Climate Policy and International Spillovers

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Outline:

- **Climate Policy Background:**
  - History
  - Inventory
- **Analysis of the Kyoto Protocol:**
  - Issues and scenarios
  - Analytical framework and parametrization
  - Results
- **International Spillovers:**
  - Issues
  - Decomposition techniques (idea and application)

History:

- **Rio 1992 - World Summit: Framework Convention (UNFCC)**
  - general agreement on climate protection policies
  - unspecified, no concrete obligations

- **Kyoto 1997 - COP3: Kyoto Protocol**
  - QELROs (*q*uantified *e*mission *l*imitation and *r*eduction *o*bjectives) for industrialized countries as listed in Annex-B
  - targeted Annex-B reduction: 5.2% below 1990 emission levels (2008-2012)
  - double trigger for enforcement: ratification by 55 countries that account for at least 55 % of industrialized world's CO_2 emission in 1990

History:

- **3/2001: U.S. withdrawal**
  - "As you know, I oppose the Kyoto Protocol because {it} ... would cause ... serious harm to the U.S. economy" (G.W. Bush)
  - Byrd-Hagels resolution (1997)

- **Bonn 7/2001 and Marrakesh 8/2001:**
  - carbon sink credits
  - unrestricted Annex-B emissions trading (hot air)

- **South Africa 2002 (Rio+10) - World Summit:**
  - Kyoto Protocol into force?

Inventory:

Region	Baseline Emissions (MtC)[a]		Nominal Reduction (% wrt 1990)[b]		Effective Reduction (% wrt 2010)		Absolute Cutback (MtC wrt 2010)	
	1990	2010	Old	New	Old	New	Old	New
CAN	126	165	6.0	-7.9	28.2	17.6	47	29
CEA	279	209	7.1	3.9	-24.0	-28.3	-50	-59
EUR	930	1040	7.8	5.2	17.5	15.2	182	158
FSU	853	593	0	-4.9	-43.8	-50.9	-260	-302
JPN	269	330	6.0	0.8	23.4	19.1	77	63
OOE	88	130	-6.8	-10.2	27.7	25.4	36	33
USA	1345	1809	7.0	3.2	30.9	28.0	558	507
Total US in[a]	3890	4276	**5.2**	1.1	**13.8**	10.0	590	429
Total US out[b]	2545	2467	4.3	**0**	1.3	**-3.2**	32	**-78**

Key: CAN - Canada, CEA- Central and Eastern Europe, EUR - OECD Europe (incl. EFTA), FSU - Former Soviet Union (incl. Ukraine), JPN - Japan, OOE - Australia and New Zealand

