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FÉDÉRALE DE LAUSANNE

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The Revival of the World Carbon Tax
- Simulations -

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Introduction

- Simulations of international carbon taxes, with emphasis on:
  - Revenue effects: generate target revenue
  - Tax efficiency : welfare impact
  - Tax effectiveness: climate impact

- The tax must be politically acceptable and technologically feasible

Model used: GEMINI-E3

- Dynamic-recursive CGE model
- Simulations of all relevant markets, incl. international trade (2001 GTAP)

GEMINI-E3 Regional Description	
Name	Countries
EUR	European Union (25)
XEU	Other European Countries
FSU	Former Soviet Union (except Baltic States)
USA	United States of America
CAN	Canada
AUZ	Australia and New Zealand
JAP	Japan
MEX	Mexico
CHI	China
IND	India
ASI	Rest of Asia
LAT	Central and Latin America
MID	Middle East
AFR	Africa

Sectors		**Markets**
Energy	**Non-Energy**	Commodities
Coal	Agriculture	Labour
Crude Oil	Forestry	Savings
Natural Gas	Mineral Product	Terms of Trade
Refined Petroleum	Chemical Rubber Plastic	
Electricity	Metal and Metal Products	
	Paper Products Publishing	
	Transport n.e.c.	
	Sea Transport	
	Air Transport	
	Consuming Goods	
	Equipment Goods	
	Services	
	Dwellings	

Reference Scenario (BaU)

Table 4: Baseline GHG Emissions in MtC-eq per year

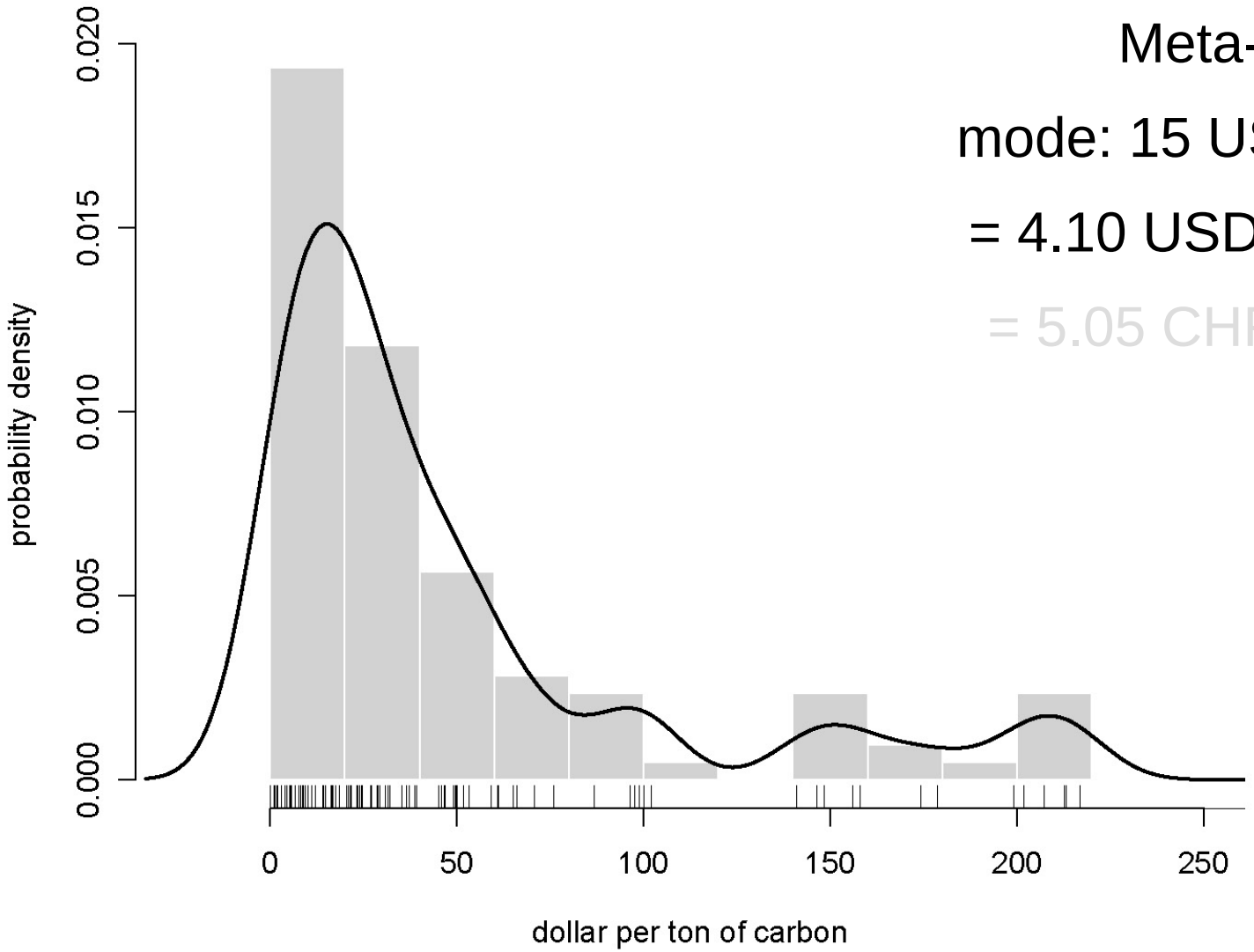
	2001	2010	2020	2030	2040	2050
EUR	1 302	1 339	1 391	1 431	1 465	1 512
XEU	139	148	160	164	164	166
FSU	812	951	1 086	1 171	1 213	1 275
USA	1 899	2 057	2 232	2 393	2 473	2 567
CAN	194	211	225	223	216	211
AUZ	170	182	194	197	195	193
JAP	340	346	341	321	307	296
MEX	157	184	229	265	295	331
CHI	1 262	1 877	2 735	3 786	4 784	5 897
IND	437	583	767	1 014	1 249	1 535
ASI	763	889	1 018	1 133	1 193	1 257
LAT	598	708	836	965	1047	1 130
MID	469	610	738	848	882	920
AFR	555	684	839	1 015	1 128	1 254
World	9 097	10 769	12 789	14 926	16 613	18 542

