

Investments and Financial Flows for Climate Change Mitigation

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Introduction

- Large literature on transformation pathways and on the economic cost of mitigation
- Limited discussion on investments and financial flows
- However, growing interest in "climate finance"
- COP 21: finance an official objective (Art 2)

"Making financial flows consistent with a pathway towards low greenhouse gas emissions and climate resilient development"

Why "Climate Finance"?

- In an ideal world:
 - Set the right incentives and investments/financial flows will follow
 - Market imperfections as in any other sector
 - Main focus on economic cost
- But in our world:
 - Investments can be observed, macroeconomic costs and emission reductions cannot be observed
 - Pledge and review/international co-operation/global funds
 - Incremental investments not observable
 - "Bridging the gap" between goals and reality
 - Financial flows as a policy tool (subsidies)

What Role for the IAM community?

1. Estimates of investments in mitigation/adaptation
 - Can capital markets provide the adequate amount of finance?
 - International cooperation/global funds
2. Estimates of financial flows
 - Public finances (carbon revenues, subsidies)
 - Global macroeconomic effects (domestic and international)
 - Price of commodities, trade, balance of payments
3. Do models without financial/monetary/public finance sector adequately estimate costs?

Outline

- Examples of what IAMs can do and knowledge gaps
- Literature and lessons learned from IPCC experience
- Estimates of investment needs and carbon finance using wider set of scenarios

The Literature

- Growing number of studies on global climate finance landscape (e.g. Buchner et al. 2014)
- Limited use of IAM to study investments and financial flows (e.g. IEA 2011; Carraro, Favero and Massetti, 2012; Riahi et al. 2012; McCollum et al. 2013)
- For the first time WGIII contribution to AR5 has chapter on cross-cutting investment and financial issues

Climate Finance

- There is no widely agreed definition of what constitutes "climate finance"
- Definition adopted by IPCC:

All financial flows whose expected effect is to reduce net greenhouse emissions and/or to enhance resilience to the impacts of climate variability and the projected climate change.

- Both mitigation and adaptation included

Climate Finance

- Total climate finance: about USD 343 to 385 billion per year.
- Around 95% goes to mitigation.
- Public climate finance to developing countries: USD 35 to 49 billion per year.
- Private climate finance flowing to developing countries: USD 10 to 72 billion per year, including foreign direct investment as equity and loans in the range of USD 10 to 37 billion