[a] Annex-B with U.S. compliance [b] Annex-B without U.S. compliance

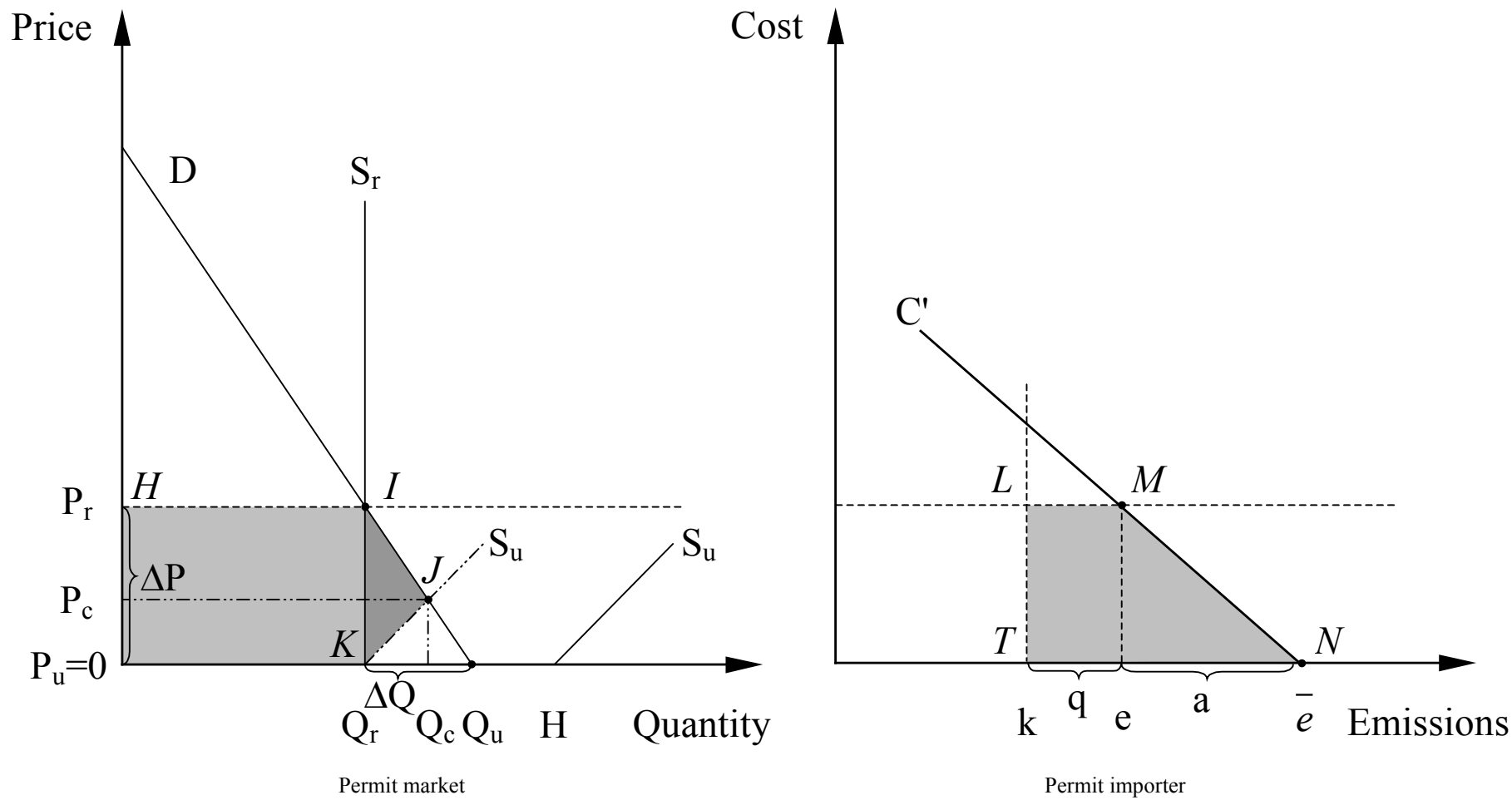
Issues:

- **Impacts of sink credits and U.S. withdrawal on:**
  - environmental effectiveness
  - distribution of compliance costs and gain

- **Emission permit market structure:**
  - perfect competition renders Kyoto to Business-as-Usual (hot air)
  - dominant permit supply position of FSU

==> Monopoly power by FSU in international emissions trading
(induced efficiency losses compared to competitive setting?)

Market Power and Hot Air in Emissions Trading:



Scenarios:

- **Assumptions:**
  - unrestricted Annex-B emissions trading
  - monopolistic permit supply by FSU

- **Overview of scenarios:**

	Emission Reduction		**U.S. Participation**	
	OLD	*NEW*	*USin*	*USout*
USin_TRD_OLD	X		X	
USout_TRD_OLD	X			X
USin_TRD_NEW		X	X	
USout_TRD_NEW		X		X

N.B.: Each of the four scenarios is complemented by a competitive setting which achieves the same environmental effectiveness (C)

Analytical Framework:

- **Basic Features :**
  - standard multi-sector, multi-region CGE model with energy focus: accounting of complex feedback and spillover effects
  - static time treatment (fixed investment)
  - representative agent in each region
  - Armington trade (product heterogeneity)
  - competitive markets apart from permit trade

Analytical Framework:

Regions		Commodities	
CAN	Canada	COL	Coal
CEA	Central European Associates	CRU	Crude oil
EUR	Europe (EU15 and EFTA)	GAS	Natural gas
FSU	Former Soviet Union (Russian Federation and Ukraine)	OIL	Refined oil products
JPN	Japan	ELE	Electricity
OOE	Other OECD (Australia and New Zealand)	EIS	Energy-intensive sectors
USA	United States	Y	Other goods
ASI	Other Asia (except for China and India)		
CHN	China (including Hong Kong and Taiwan)		
IND	India		
MPC	Mexico and OPEC		
ROW	Rest of World		

Parametrization:

