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Canada

A Canadian Perspective On The Use Of CGE Analysis For Assessing Comparable Effort

Workshop on Mitigation Potential/Comparable Efforts

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Outline

- The use of CGE analysis for assessing mitigation costs
  - Cost considerations
  - Canada's CGE model (specification, results)
  - Canada's national circumstances

- Key Considerations and Next Steps

Cost is an important consideration

- As noted in the IPCC's Fourth Assessment Report from Working Group III Report "Mitigation of Climate Change"
  - Cost provides important information on the magnitude and distribution of effort across and within countries, and across generations
  - For a given level of mitigation, models can estimate the cost of achieving that potential
  - For a specific cost of abatement, models can estimate a the level of mitigation potential

➢ **Costs are relevant to compare efforts among developed countries**

There are different metrics for measuring cost

- Marginal cost of abatement
  - Cost to abate one more unit of emissions
- Cost of emission reductions as percent of GDP
  - Economy-wide abatement costs relative to the value of economic output
- Cost of emissions reductions as percentage welfare change
  - Economy-wide welfare costs (typically measured in terms of changes in real income or consumption)

The impacts of mitigation targets should be addressed by more sophisticated CGE analysis

- Marginal abatement cost curves are useful as they:
  - Provide information about the direct cost of abatement for alternative policy options
  - Help rank discrete actions – particularly with bottom-up curves
- Commonly accepted modeling approaches produce similar rankings of marginal abatement costs across economies
- However, marginal abatement cost curves do have limitations:
  - Market interactions and income effects are not captured
- While marginal abatement cost curves provide simplicity and transparency, the impacts of mitigation targets should be addressed by more sophisticated CGE analysis

Carbon Pricing for Central Government Cost Benefit Analysis in Ireland, Comhar Sustainable Development Council, November 2008

A wide range of CGE and non-CGE based models are used to assess mitigation cost

- Examples of CGE models used to assess the cost of mitigation include:
  - The Global Trade and Environment Model (GTEM): Australian Bureau of Agricultural and Resource Economics
  - The Asian-Pacific Integrated Model: National Institute for Environment Studies, Japan)
  - Emissions Projection and Policy Analysis Model: Massachusetts Institute of Technology, US)
  - Second Generation Model and Mini-CAM model: Pacific Northwest National Laboratory)
  - GEMINI-E3: the National Technical University of Athens (NTUA), the Centre for Economic Studies of the Katholieke Universiteit Leuven and the Centre for European Research (ZEW)
  - MESSAGE: International Institute for Applied Systems Analysis, Austria
- Other models include:
  - GAINS on-line calculator: International Institute for Applied Systems Analysis, Austria
  - FAIR Model: Netherlands Environmental Assessment Agency (MNP), in The Netherlands.
  - McKinsey Cost Curves

Canada has developed a multi-region/multi-sector computable general equilibrium model

- Canada is using a multi-sector, multi-region general equilibrium model of the world
- The model is built on a comprehensive energy-economy dataset
  - Global Trade Analysis Program (GTAP7) database maintained by the Center for Global Trade Analysis, Purdue University
- The model's business-as-usual baseline for economic growth, energy demand and emissions is based on the US Energy Information Administration's International Energy Outlook 2008
- The model also uses internationally recognized elasticities
  - International trade: based on empirical estimates reported in the GTAP7 database
  - Substitution: are taken from Okagawa and Ban (2008)
- The model is formulated and solved as a mixed complementarity problem using the Mathematical Programming Subsystem for General Equilibrium described by Professor Thomas Rutherford (Centre for Energy Policy and Economy Department of Management, Technology and Economics, Zürich)