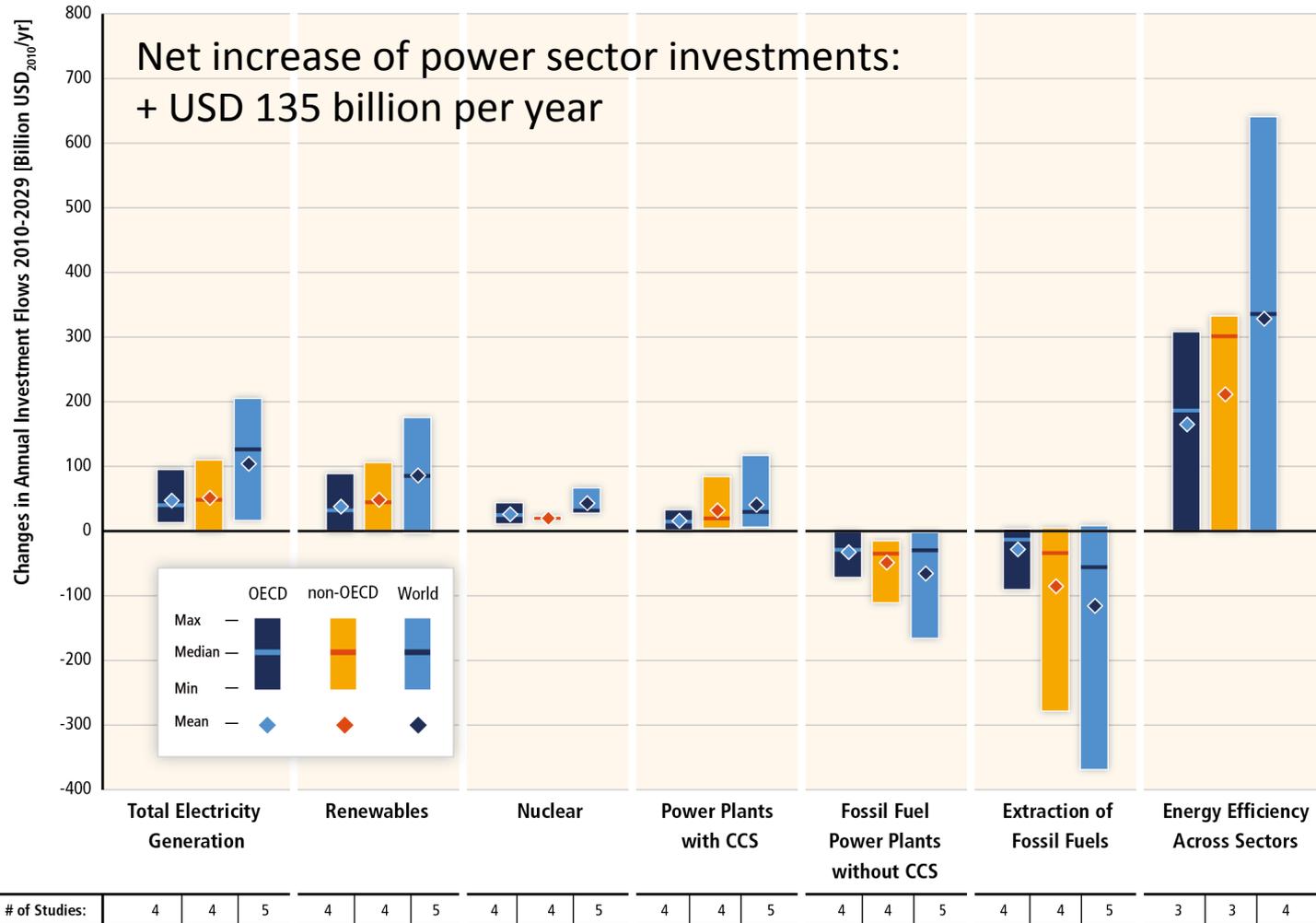
Incremental Investments

- Incremental investment:

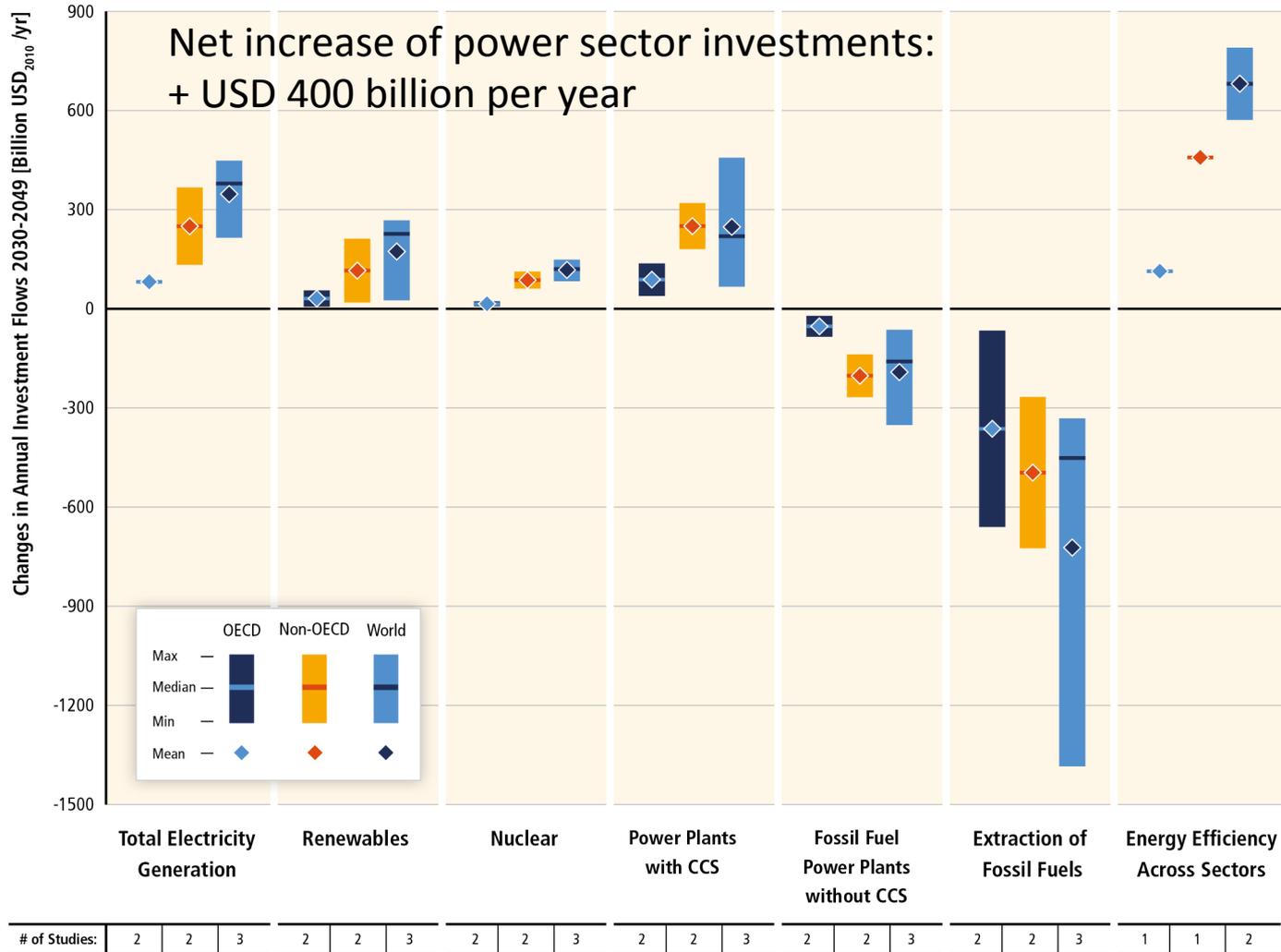
“Extra capital required for the initial investment for a mitigation or adaptation project in comparison to a reference project.”