- **Benchmark Calibration (1995)**:
  - GTAP: input-output-tables and bilateral trade data (V4.0, McDougall 1997)
  - IEA: energy balances and prices for industries and households (IEA 1996)
    $\Rightarrow$ *bottom-up* calibration of energy flows

- **Forward Calibration (2010)**:
  - DOE: projections for GDP, fossil fuel production through 2100 (DOE 1998)
    $\Rightarrow$ calibration to *BaU* emission trajectories
    $\Rightarrow$ *aeei* to match GDP forecasts with energy production projections (on demand side)
    $\Rightarrow$ fossil fuel supply calibration (after initial fixation of fossil fuel supply to control emission path from supply side)

	USin_old	USin_new	USout_old	USout_new
Carbon tax ($US)	83	58	68	41
Cutback (in %)	4.8	3.3	1.4	0.9
Leakage (in %)	22	19	24	19
		Consumption (in %)		
CAN	-0.87	-0.46	-0.57	-0.25
CEA	1.18	0.81	0.75	0.45
EUR	-0.20	-0.14	-0.23	-0.14
FSU	7.30	5.19	2.47	1.47
JPN	-0.18	-0.11	-0.21	-0.12
OOE	-0.78	-0.58	-0.50	-0.33
USA	-0.40	-0.28	0.01	0.00
ASI	0.13	0.09	0.02	0.01
CHN	0.27	0.20	0.06	0.04
IND	0.24	0.15	0.05	0.03
MPC	-0.56	-0.36	-0.13	-0.08
ROW	-0.05	-0.04	-0.02	-0.02
Total	-0.074	-0.046	-0.053	-0.030
AnnexB	-0.086	-0.053	-0.101	-0.056
OECD*	-0.208	-0.139	-0.173	-0.099
Non-AnnexB	-0.038	-0.024	-0.004	-0.003

Results:

	USin_old	USin_new	USout_old	USout_new
Cutback (in %)				
Monopolistic	4.8	3.3	1.4	0.9
Competitive	4.8	3.3	1.4	0.9
Carbon tax ($US)				
Monopolistic	83	58	68	41
Competitive	71	45	29	19
Global consumption (in %)				
Monopolistic	-0.074	-0.046	-0.053	-0.030
Competitive	-0.056	-0.025	-0.009	-0.004
AnnexB consumption (in %)				
Monopolistic	-0.086	-0.053	-0.101	-0.056
Competitive	-0.060	-0.024	-0.017	-0.008
Excess Burden* (in %)	32	84	489	650

Calculated as: 100 (Global Consumption_Monopolistic - Global Consumption Competitive) / Global Consumption Competitive

Summary:

- Sink credits and, particularly, U.S. withdrawal drive down the global costs of compliance but also reduce environmental effectiveness to a larger extent.

- Monopolistic cutback of hot air supply from FSU prevents the effectiveness of Kyoto from falling to zero (upon U.S. withdrawal and sink credits) but global cutback is only around 1 % below BaU.

- FSU bears the largest burden from both U.S. withdrawal and sink credits.

- Excess burden of monopolistic permit supply decrease due to U.S.withdrawal and sink credits in absolute terms but increases considerably in relative terms (reason: global cost-cut due to less stringent emission constraint gets partially appropriated by monopolist).

Issues:

- **Basic mechanism:**
  - Policies in large open economies affect international prices (ToT)
  - indirect *secondary* burden of benefit for *all* trading countries

- **Typology:**
  - International trade in goods and services (terms-of-trade changes):
    - $\Rightarrow$ fossil fuel markets (importers versus exporters)
    - $\Rightarrow$ non-energy markets (tax burden shifting)
    - $\Rightarrow$ carbon trade effect (unambiguously beneficial for all trading regions)
  - Technology transfers (diffusion, knowledge spillovers)
  - Capital flows

Issues:

- **Environmental implications (leakage):**
  - Trade channel: shift of comparative advantage in production of energy-intensive goods towards non-abating countries
  - Factor channel: environmental capital flight (relocation of emission-intensive industries from abating to non-abating countries)
  - Energy channel: increase of energy demand in non-abating countries due to depressed world energy prices