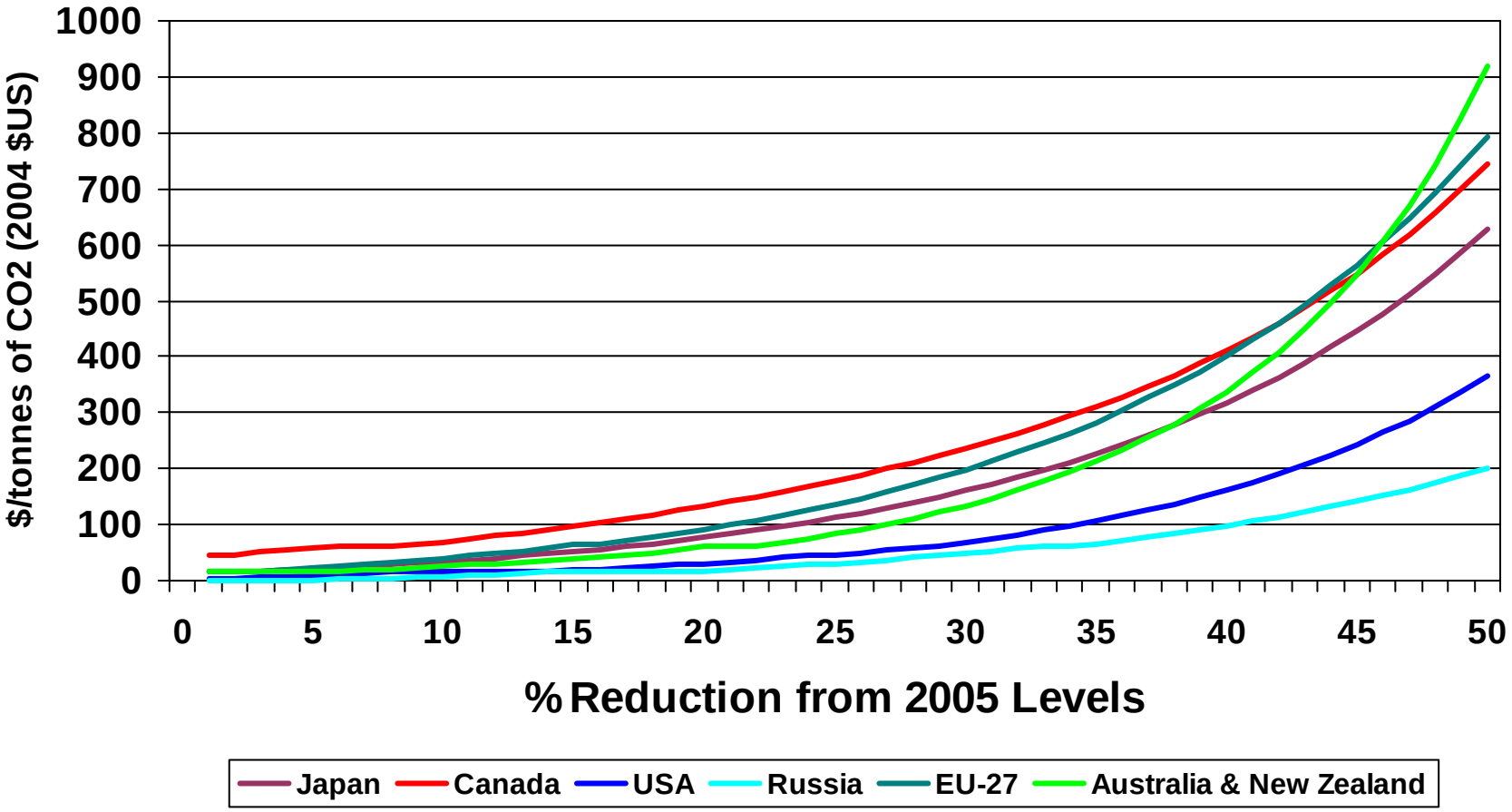
Canada's CGE model has the following country and sectoral disaggregation

Sectors and Regions Specifications	
Energy Inputs •Electricity •Coal •Oil •Natural Gas •Crude Oil **Energy-Intensive Industries** •Iron and steel industry •Chemical industry •Non-ferrous metals •Non-metallic minerals •Mining •Paper-pulp-print •Transport (Include Air transport) **Other Sectors** •Transport equipment •Other machinery •Food products •Wood and wood-products •Construction •Textiles •Other manufacturing •Agricultural products •Commercial and public services •Dwellings	**Annex I Region** Australia- New Zealand Canada Japan Russia USA European Union (EU-27) **Non-annex I Region** Brazil China India Mexico Indonesia & South Korea Rest of the World