- Need models/reference scenarios
- Not regularly estimated and reported
- IPCC Chapter uses the few studies in the literature consistent with a 2C scenario

Changes in Investment for Mitigation (2010-2029)



Changes in Investment for Mitigation (2030-2049)



Conclusions (I)

- Sharp redistribution of investment flows but overall increment appears to be manageable
 - 2030-2049 about 0.2% of GWP (2.5% growth rate)
- Incremental non-OECD investments in power generation: 48 billion USD / year from 2010 to 2029
- Well-functioning financial markets capable of reallocating investments over a long time period
 - Increased investments push interest rates up
 - Impact on other investments depends on savings decisions

Limits of the Literature

- Very few studies report data on investments
 - Power generation
 - Extraction of fossil fuels
 - Energy efficiency
 - Energy related R&D
- Very few models have a rich description financial flows/monetary variables
 - Lack of financial/monetary feedback of climate policy

A Larger Set of Scenarios

Focus on Power Generation and Carbon Finance

Method

- IPCC database of scenarios
- Use power generation data to estimate investments

$$I \downarrow t = C [(X \downarrow t + 10 - X \downarrow t) / 10 + X \downarrow t / \theta / L]$$

X: power generation; I: investment (\$); C: investment cost (\$/MW); L: load factor ($0 < L < 1$); θ : lifetime (years)

- Cost of renewables fixed: overestimate investment needs
- Lifetime, investment cost and load factor from IPCC WGIII, Annex III
 - Central case: median cost and max load factor
 - Sensitivity analysis using min and max cost and min load factor

Scenarios

	2010-2050	2010-2100	Total
430-530 ppm CO ₂ -eq	7	96	103
530-650 ppm CO ₂ -eq	15	91	106
650-1000 ppm CO ₂ -eq	14	78	92
Total	36	265	301

- Tech flexibility: model default
- Where flexibility: full
- Energy intensity: model default