Reference Scenario (BaU)

Table 5: Temperature increase from the preindustrial era

Climate sensitivity in °C	2	2.5	3
Year	Temperature °C		
2000	0.6	0.6	0.6
2001	0.61	0.61	0.61
2010	0.69	0.71	0.73
2020	0.83	0.89	0.94
2030	1.02	1.12	1.21
2040	1.23	1.38	1.53
2050	1.47	1.68	1.88

Previous Estimates of World Carbon Taxes



Meta-analysis:

mode: 15 USD_{2001}/tC

= 4.10 USD_{2001}/tCO_2

= 5.05 CHF_{2001}/CO_2

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15$ World Carbon Tax Redistributed Within Each Region [1]

Scenario World Carbon Tax with Regional Redistribution [1]				
	2010	2020	2030	2040
Carbon tax in USD	15	15	15	15
Carbon tax revenue in billion USD	107	125	144	158
GHG Emissions reduction in %	-5.9%	-7.8%	-9.4%	-11.1%
CO2 Emissions reduction in %	-7.9%	-10.4%	-12.5%	-14.6%
Welfare impact (% of household consumption)	-0.03%	-0.03%	-0.03%	-0.06%

15$ World Carbon Tax Redistributed Within Each Region [1]

CO_2 Emissions change in %				
	2010	2020	2030	2040
EUR	-2.6%	-2.6%	-2.5%	-2.4%
XEU	-3.8%	-4.0%	-3.8%	-3.8%
FSU	-4.8%	-5.1%	-5.5%	-6.0%
USA	-4.2%	-4.2%	-4.1%	-4.0%
CAN	-2.6%	-2.3%	-2.1%	-1.9%
AUZ	-4.2%	-4.4%	-4.4%	-4.3%
JAP	-2.0%	-2.1%	-2.1%	-2.1%
MEX	-2.1%	-1.7%	-1.7%	-1.8%
CHI	-25.8%	-30.2%	-32.9%	-35.5%
IND	-10.2%	-12.1%	-13.8%	-15.4%
ASI	-3.9%	-4.5%	-4.8%	-5.0%
LAT	-2.1%	-2.0%	-2.0%	-2.1%
MID	-2.6%	-2.3%	-2.4%	-2.5%
AFR	-4.4%	-4.8%	-5.4%	-5.8%
World	-7.9%	-10.4%	-12.5%	-14.6%