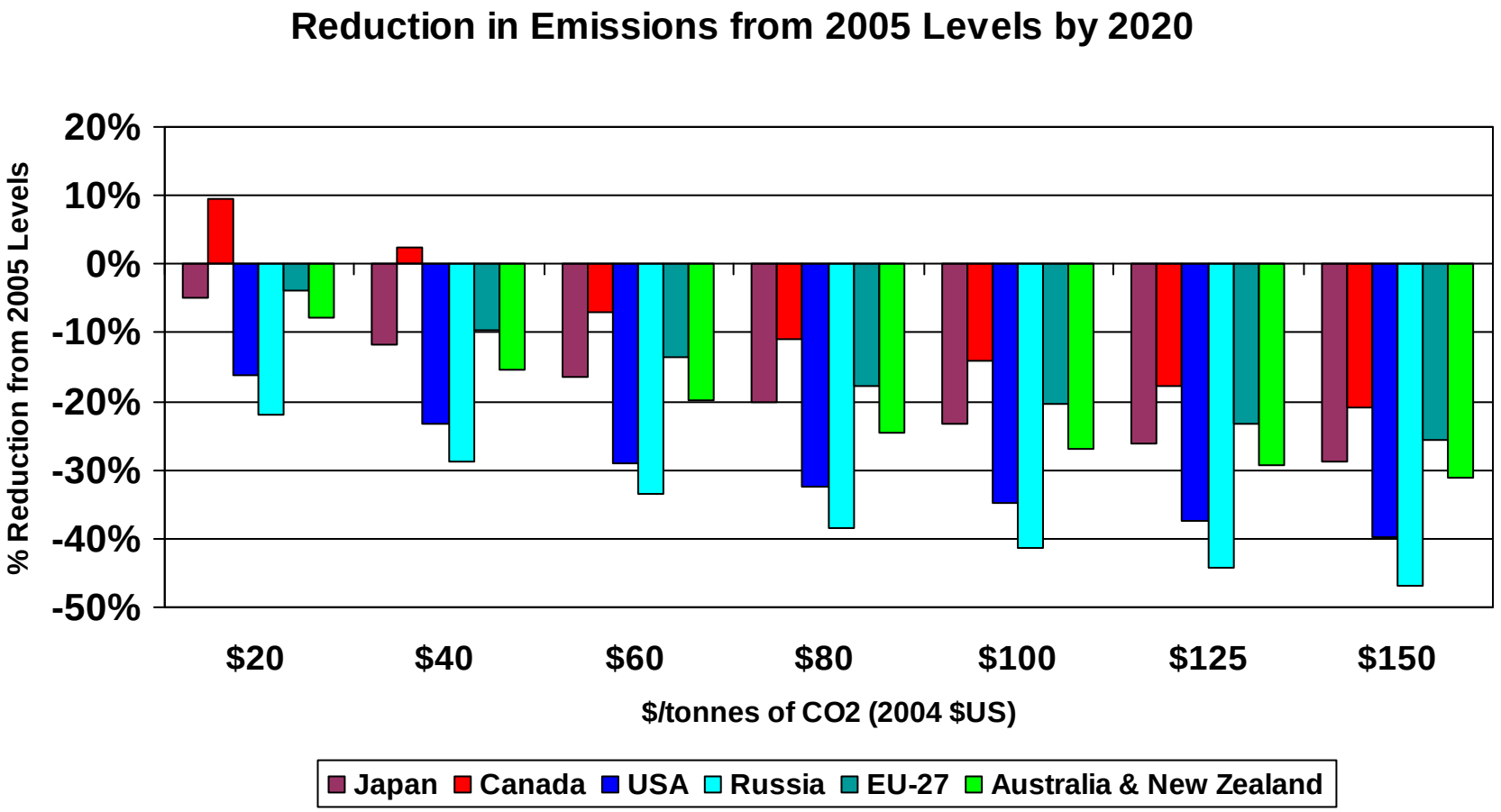
CGE model was used to generate explicit marginal abatement cost curves

- Implicit marginal abatement cost curves of the CGE model can be made explicit
- A country-specific marginal abatement cost curve is constructed by plotting a CO_2 price against an associated reduction at a specific point in time
  - Construction of the curve involved multiple runs of the model to provide different price-quantity pairs
  - The discrete price-quantity pairs were then fitted to a continuous abatement cost function
- The resulting CGE-based marginal abatement cost curves provide a first picture of the cost of emission abatement across various sectors and regions
- The marginal abatement cost curves being used for this analysis reflect domestic abatement effort only