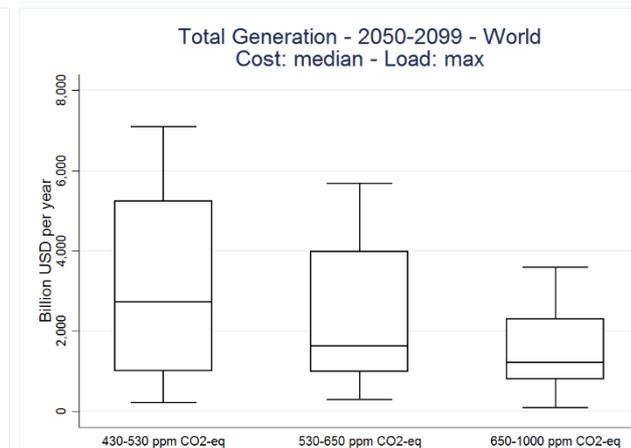
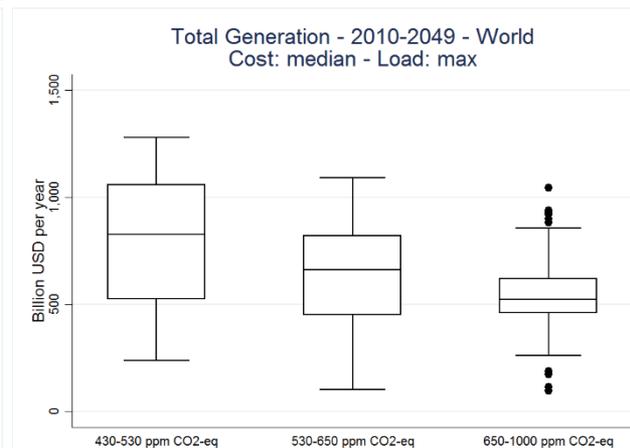
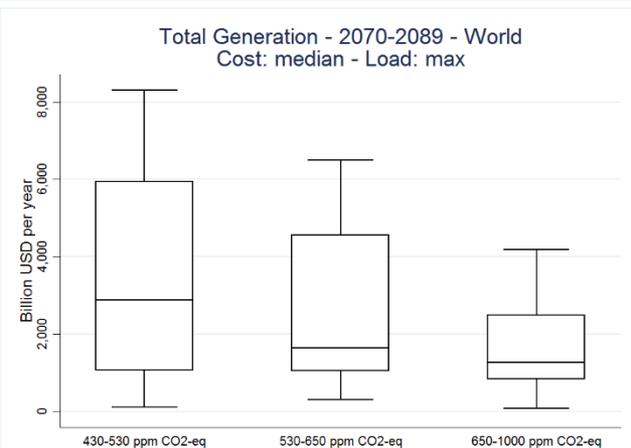
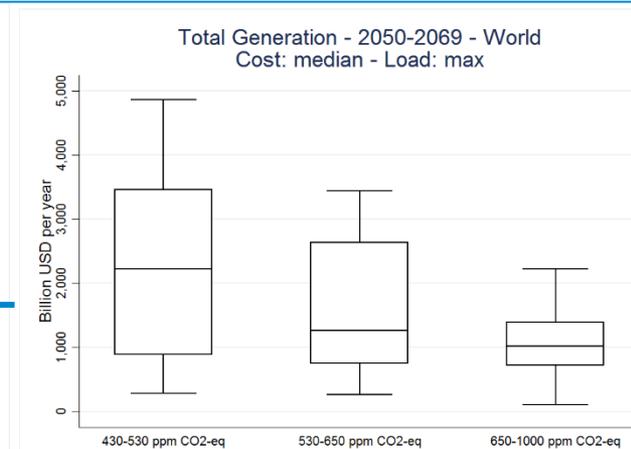
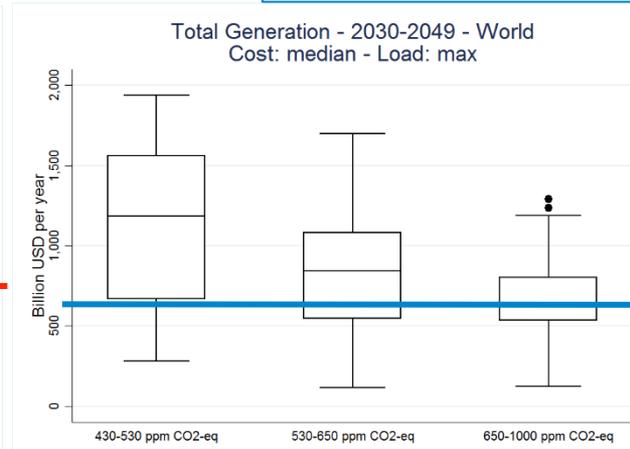
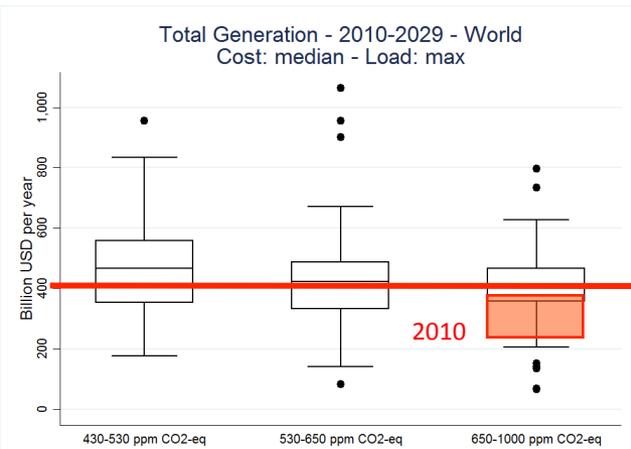
Models (24) and Projects (9)

	AME	AMPERE	EMF27	GEA	LIMITS	N/A	POEM	RCP	RECIPE	ROSE	Total
AIM-Enduse			3		3						6
BET 1.5			3								3
DNE21	6	6									12
EC-IAM			2								2
ENV-Linkages			3								3
FARM			2								2
GCAM	6	10	3		3						22
GEM-E3		3									3
GRAPE	5		2								7
GTEM	4										4
IEEJ						1					1
IGSM						1					1
IMACLIM		9	3								12
IMAGE	6	8	3		3		1				21
MARIA23	5										5
MERGE	5	10	3								18
MESSAGE	6	10	3	3	3			4			29
POLES	4	10	3								17
Phoenix	5		3								8
REMIND	6	10	3		3					29	51
TIAM	6		3		3						12
TIMES	6										6
WITCH	5	10	3		3				1	31	53
WorldScan		3									3
Total	75	89	45	3	21	2	1	4	1	60	301