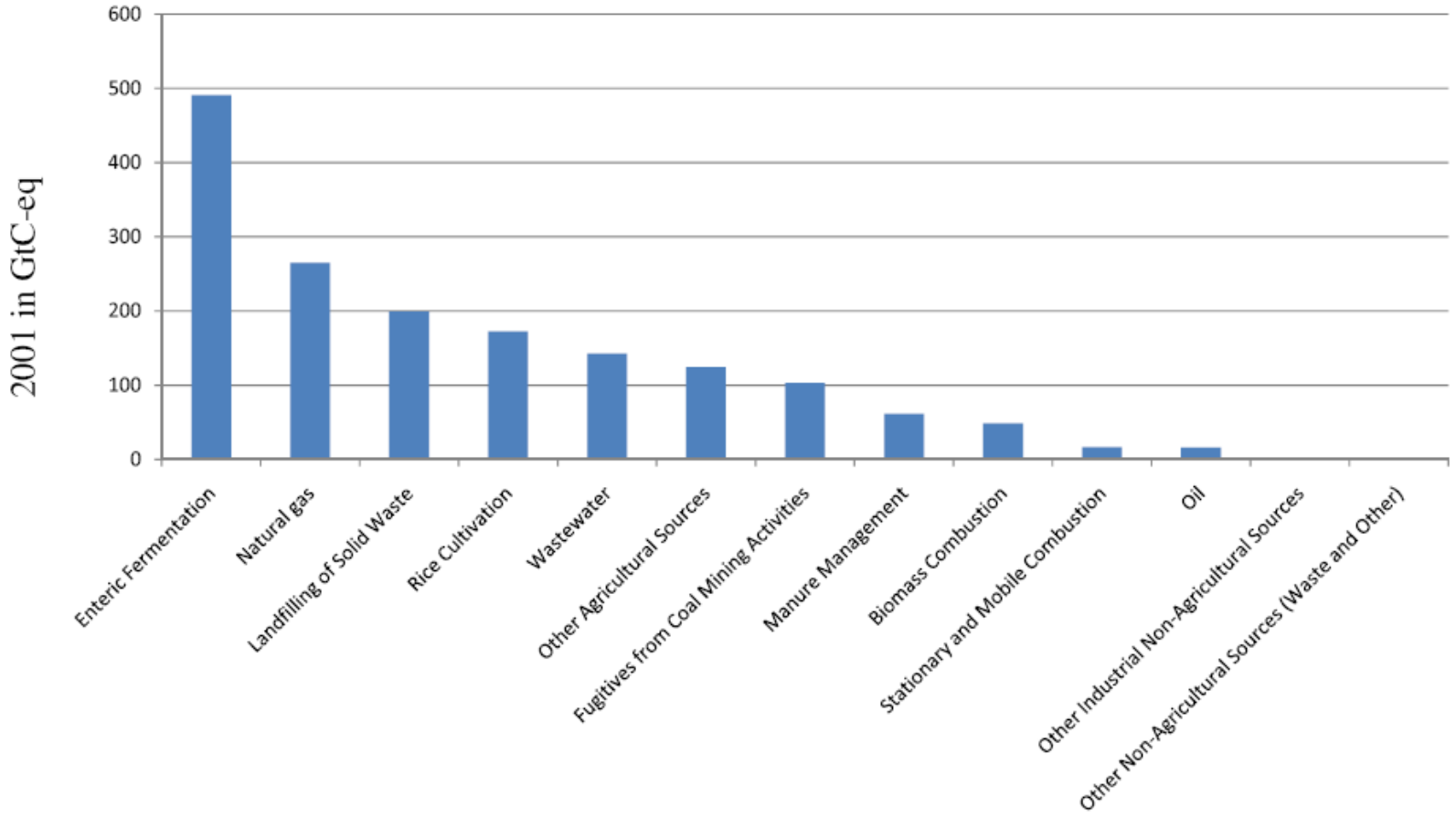
Welfare impact in % household consumption				
	2010	2020	2030	2040
EUR	0.04%	0.05%	0.05%	0.04%
XEU	-0.14%	-0.15%	-0.13%	-0.11%
FSU	-0.26%	-0.27%	-0.22%	-0.18%
USA	-0.01%	-0.01%	-0.01%	-0.01%
CAN	-0.09%	-0.10%	-0.09%	-0.09%
AUZ	-0.34%	-0.30%	-0.24%	-0.20%
JAP	0.06%	0.07%	0.05%	0.04%
MEX	-0.09%	-0.07%	-0.06%	-0.04%
CHI	-0.28%	-0.25%	-0.23%	-0.21%
IND	-0.07%	-0.04%	-0.04%	-0.04%
ASI	0.14%	0.14%	0.12%	0.10%
LAT	-0.08%	-0.07%	-0.06%	-0.05%
MID	-0.54%	-0.46%	-0.38%	-0.31%
AFR	-0.35%	-0.33%	-0.28%	-0.23%
World	-0.03%	-0.03%	-0.03%	-0.06%