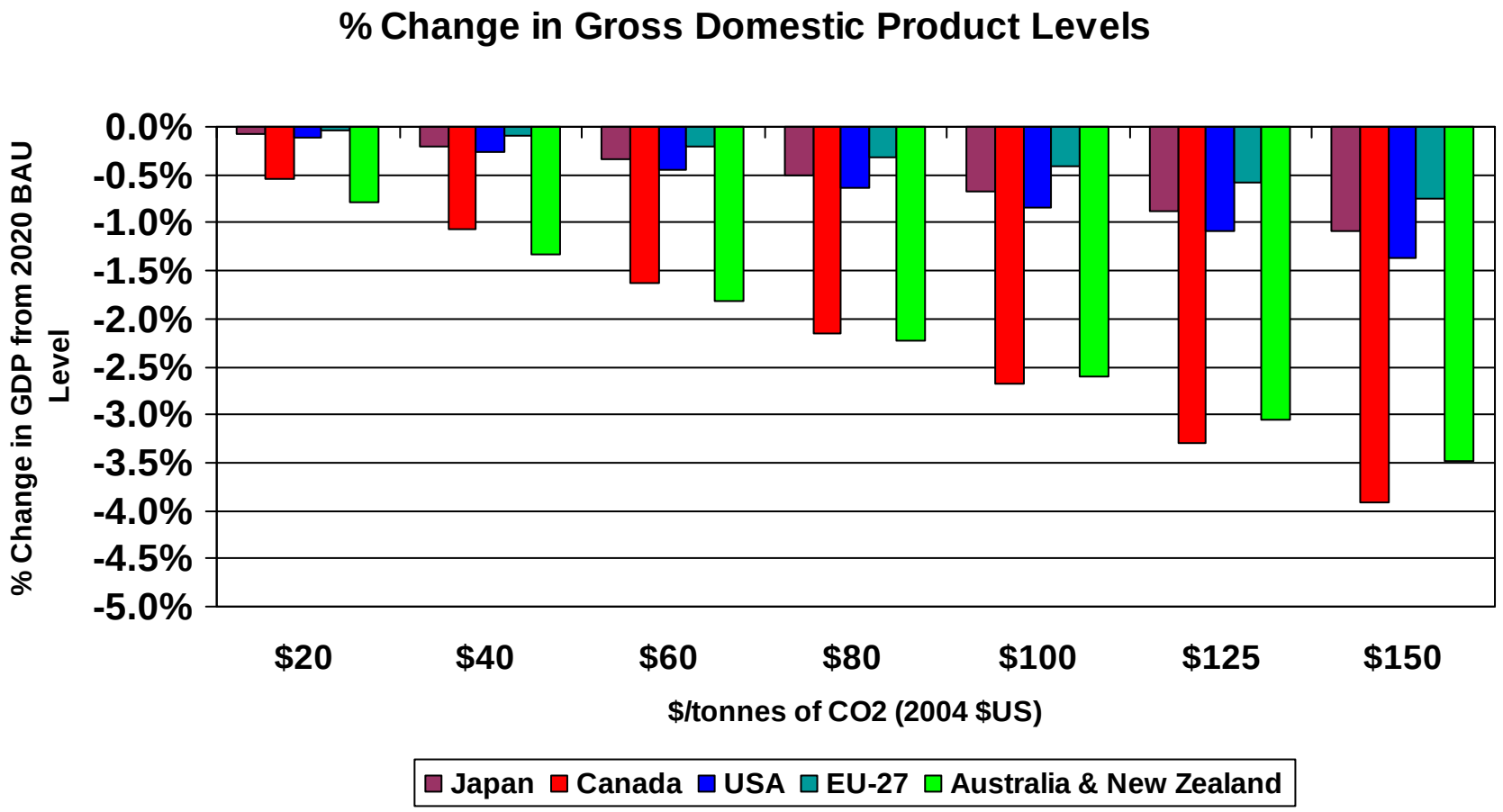
CGE-model's marginal abatement cost curves