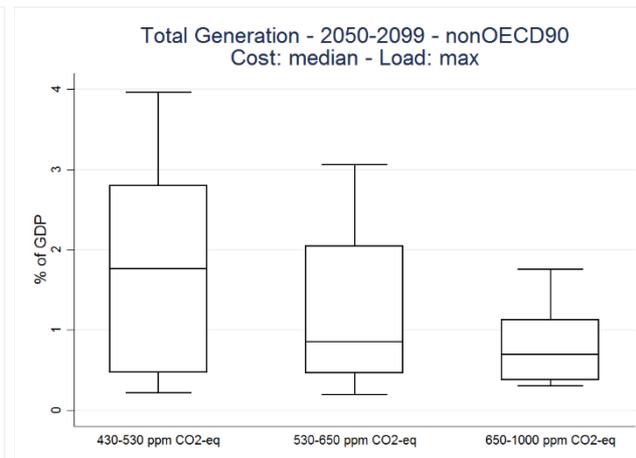
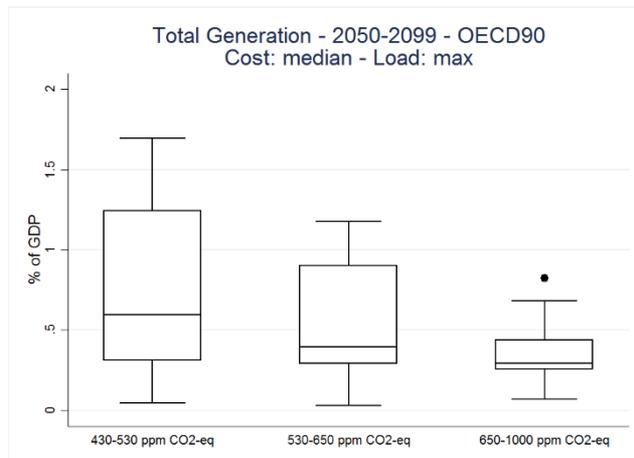
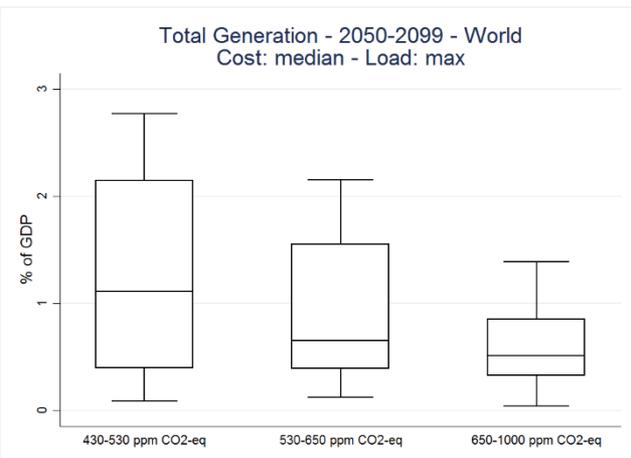
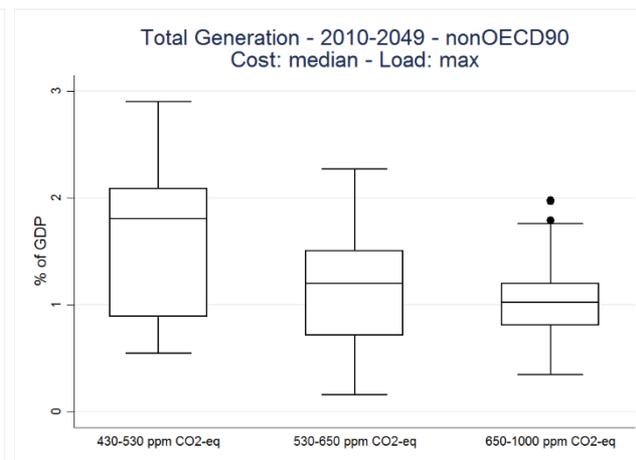
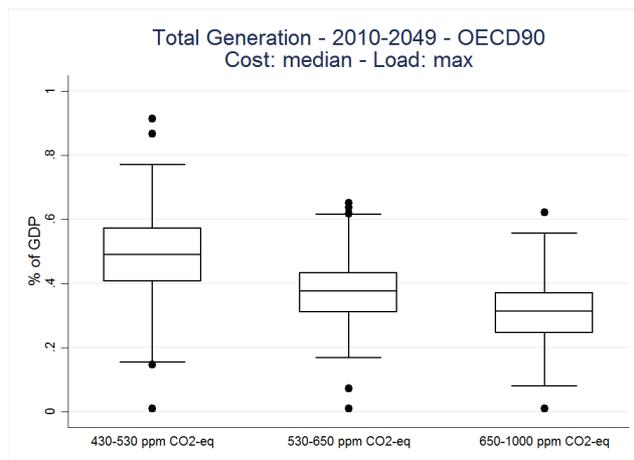
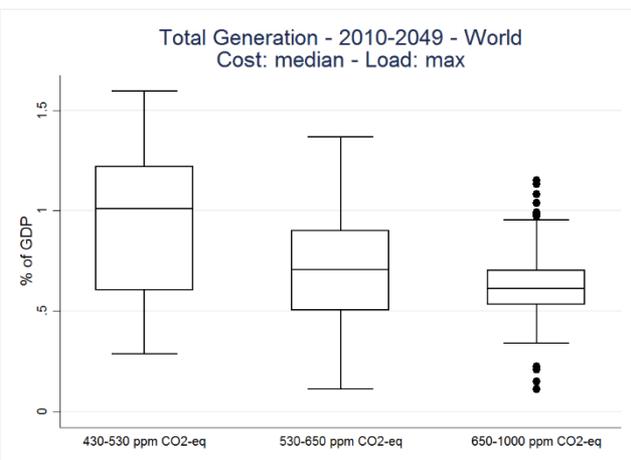
Investments in Power Generation