World GHG Tax Redistributed Within Each Region [2]

Comparaison between scenarios [1] and [2]		
	[1]	[2]
	2040	2040
GHG tax in USD	15	15
GHG tax revenue	158	210
GHG Emissions Variation	-11.1%	-15.5%
CO2 Emissions Variation	-14.6%	-14.7%
Welfare impact: household cons. World	-0.06%	-0.07%

- Effectiveness is improved : GHG emissions variation is 40% better (-15.5% vs -11.1%)
- Mainly due to decline in CH_4 emissions
- Feasibility difficult (impact on agricultural activity)

Sources of Methane Emissions



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World Carbon Tax,
Revenue Redistribution Based on Income and Population [3]

Evolution of Allocation Shares					
	2001	2010	2020	2030	2040
EUR	0.42%	0.45%	0.45%	0.45%	0.42%
XEU	0.12%	0.12%	0.11%	0.11%	0.09%
FSU	3.01%	2.23%	1.79%	1.49%	1.22%
USA	0.14%	0.15%	0.16%	0.17%	0.18%
CAN	0.02%	0.03%	0.03%	0.04%	0.04%
AUZ	0.02%	0.03%	0.03%	0.03%	0.04%
JAP	0.07%	0.07%	0.08%	0.08%	0.08%
MEX	0.28%	0.33%	0.33%	0.30%	0.27%
CHI	21.68%	15.49%	11.97%	9.23%	7.00%
IND	38.88%	37.76%	34.79%	30.90%	26.64%
ASI	10.75%	13.11%	14.73%	16.23%	17.10%
LAT	2.27%	2.63%	2.80%	2.86%	2.85%
MID	1.22%	1.41%	1.63%	1.80%	2.00%
AFR	21.13%	26.19%	31.11%	36.31%	42.08%
Sum	100.00%	100.00%	100.00%	100.00%	100.00%

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World Carbon Tax, Revenue Redistribution Based on Income and Population [3]

Comparison between scenarios [1] and [3], 2040

	[1]	[3]
Tax rate in USD	15	15
Tax revenue	158	144
CO_2 emissions variation	-14.6%	-14.6%
Welfare impact: hh cons. world	-0.06%	-0.05%

- Attractive for the poorest regions
- Unattractive for China and Latin America

Welfare impact in % of household consumption	
	2040
EUR	-0.12%
XEU	-0.27%
FSU	-1.76%
USA	-0.24%
CAN	-0.40%
AUZ	-0.55%
JAP	-0.08%
MEX	-0.25%
CHI	-1.40%
IND	3.53%
ASI	0.73%
LAT	-0.10%
MID	-0.60%
AFR	4.84%
WORLD	-0.05%

OECD Carbon Tax, Revenue Redistribution Based on Income and Population [4]

Comparaison between scenarios [3] and [4]		
	[3]	[4]
	2040	2040
Carbon tax in USD	15	15
Tax revenue	144	53
CO2 Emissions Variation	-14.6%	-1.0%
Welfare impact: household cons. World	-0.05%	-0.02%

- Tax revenue very small: only $53 billion
- No impact on climate
- Extensive carbon leakage: tax on 40% of 2010 CO_2 emissions yields only 22% of the CO_2 emissions reduction (in 2010) obtained with worldwide tax (7% in 2040)