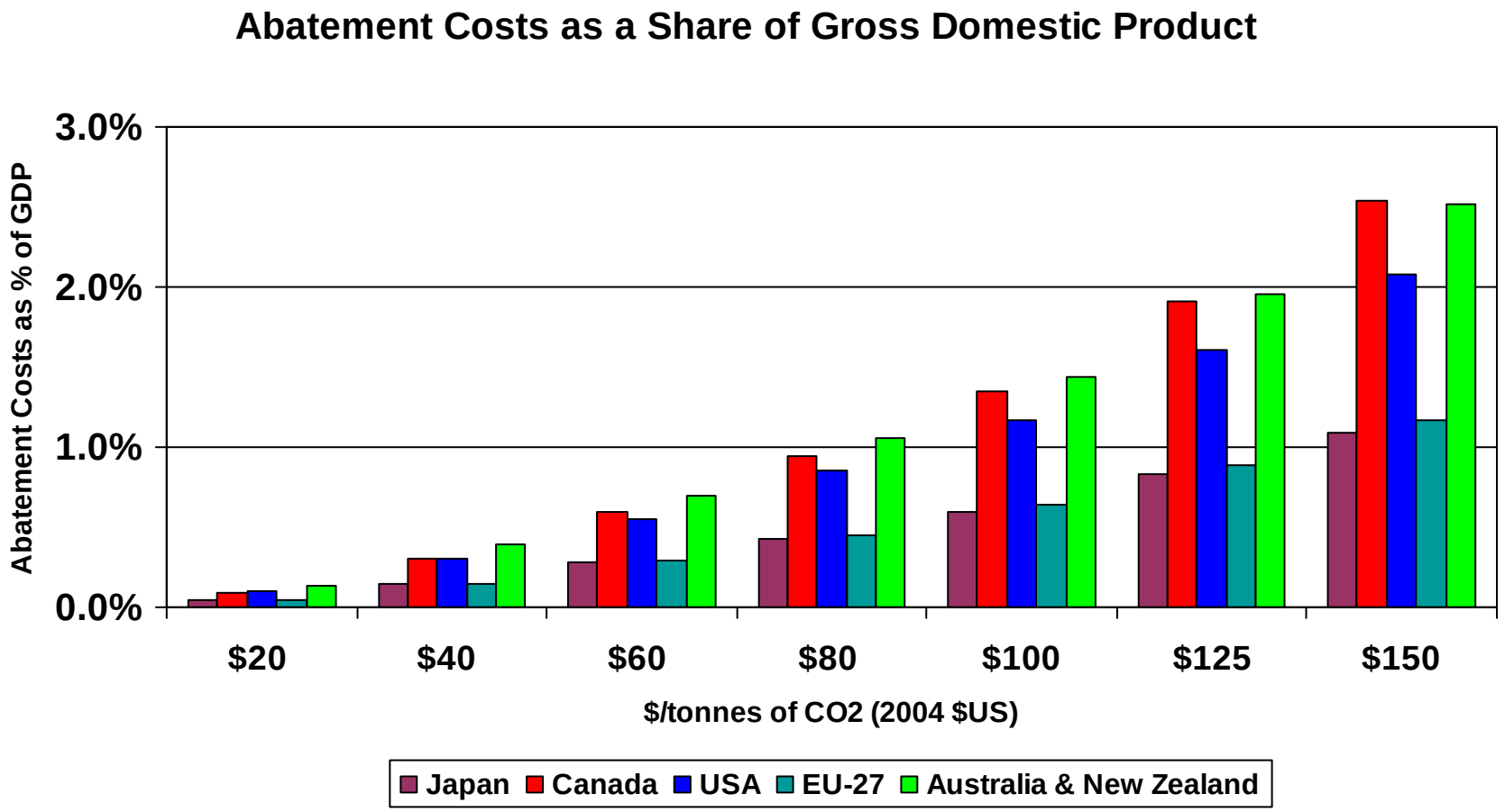
Canada's modeling indicates that an equal carbon charge applied to different Annex I countries would result in significantly different aggregate emissions reductions



An equal carbon emission charge results in significantly different GDP impacts



Similarly, an equal carbon charge leads to different abatement cost as a share of GDP



National circumstances are key to determining the overall cost of abatement

- Canada is part of an integrated North American economy and energy market
  - Canadian emissions represent about 8.6% of total North American emissions
- Industrial structure affects emissions profile
  - If Canada had the same industrial structure as average for Annex I countries, its energy intensity would be 18% lower
  - Unlike other countries, Canada generates much of its electricity from “non-emitting” sources and consequently has much less mitigation potential in this key sector
- Population growth is a major driver of emissions growth
  - Canada population is expected to grow more rapidly than most other developed countries

