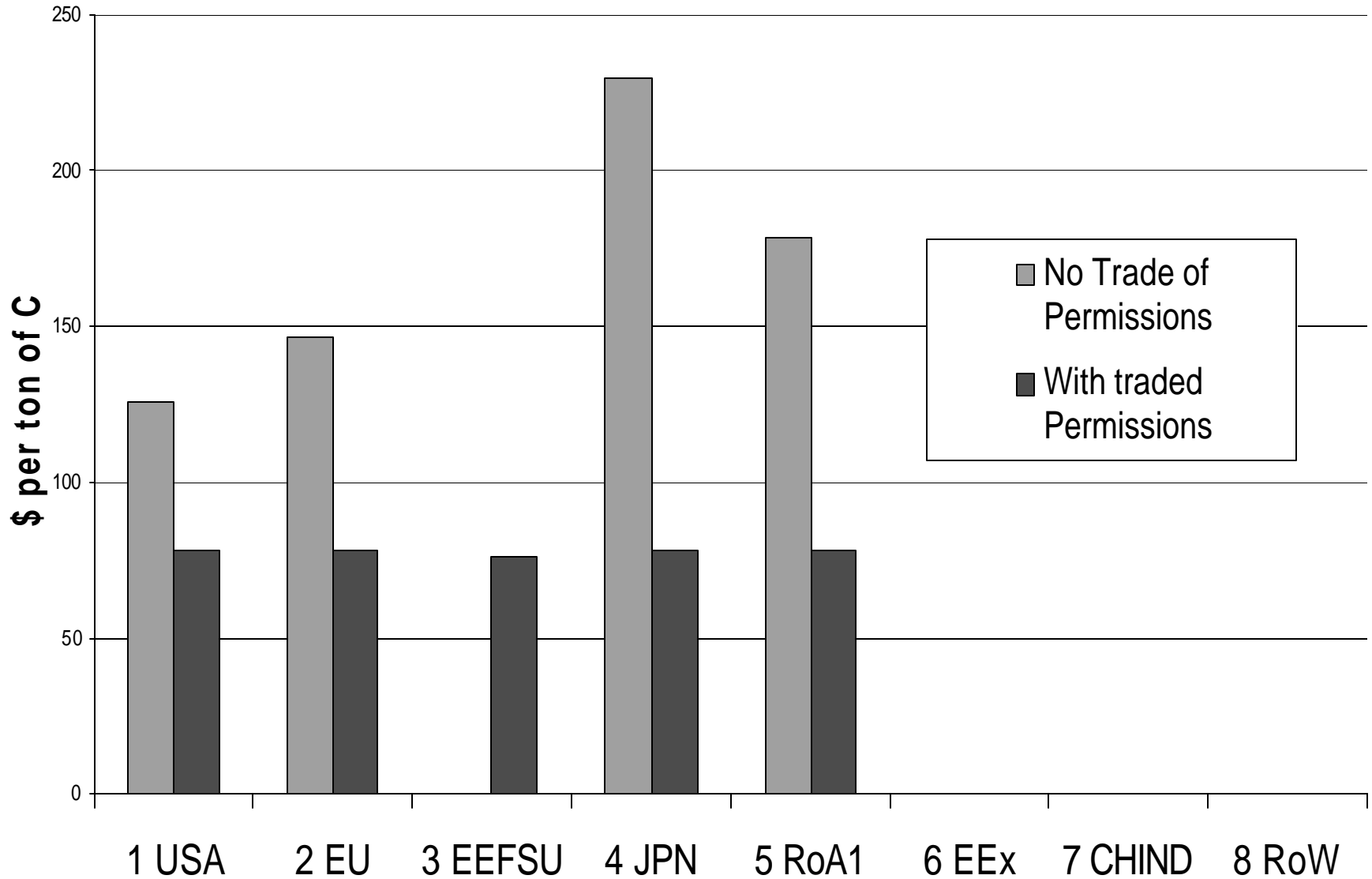
## Objective:

Find optimal CO2 Emissions Tax (endog)...