Tax Revenue Redistribution to DC Based on Climate Impacts

Table 20: Temperature increase and damage costs for developing countries

	2010	2020	2030	2040
Temperature increase Reference scenario	0.71	0.89	1.12	1.38
Impacts as % of GDP				
MEX	0.20%	0.25%	0.31%	0.39%
CHI	0.00%	0.00%	0.01%	0.01%
IND	0.83%	1.04%	1.30%	1.61%
ASI	0.83%	1.04%	1.30%	1.61%
LAT	0.20%	0.25%	0.31%	0.39%
MID	0.50%	0.63%	0.79%	0.98%
AFR	0.50%	0.63%	0.79%	0.98%
Impacts in millions of USD				
MEX	1 831	3 480	6 119	9 055
CHI	109	235	480	784
IND	8 726	18 841	38 921	65 085
ASI	20 042	33 223	51 481	66 830
LAT	4 473	7 586	13 128	18 688
MID	7 580	13 910	25 766	37 378
AFR	5 054	9 357	17 223	25 551
Sum	47 815	86 632	153 118	223 372

Derived from PAGE2002 model (Stern Review)

OECD Carbon Tax With Climate Change Compensation [5]

Comparaison between scenarios [4] and [5]		
	[4]	[5]
	2040	2040
Carbon tax in USD	15	72
Tax revenue	53	223
CO2 Emissions Variation	-1.0%	-3.6%
Welfare impact: household cons. World	-0.02%	-0.09%
Welfare impact: household cons. EUR	-0.18%	-0.77%
Welfare impact: household cons. USA	-0.17%	-0.74%
Welfare impact: household cons. CAN	-0.37%	-1.68%
Welfare impact: household cons. AUZ	-0.46%	-1.80%

- USA, Canada and Australia/New Zealand likely to oppose this

Carbon Tax in Europe and Japan With Climate Change Compensation [6]

Comparaison between scenarios [5] and [6]		
	[5]	[6]
	2040	2040
Carbon tax in USD	72	194
Tax revenue	223	223
CO2 Emissions Variation	-3.6%	-2.7%
Welfare impact: household cons. World	-0.09%	-0.26%
Welfare impact: household cons. EUR	-0.77%	-2.10%
Welfare impact: household cons. XEU	-1.23%	-2.68%
Welfare impact: household cons. JAP	-0.45%	-4.18%

- Europe and Japan must bear high welfare costs
- Small impact on climate change in spite of high tax

World Carbon Tax With Climate Change Compensation [7]

Comparaison between scenarios [5] and [7]		
	[5]	[7]
	2040	2040
Carbon tax in USD	72	25
Carbon tax revenue	223	223
CO2 Emissions Variation	-3.6%	-19.30%
Welfare impact: household cons. World	-0.09%	-0.10%
Welfare impact: household cons. FSU	-0.60%	-3.44%
Welfare impact: household cons. USA	-0.74%	-0.38%
Welfare impact: household cons. CHI	-0.09%	-2.75%

[5] = OECD carbon tax with climate change compensation

- High welfare cost for China & FSU
- Effective against climate change

Tax Revenue Redistribution to DC Based on Adaptation Costs

Table 37: Adaptation costs in millions of USD

	2010	2020	2030	2040
MEX	366	696	1224	1811
CHI	22	47	96	157
IND	1745	3768	7784	13017
ASI	4008	6645	10296	13366
LAT	895	1517	2626	3738
MID	1516	2782	5153	7476
AFR	1011	1871	3445	5110
Sum	9563	17326	30624	44674

OECD Carbon Tax For Climate Change Adaptation [8]