Key observations from this analysis

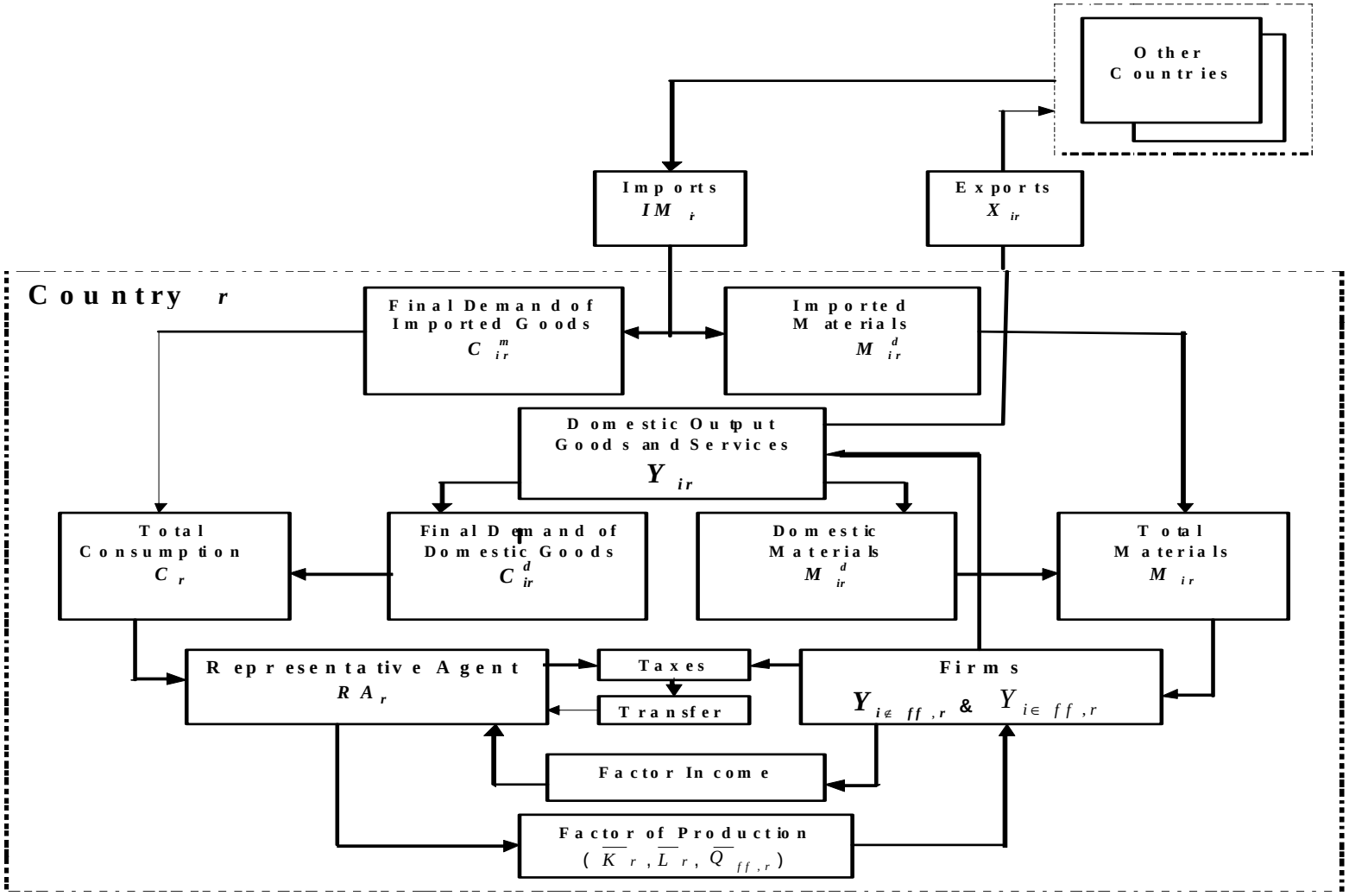
- The impacts of mitigation targets should be addressed using more sophisticated CGE analysis
  - Marginal abatement cost curves are useful as they provide simplicity and transparency
- An equal carbon charge applied to all Annex I countries would imply different reduction levels for each country
  - However, lower percentage reduction in emissions does not necessarily imply a smaller GDP reduction
- An equally applied carbon charge will not result in equal abatement costs as a share of GDP

Key considerations for further analysis

- Baseline assumptions matter
  - Annex I countries, as well as developing countries, should work together to ensure that baseline emissions represents national circumstances
- The level of country aggregation (i.e., country-specific versus regional economic blocks) has a significant influence on comparison of effort
  - Need to compare EU countries individual and not as a block
  - Need to compare countries with similar circumstances in a disaggregated manner
- Joint work to arrive at common assumptions would be beneficial
  - Country specific economic and population growth rates
  - Technology characteristics