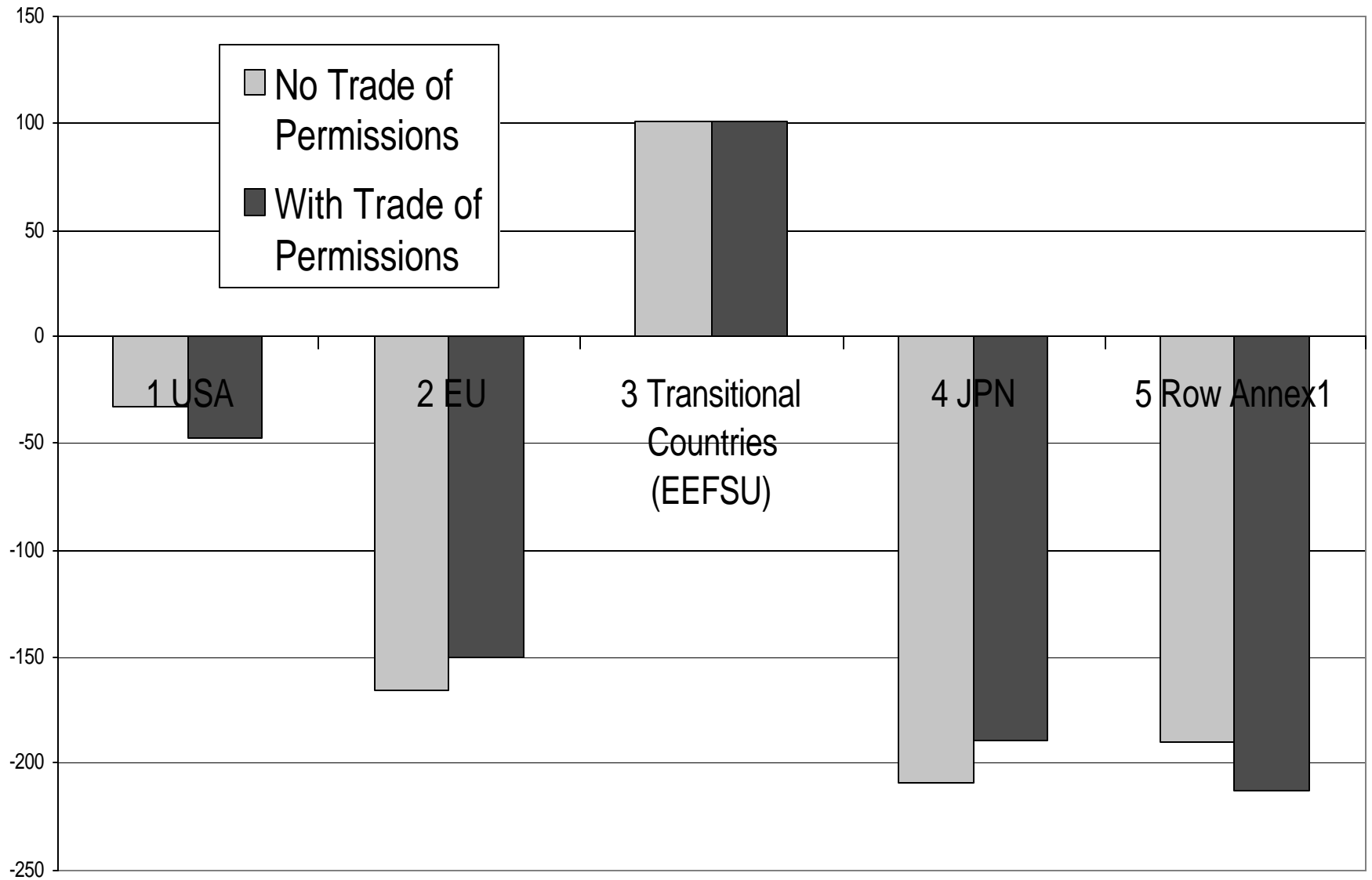
... for given (exog.) Reductions of CO2 output.