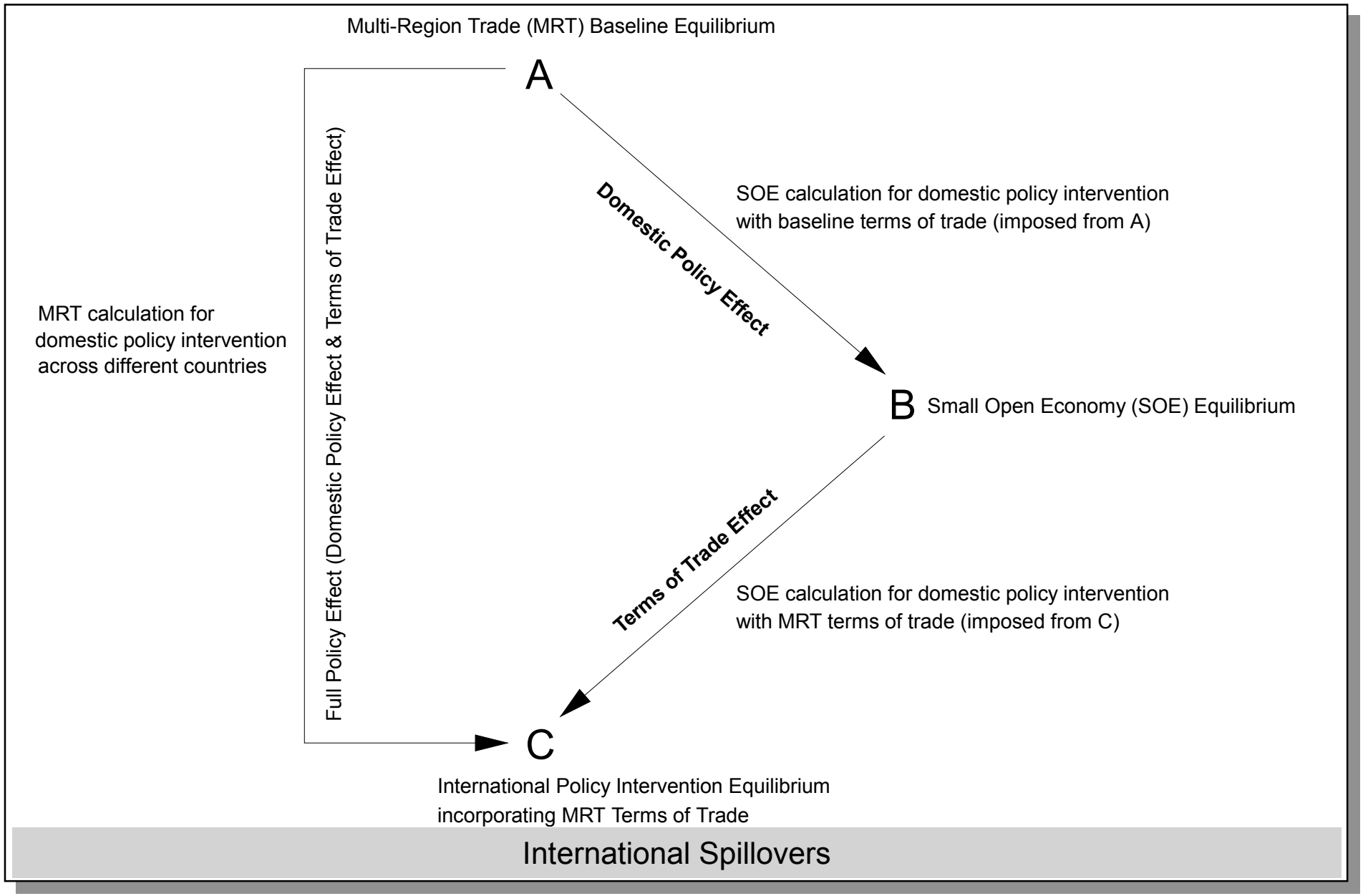
- **Policy Implications**
  - distribution of costs (equity): "... *adverse economic impacts on other Parties, especially developing countries...",* burden sharing
  - global cost-effectiveness: leakage and countermeasures (e.g.: exemptions, VER, tax rebates, tax on embodied carbon, grandfathering)

Decomposition Technique 1:

- **Objective:** Isolation of secondary terms-of-trade effect

- **Key idea:** Parametric imposition of export and import prices from multi-region trade model on small-open-economy sub-models with supply and import demand functions.