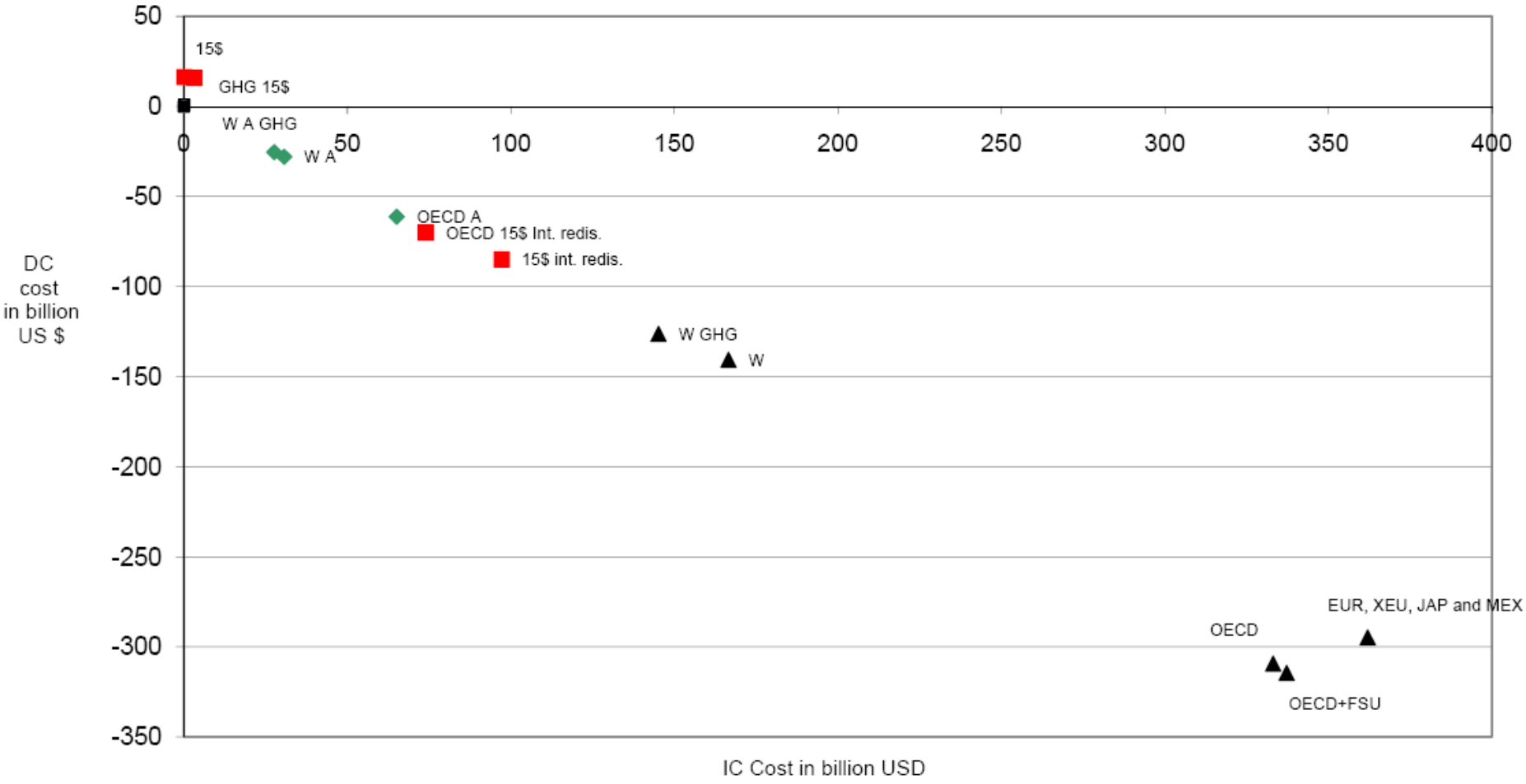
Comparaison between scenarios [5] and [8]		
	[5]	[8]
	2040	2040
Carbon tax in USD	72	13
Tax revenue	223	45
CO2 Emissions Variation	-3.6%	-0.9%
Welfare impact: household cons. World	-0.09%	-0.01%
Welfare impact: household cons. EUR	-0.77%	-0.15%
Welfare impact: household cons. XEU	-1.23%	-0.24%
Welfare impact: household cons. USA	-0.74%	-0.15%
Welfare impact: household cons. CAN	-1.68%	-0.39%
Welfare impact: household cons. AUZ	-1.80%	-0.32%
Welfare impact: household cons. CHI	-0.09%	-0.02%
Welfare impact: household cons. IND	8.15%	1.82%

[5] = OECD carbon tax with climate change compensation

World Carbon Tax For Climate Change Adaptation [9]

Comparaison between scenarios [8] and [9]		
	[8]	[9]
	2040	2040
Carbon tax in USD	13	4
Tax revenue	45	45
CO2 Emissions Variation	-0.9%	-5.9%
Welfare impact: household cons. World	-0.01%	-0.01%
Welfare impact: household cons. USA	-0.15%	-0.07%
Welfare impact: household cons. FSU	-0.11%	-0.58%
Welfare impact: household cons. CHI	-0.02%	-0.63%
Welfare impact: household cons. IND	1.82%	1.32%