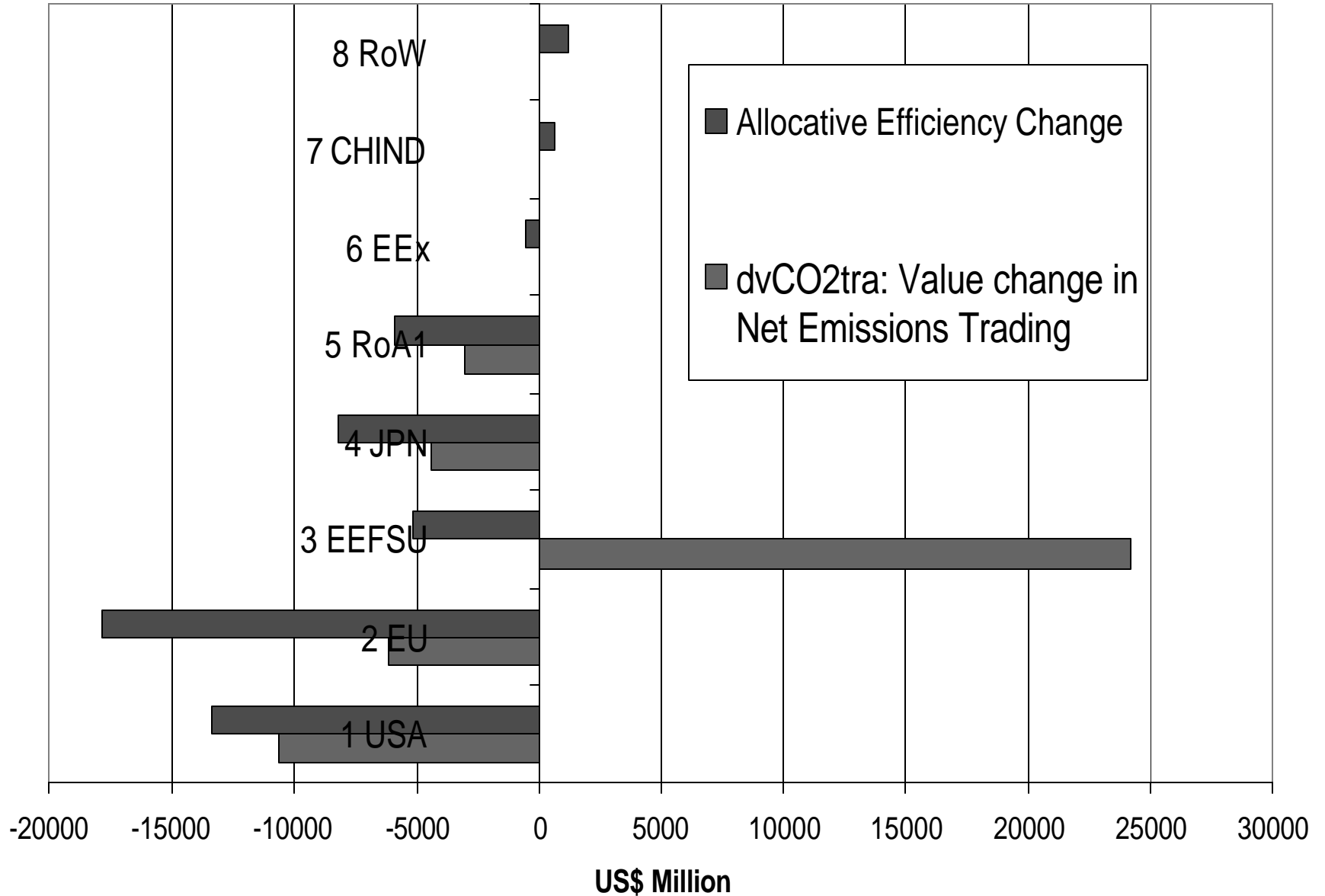
# "Kyoto" Tax on Carbon Emissions by Region