+61B USD wrt to BaU – IPCC: +135B USD wrt BaU

+561B USD wrt to BaU – IPCC: +400B USD wrt BaU

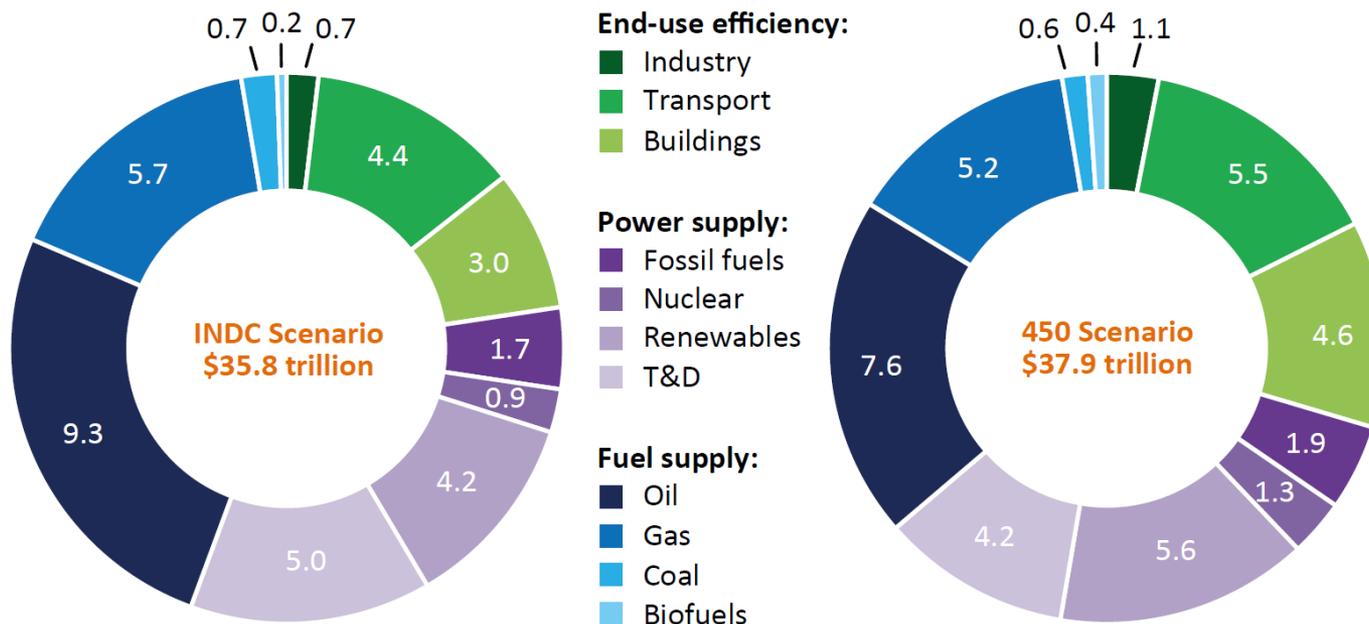


Investments as % of GDP



IEA Investment Scenarios

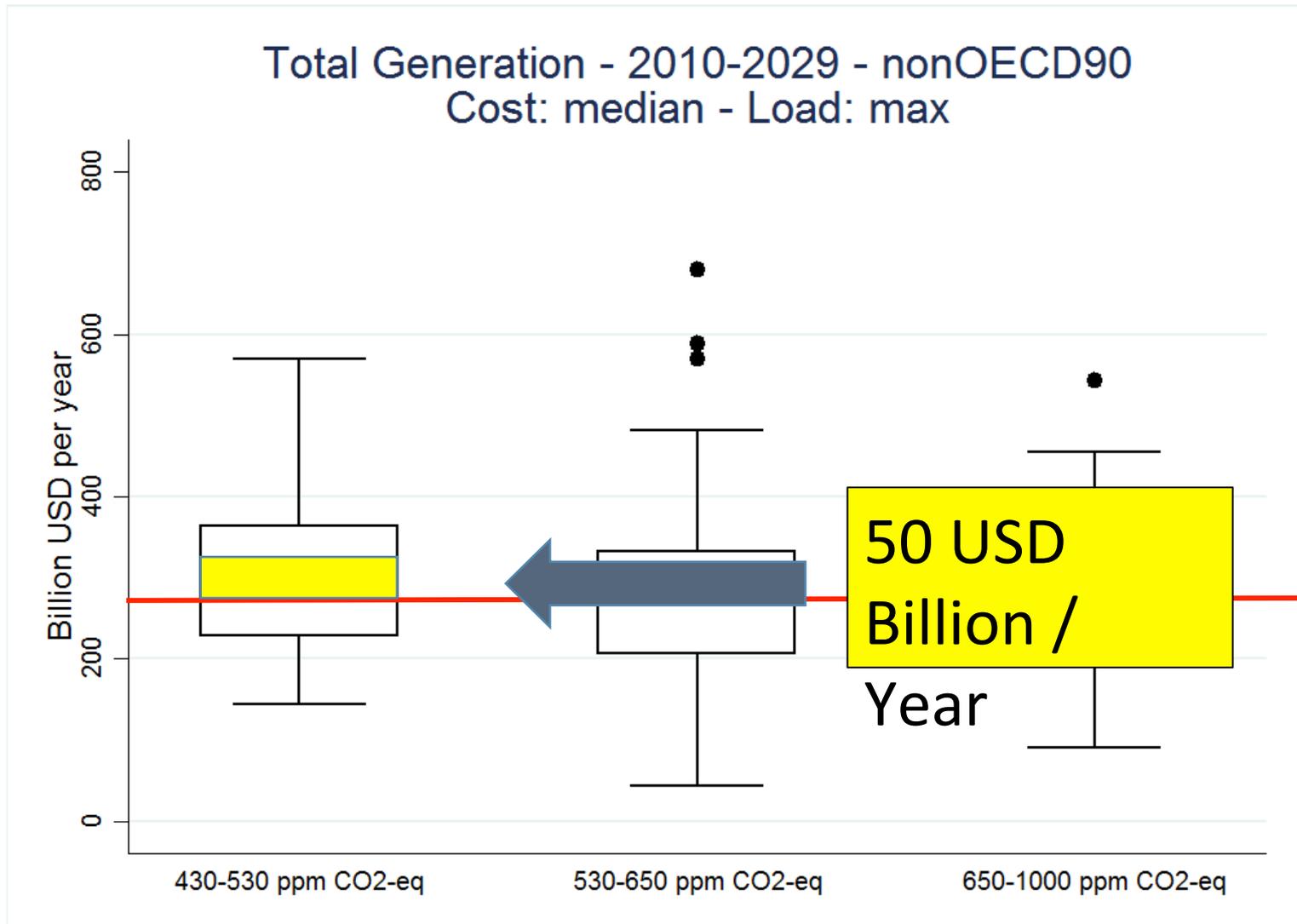
+130 Billion USD / year in power generation to go from INDC to 450



Note: T&D is transmission and distribution.

3. Energy efficiency investment is defined as the additional expenditure made by energy users to improve the performance of their energy-using equipment above the average efficiency level of that equipment in 2012.

"Climate Mitigation Fund"



Summary

- Investment needs (median estimate, central case)