Annex 1
Overview of Environment Canada's CGE International Model

Canada has developed a standard GTAP-based multi-region/multi-sector model



Strengths of the CGE Approach

- Microeconomic foundation:
  - Sound interpretation of results
- Integration of market interactions
- Origination and spending of income for agents:
  - efficiency effects and distributional impacts
- Incorporation of market imperfections:
  - Market power on good and permit markets
  - Involuntary unemployment
- Applicability to structural policy changes

Annex 2
GAINS On-line Calculator

The GAINS model compares GHG mitigation potentials and costs across Annex I Parties

- IIASA On-line Mitigation Efforts Calculator (GAINS model) was used to compare GHG mitigation potentials and costs across Annex I Parties

- The interactive model was used to examine a set of common cost metrics
  - Equal marginal cost of abatement
  - Equal mitigation cost as a percentage of GDP
  - Equal mitigation costs per capita

- The results using the GAINS model seem to re-enforce the preliminary findings based on Canada's CGE model

GAINS On-line calculator

GAINS Mitigation Efforts Calculator

Version 1.2	Scenario IEA 2008			Year 2020		Interest rate 10%			
Party	Base year 1990	Emission range in 2020		Emission target			Mitigation Cost			
		Baseline	max. mitig	Total	Change to 1990	Per capita	Carbon price	Total costs	% of GDP	Per capita
	Mt CO2eq	Mt CO2eq	Mt CO2eq	Mt CO2eq		tCO2eq/cap	€/t CO2eq	bln €/yr	%	€/cap/yr
Target for each Party					-25%					
Australia	416	611	385	385	-7.6	16.4	20000	27.40	3.99	1169.9
Canada	592	796	536	536	-9.5	14.6	20000	23.66	1.84	646.7
EU 27	5568	5653	3756	4176	-25.0	8.4	130	23.08	0.15	46.5
Japan	1272	1315	970	970	-23.7	7.8	20000	84.27	1.24	676.3
New Zealand	62	85	60	60	-3.6	12.9	20000	3.50	3.82	756.9
Norway	50	58	49	49	-2.0	10.2	20000	2.09	0.53	438.9
Russian Federation	3326	2831	1743	2495	-25.0	17.7	5	-2.78	-0.22	-19.8
Switzerland	53	61	40	40	-23.9	5.6	20000	5.11	1.40	706.7
Ukraine	922	442	237	442	-52.0	10.7	-1000	0.00	0.00	0.0
United States of America	6135	7153	4953	4953	-19.3	14.5	20000	265.27	1.54	774.4
Total for Annex I	**18396**	**19005**	**12729**	**14105**	**-23.3**	**11.5**		**431.61**	**0.98**	**353.1**

The GAINS On-line calculator provides an opportunity to input targets and levels
Internet: http://gains.iiasa.ac.at/MEC/

According to IIASA's GAINS Model the maximum mitigation potential for Canada is 9.5 below 1990

Version 1.1		Scenario IEA 2008	
Party	**Base year 1990 Mt CO2eq**	**Emission range in 2020**	
		Baseline Mt CO2eq	**Maximum Mitigation Mt CO2eq**
Australia	416	611	385
Canada	592	796	536
EU 27	5568	5653	3756
Japan	1272	1315	970
New Zealand	62	85	60
Norway	50	58	49
Russian Federation	3326	2831	1743
Switzerland	53	60	43
Ukraine	922	442	237
United States of America	6135	7153	4953
Total for Annex I	**18396**	**19004**	**12732**

Using common cost metrics, the GAINS model provides the maximum mitigation effort relative to 1990 levels

	% Reduction from 1990 Levels Under Comparable Effort		
Party	**Carbon Price** **€ 180/tonne of CO2e**	**Mitigation Cost as % GDP** **0.55%**	**Mitigation Costs per Capita** **€ 140/capita**
Australia	4.4	7.7	8.9
Canada	-4.1	-5.3	-4.8
EU 27	-26.7	-29.1	-28.8
Japan	-16.9	-21.1	-19.7
New Zealand	3.4	5.7	3.6
Norway	1.8	-2.0	0.2
Russian Federation	-44.5	-36.6	-41.7
Switzerland	-10.9	-16.8	-15.0
Ukraine	-72.6	-65.0	-72.7
United States of America	-12.3	-14.8	-11.2
Reductions from 1990 Levels for Annex I	**-25.1**	**-25.1**	**-25.0**