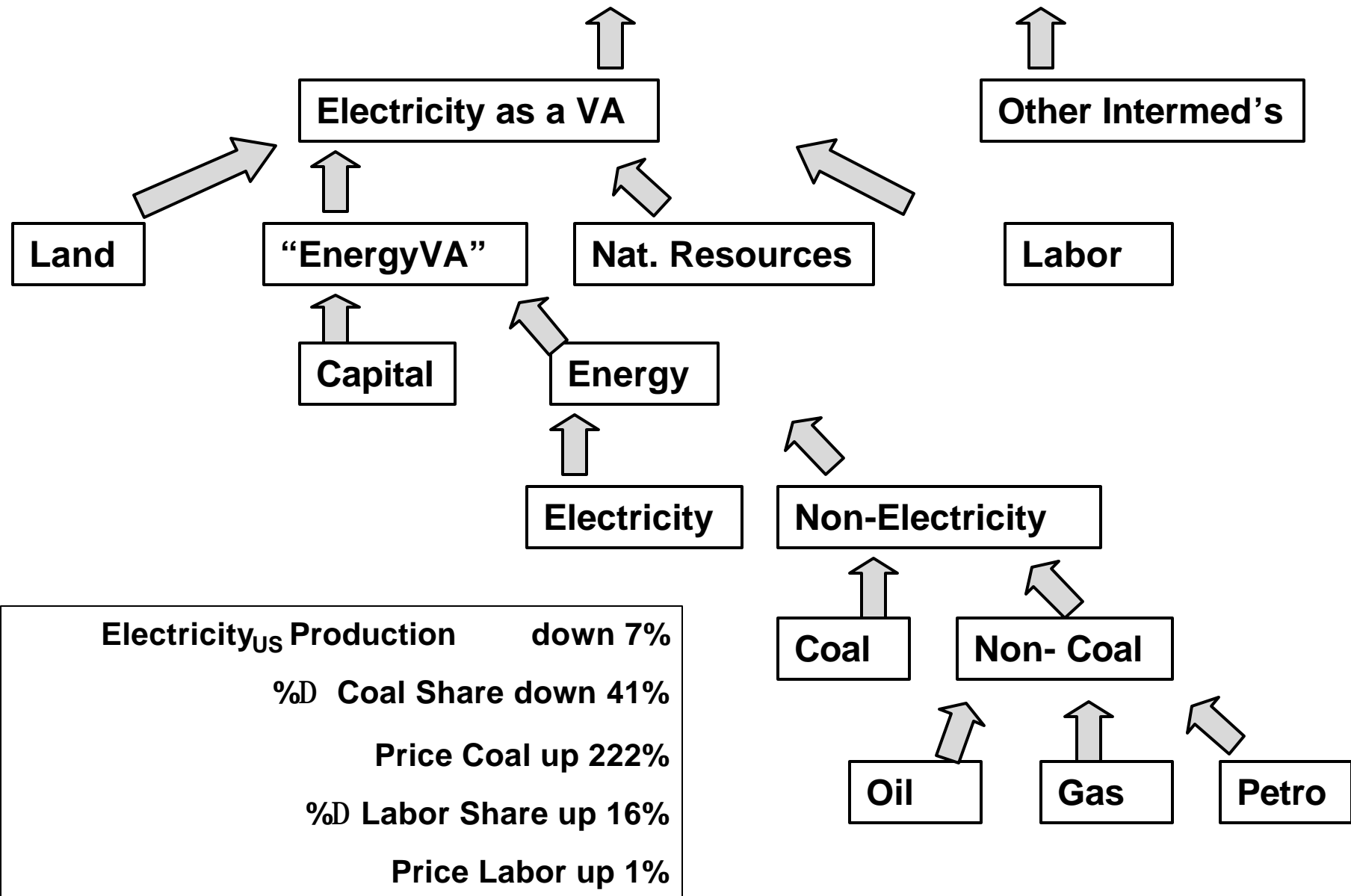
## Welfare Change per abated Ton of Carbon