  – Domestic policy effect: international prices constant at benchmark level (A)
  – Full (MRT) equilibrium effect: imposition of MRT counterfactual ToT (B)
  – International spill-over effect: (B) - (A)


Multi-Region Trade (MRT) Baseline Equilibrium
A
Domestic Policy Effect
SOE calculation for domestic policy intervention
with baseline terms of trade (imposed from A)
MRT calculation for
domestic policy intervention
across different countries
Full Policy Effect (Domestic Policy Effect & Terms of Trade Effect)
B
Small Open Economy (SOE) Equilibrium
Terms of Trade Effect
SOE calculation for domestic policy intervention
with MRT terms of trade (imposed from C)
C
International Policy Intervention Equilibrium
incorporating MRT Terms of Trade
International Spillovers

	Domestic Market Effect (in % HEV)	Carbon Trade Effect (in % HEV)	Total Policy Effect (in % HEV)	International Spillover* (in % of Total Policy Effect)
CAN	-1.05	-0.62	-0.87	29
CEA	0.00	0.68	1.18	42
EUR	-0.55	-0.33	-0.20	-64
FSU	0.00	7.47	7.30	-2
JPN	-0.90	-0.29	-0.18	-61
OOE	-0.38	-0.37	-0.78	52
USA	-0.61	-0.44	-0.40	-8
ASI	0.00	0.00	0.13	100
CHN	0.00	0.00	0.27	100
IND	0.00	0.00	0.24	100
MPC	0.00	0.00	-0.55	100
ROW	0.00	0.00	-0.05	100

* Calculated as: 100* [(Total Policy Effect) - (Carbon Trade Effect)] / (Total Policy Effect)

Results: *USin_Old*

	Domestic Market Effect (in % HEV)	Carbon Trade Effect (in % HEV)	Total Policy Effect (in % HEV)	International Spillover* (in % of Total Policy Effect)
CAN	-0.42	-0.30	-0.46	35
CEA	0.00	0.46	0.81	44
EUR	-0.44	-0.22	-0.14	-65
FSU	0.00	5.25	5.19	-1
JPN	-0.64	-0.19	-0.11	-67
OOE	-0.30	-0.27	-0.58	54
USA	-0.48	-0.30	-0.28	-8
ASI	0.00	0.00	0.09	100
CHN	0.00	0.00	0.20	100
IND	0.00	0.00	0.15	100
MPC	0.00	0.00	-0.35	100
ROW	0.00	0.00	-0.04	100

* Calculated as: 100* [(Total Policy Effect) - (Carbon Trade Effect)] / (Total Policy Effect)

Results: *USin_New*

	Domestic Market Effect (in % HEV)	Carbon Trade Effect (in % HEV)	Total Policy Effect (in % HEV)	International Spillover* (in % of Total Policy Effect)
CAN	-1.05	-0.53	-0.56	7
CEA	0.00	0.43	0.75	43
EUR	-0.55	-0.28	-0.23	-19
FSU	0.00	2.71	2.47	-10
JPN	-0.90	-0.24	-0.21	-16
OOE	-0.38	-0.33	-0.50	33
USA	0.00	0.00	0.01	100
ASI	0.00	0.00	0.02	100
CHN	0.00	0.00	0.06	100
IND	0.00	0.00	0.04	100
MPC	0.00	0.00	-0.13	100
ROW	0.00	0.00	-0.02	100

* Calculated as: 100* [(Total Policy Effect) - (Carbon Trade Effect)] / (Total Policy Effect)

Results: *USout_Old*

	Domestic Market Effect (in % HEV)	Carbon Trade Effect (in % HEV)	Total Policy Effect (in % HEV)	International Spillover* (in % of Total Policy Effect)
CAN	-0.42	-0.23	-0.25	6
CEA	0.00	0.23	0.45	50
EUR	-0.44	-0.17	-0.14	-22
FSU	0.00	1.62	1.47	-10
JPN	-0.64	-0.14	-0.12	-20
OOE	-0.30	-0.21	-0.33	34
USA	0.00	0.00	0.00	100
ASI	0.00	0.00	0.01	100
CHN	0.00	0.00	0.04	100
IND	0.00	0.00	0.03	100
MPC	0.00	0.00	-0.08	100
ROW	0.00	0.00	-0.02	100

* Calculated as: 100* [(Total Policy Effect) - (Carbon Trade Effect)] / (Total Policy Effect)

Results: *USout_New*

Summary:

- International spillovers from abatement in Annex-B countries:
  - fossil fuel market effect:
    - $\Rightarrow$ benefits to fuel importers
    - $\Rightarrow$ losses to fuel exporters
  - significant leakage through energy channel (total leakage rate: ~20%)

- International spillovers - beyond positive carbon trade effects - alter considerably the primary costs of abatement in Annex-B countries

Decomposition Technique 2:

- **Objective:** Quantification of *bilateral* spillovers - decomposition of aggregate impact into the individual contributions from abatement policies

- **Key idea:** Generic procedure by Harrison, Horridge and Pearson (*Computational Economics* 2000)

  – no obvious sequential ordering for many multilateral policies
  – HHP method: "natural path" along which exogenous policy variables move together at the same rate towards their final value.

Caveat: illustrative simulations (USin_old without permit trade)

Model result (Z) is a function of policy instruments (x): $$Z = F(\vec{X}) = F(x_1, x_2, ..., x_n)$$

Attribute model outcome to changes in policy instruments: $$\Delta Z = \Delta Z_1 + \Delta Z_2 + ... + \Delta Z_n$$

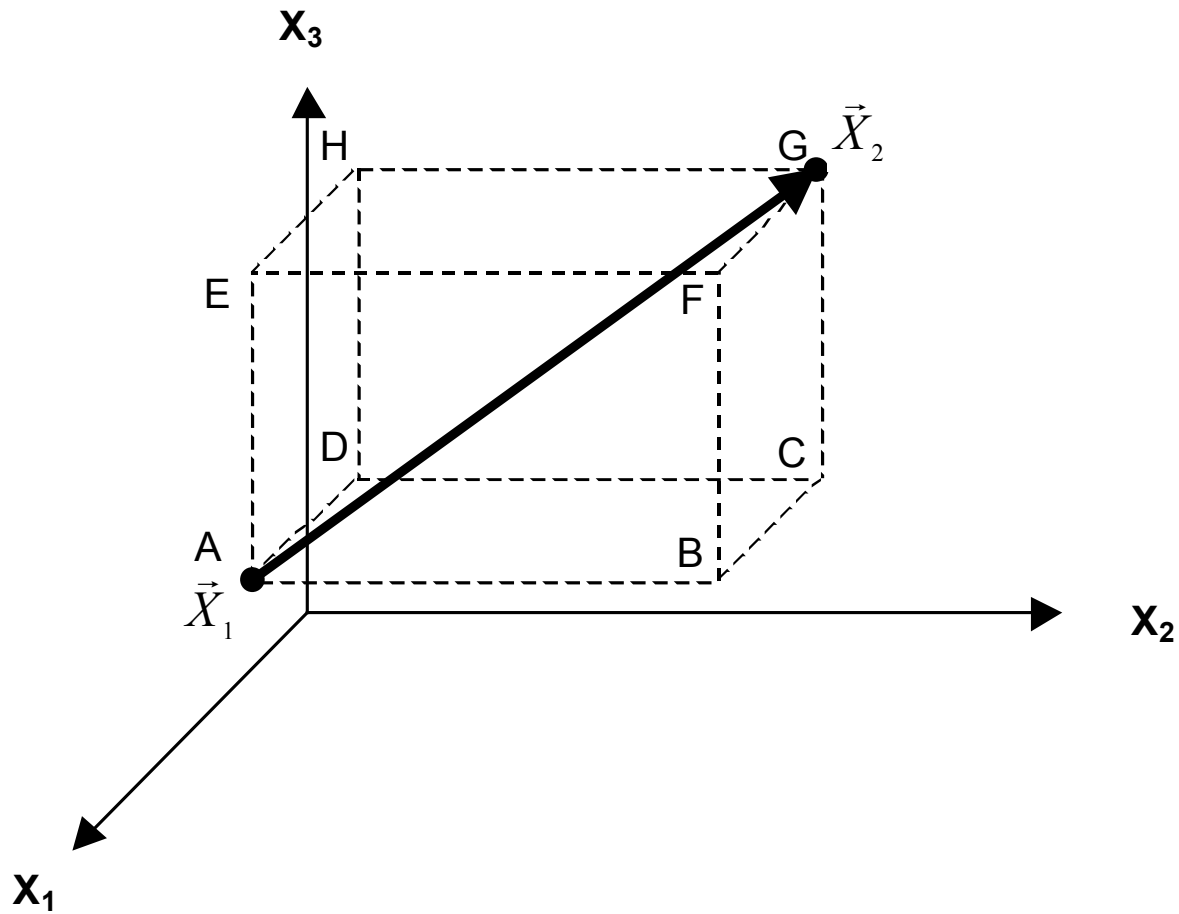
Uniform scaling (t) of changes in instrument values: $$x_i = x_{i,0} + t\Delta x_i$$