Overview: DC vs IC costs



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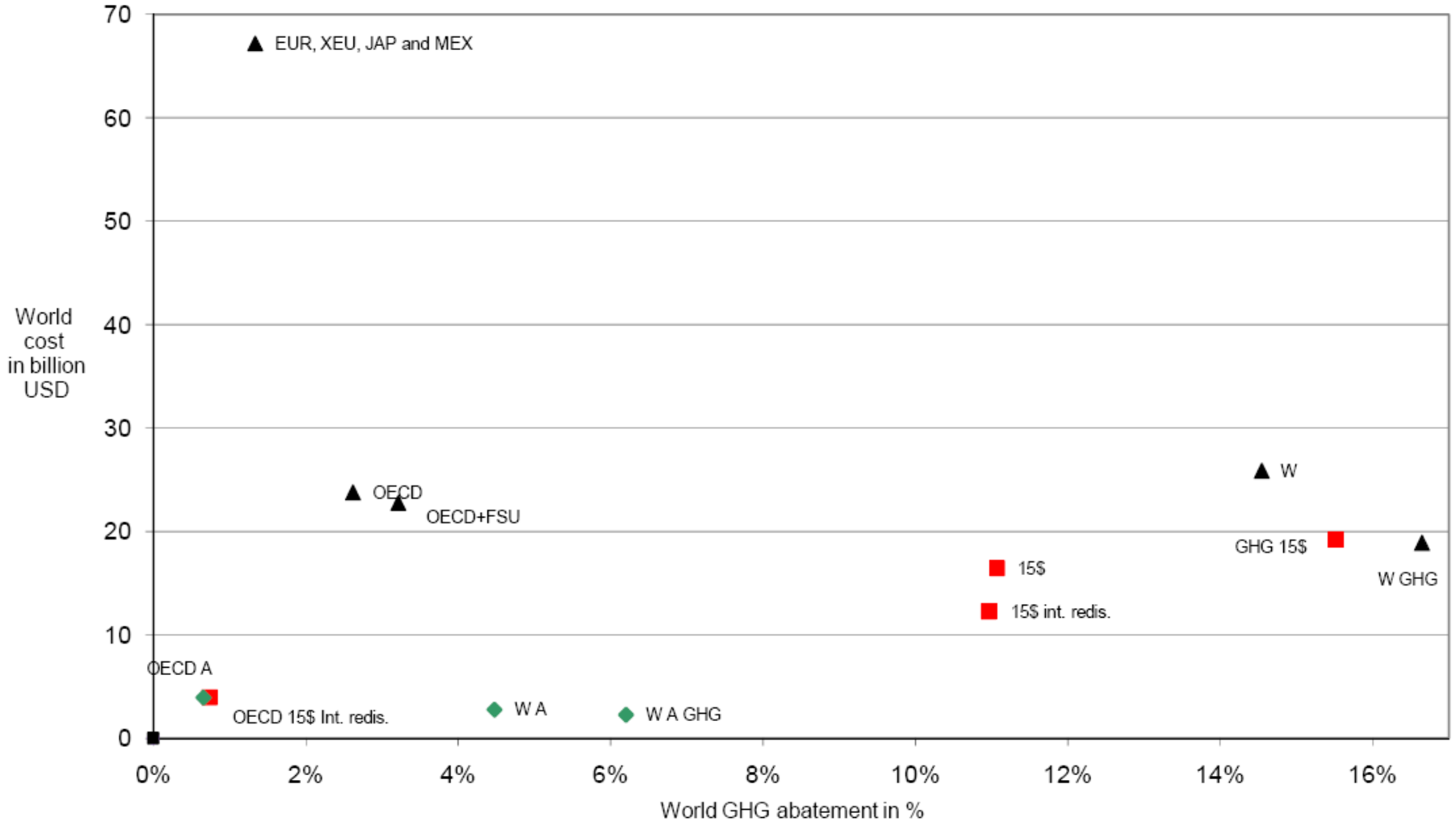
Overview: cost vs effectiveness



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Conclusions

- A uniform worldwide carbon tax is costly to most DCs, especially China, Africa and Middle-East
- But taxing only industrialized countries would be ineffective and inefficient, generating high costs for some countries and substantial carbon leakage
- A small worldwide tax ($15/tC) yields significant CO_2 reductions at small cost but too little revenue to compensate climate damages
- The worldwide tax must to rise to $72/tC in 2040 to generate sufficient revenue for damage costs
- A worldwide CO2 tax rising to $4/tC is enough for DC adaptation costs
- A GHG tax is always more effective and more efficient than a carbon tax
- Very different impacts for different DC (e.g. India vs China)