# Region's Adaption Process in Order to achieve Global Reduction



# The Effects of a CO2 Tax in GTAPE



# Shock: Kyoto Protocol with global trading

- Quotas identical to Kyoto Protocol
- Introduce international trade
- Economic theory suggests that by maximizing participation, total costs will be minimized
- Hypothesis: compared to the original Kyoto Protocol, we expect the permit price to fall - leading to a smaller EV loss

# The permit market

- New sellers push price down – EEFSU loses out

| <b>Permit Flows (MtCO<sub>2</sub>)</b> | <b>World trading</b> | <b>A1 trading</b> |
|----------------------------------------|----------------------|-------------------|
| <b>USA</b>                             | -343                 | -135              |
| <b>EEFSU</b>                           | 201                  | 307               |
| <b>JPN</b>                             | -86                  | -56               |
| <b>CHIIND</b>                          | 344                  | 0                 |
| <b>GLOBAL VOLUME</b>                   | 648                  | 307               |

| <b>Scheme</b>  | <b>Permit Price (\$/tCO<sub>2</sub>)</b> |
|----------------|------------------------------------------|
| KP world trade | 29.8                                     |
| KP A1 trade    | 78.72                                    |

# Output

- Energy outputs fall, but worldwide trading distributes the burden

|               | <b>qo (%)</b> | <b>Coal</b> | <b>Gas</b> | <b>Oil Products</b> |
|---------------|---------------|-------------|------------|---------------------|
|               |               |             |            |                     |
|               | USA           | -21         | -11        | -7                  |
| World trading | EEFSU         | -22         | -9         | -3                  |
|               | JPN           | -19         | -9         | -2                  |
|               | CHIIND        | -38         | -18        | -4                  |
|               |               |             |            |                     |
|               | USA           | -38         | -25        | -17                 |
| A1 trading    | EEFSU         | -39         | -19        | -9                  |
|               | JPN           | -25         | -20        | -6                  |
|               | CHIIND        | -2          | -1         | 2                   |

# EV

- Buying countries get more permits for their dollar, and undertake less abatement at home. World total EV loss roughly halved.

|                      | (million\$) | <b>Trading<br/>Contribution</b> | <b>Alloc<br/>Contribution</b> |
|----------------------|-------------|---------------------------------|-------------------------------|
|                      | USA         | -10187                          | -2853                         |
| <b>World Trading</b> | EEFSU       | 5957                            | -1089                         |
| (-22297)             | JPN         | -2561                           | -2038                         |
|                      | CHIIND      | 10159                           | -7246                         |
|                      |             |                                 |                               |
|                      | USA         | -10549                          | -13363                        |
| <b>A1 Trading</b>    | EEFSU       | 23764                           | -5202                         |
| (-49576)             | JPN         | -4371                           | -8208                         |
|                      | CHIIND      | 0                               | 654                           |



# CHIIND dominance of carbon market (1/2)

- Substitution elasticities in energy nests are constant across regions – look for other reasons:

|                    | <b>CO2<br/>(MtCO2)</b> |
|--------------------|------------------------|
| <b>USA</b>         | 1499                   |
| <b>EEFSU</b>       | 777                    |
| <b>JPN</b>         | 337                    |
| <b>CHIIND</b>      | 1081                   |
| <b>World Total</b> | 6170                   |