Local dependence of Z on t: $$\frac{dZ}{dt} = \sum_{i=1}^{n} \frac{\partial F}{\partial x_i} \Delta x_i$$

Total change in Z may then be written: $$\Delta Z = \sum_{i=1}^{n} \int_{t=0}^{t=1} \left. \frac{\partial F}{\partial x_i} \right|_t \Delta x_i dt$$

Numerical approximation: $$\left. \frac{\partial F}{\partial x_i} \right|_t \approx \frac{F(x_i + t\Delta x_i + \varepsilon) - F(x_i + t\Delta x_i)}{\varepsilon}$$

Sequential ordering versus “natural” path



Total welfare impact of Kyoto without trade:

(Caveat: update of model structure/parametrization for consistency with previous results)

Region	% Change as compared to *BaU* consumption
CAN: Canada	-1.07
CEA: Central European Associates	0.26
EUR: EU15 and EFTA	-0.12
FSU: Russian Federation and Ukraine	-0.17
JPN: Japan	-0.22
OOE: Australia and New Zealand	-0.81
USA: United States	-0.42
ASI: Other Asia	0.12
BRA: Brazil	0.13
CHN: China	0.13
IND: India	0.16
MPC: Mexico and OPEC	-0.90
ROW: Rest of the World	-0.21
World Total	-0.24

Percentage of welfare variation attributable to actions of individual Annex B countries (*tax instrument decomposition*)

	CAN	CEA	EUR	JPN	OOE	USA
CAN	87		1			11
CEA	6	7	13	11	1	62
EUR	-9		208	-14	-3	-81
FSU	-79	4	76	8	-1	93
JPN	-7		-13	173	-4	-49
OOE			14	28	42	16
USA			-7	-3	-1	110
ASI	12		21	-40	5	102
BRA	10		11	14	2	62
CHN	12		24	-3	5	62
IND	9		13	12	2	64
MPC	8		14	14	1	64
ROW	7		24	19	1	48

Compensating bilateral transfers from region (row) to region (column) in $-billion per year (*tax instrument decomposition*)

	USA	CAN	EUR	JPN	OOE
CAN	-0.07				
EUR	0.72	0.11			
JPN	0.46	0.08	-0.02		
OOE	-0.08		-0.08	-0.14	
FSU	-0.09	0.07	-0.07	-0.01	
CEA	0.05		0.01	0.01	
CHN	0.12	0.02	0.05	-0.01	0.01
IND	0.04	0.01	0.01	0.01	
BRA	0.06	0.01	0.01	0.01	
ASI	0.12	0.01	0.02	-0.05	0.01
MPC	-0.69	-0.09	-0.15	-0.15	-0.01
ROW	-0.14	-0.02	-0.07	-0.06	

Percentage of welfare variation attributable to actions of individual Annex B countries (*quota instrument decomposition*)

	CAN	CEA	EUR	JPN	OOE	USA
CAN	75		3	1		20
CEA	7	3	16	12	1	62
EUR	-7		161	-10	-1	-44
FSU	-72	2	72	7		91
JPN	-5		-8	147	-1	-31
OOE	1		17	26	25	30
USA	1		1			97
ASI	12		21	-32	3	96
BRA	10		12	15	1	62
CHN	10		22	2	3	63
IND	9		13	13	1	64
MPC	8		14	15	1	63
ROW	7		21	19	1	52

Summary:

- **Bilateral policy impacts:**
  - Greatest individual contribution to spillovers is due to actions of the U.S.
  - Significant positive spillover effects from U.S. action for Japan and Europe (actions of other AnnexB countries have only negligible impact on the U.S.)
  - NonAnnexB countries with positive and negative spillovers
    $\Rightarrow$ fundamental problems to the issue of compensation

- **Appraisal of HHP procedure:**
  - Order-independency however no path-independency (instrument choice)
  - Useful tool for diagnosing the channels through which trade transmits policy impacts between countries