Large share of world emissions

|              | <b>Coal</b> | <b>Oil</b> | <b>Gas</b> | <b>Ref<br/>Oil</b> |
|--------------|-------------|------------|------------|--------------------|
| <b>USA</b>   | 54          | 18         | 17         | 13                 |
| <b>EEFSU</b> | 62          | 19         | 18         | 12                 |
| <b>JPN</b>   | 41          | 18         | 11         | 4                  |
| <b>CHIND</b> | 193         | 18         | 23         | 10                 |

Lower cost fuels, esp. coal

# CHIIND dominance of carbon market (2/2)

- Energy use in firms gives more opportunity to abate

|                                              |        | <b>Energy Intense Industries</b> | <b>Other Industries/Services</b> |
|----------------------------------------------|--------|----------------------------------|----------------------------------|
|                                              | US     | 47%                              | 53%                              |
| <b>electricity (as share of energy nest)</b> | JPN    | 54%                              | 61%                              |
|                                              | CHIIND | 43%                              | 45%                              |
|                                              | EEFSU  | 47%                              | 46%                              |
|                                              |        |                                  |                                  |
|                                              | US     | 53%                              | 47%                              |
| <b>fuels (as share of energy nest)</b>       | JPN    | 46%                              | 39%                              |
|                                              | CHIIND | 57%                              | 55%                              |
|                                              | EEFSU  | 53%                              | 54%                              |
|                                              |        |                                  |                                  |
| <b>coal (as share of fuels nest)</b>         | US     | 3%                               | 0%                               |
|                                              | JPN    | 5%                               | 0%                               |
|                                              | CHIIND | 16%                              | 8%                               |
|                                              | EEFSU  | 13%                              | 4%                               |

# Kyoto Without the US

- **Baseline:**

Kyoto with all annex 1 regions trading emission permits.

- **Extension:**

The US opts out of Kyoto protocol.

Remaining annex 1 regions implement existing Kyoto emission reduction targets.

# Welfare Effects (\$M)

|                      | With US | Without US |
|----------------------|---------|------------|
| USA                  | -18,814 | 301        |
| European Union       | -19,048 | -16,533    |
| Former Soviet Union  | 20,855  | 9,942      |
| Japan                | -9,731  | -7,264     |
| Rest Annex 1         | -11,451 | -6,347     |
| Net Energy Exporters | -15,329 | -4,444     |
| China & India        | 611     | 18         |
| Rest of World        | 3,330   | 656        |
| Total                | -49,576 | -23,670    |

# Welfare Comparison: Baseline v Kyoto without US

|                      | Carbon Trading | Allocative Efficiency | Terms of Trade | Total         |
|----------------------|----------------|-----------------------|----------------|---------------|
| USA                  | 10,548         | 13,306                | -4,578         | 19,115        |
| European Union       | 1,001          | 4,699                 | -3,347         | 2,515         |
| Former Soviet Union  | -13,172        | 3,091                 | -746           | -10,912       |
| Japan                | 1,213          | 3,078                 | -1,978         | 2,466         |
| Rest Annex 1         | 589            | 2,550                 | 1,966          | 5,103         |
| Net Energy Exporters | 0              | 254                   | 10,615         | 10,885        |
| China & India        | 0              | -480                  | -135           | -592          |
| Rest of World        | 0              | -864                  | -1,705         | -2,674        |
| <b>Total</b>         | <b>180</b>     | <b>25,635</b>         | <b>89</b>      | <b>25,906</b> |

# Permit Trading

- “Hot Air”: Former Soviet Union is seller of permits.
- US opts out of Kyoto: no longer trades permits.

World demand for permits falls: Price ↓

- Remaining of Annex 1 regions buy more.

Emission reductions achieved by trading ↑

- CO2 tax level required to achieve Kyoto target reduced.



# Terms of Trade


- **Baseline: international energy prices fall.**

Annex 1 regions are net energy importers  terms of trade gain.

Non-trading regions: net energy exporters  terms of trade loss.

- **US opts out of Kyoto:**

 Fall in world energy prices reduced.

 Terms of trade gain reduced for remaining annex 1 regions.