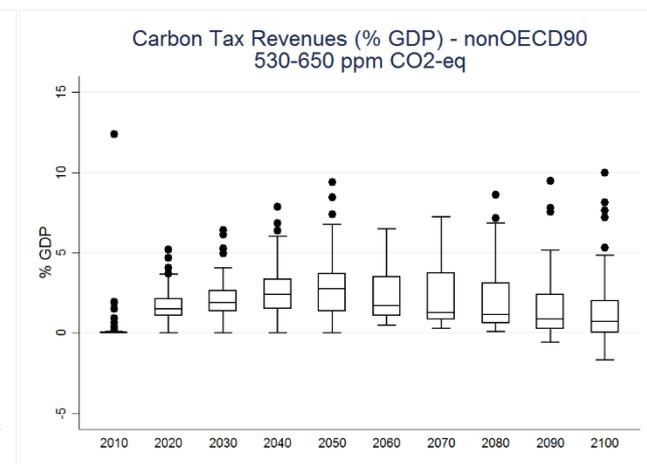
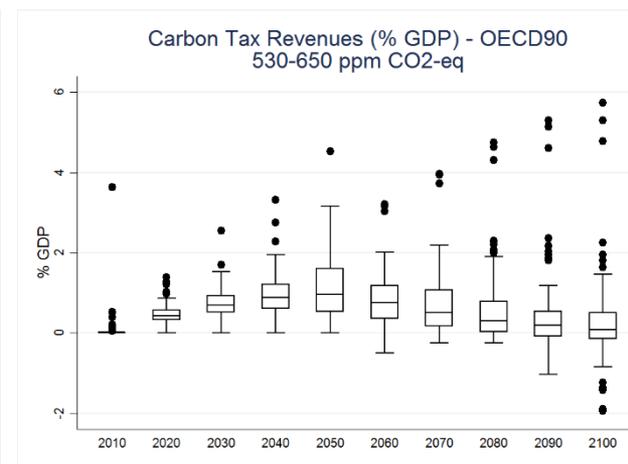
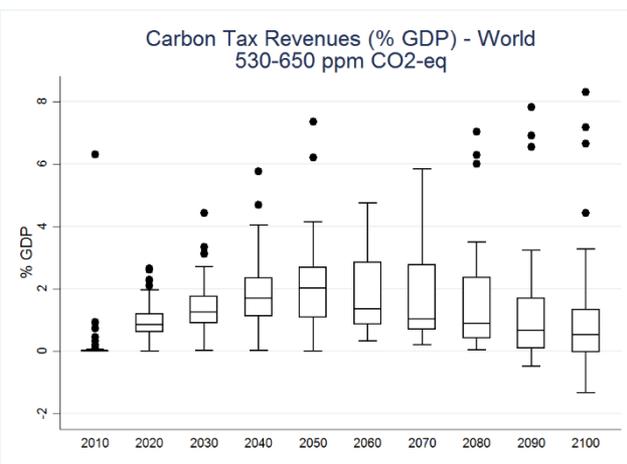
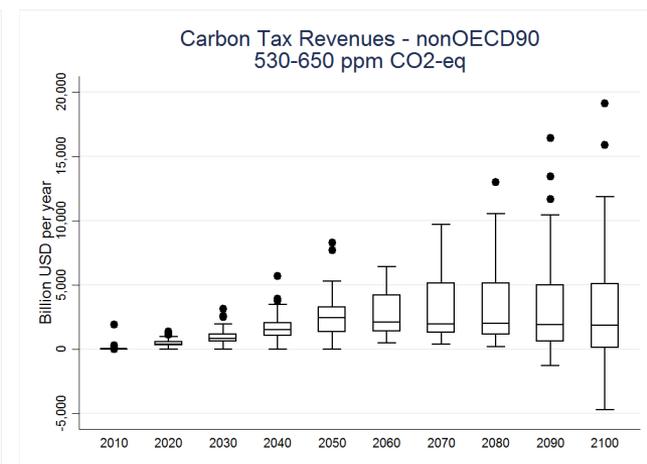
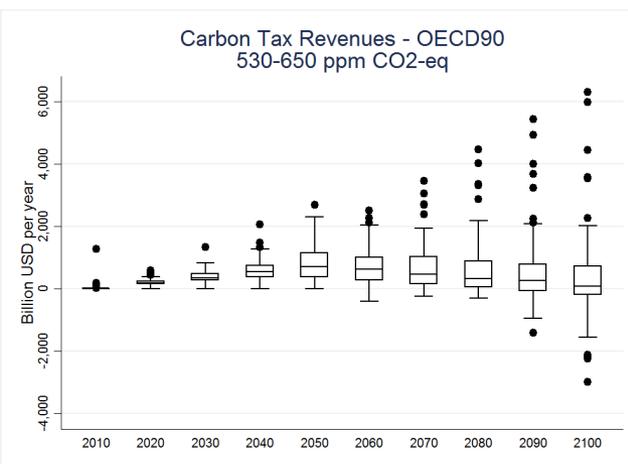
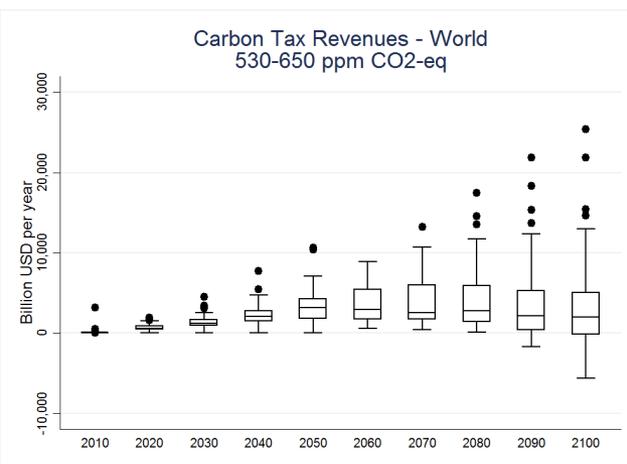
		World	OECD90	nonOECD90
2010-2029	430-530 ppm CO ₂ -eq	467 (+ 61)	163 (+ 30)	321 (+ 49)
	530-650 ppm CO ₂ -eq	423 (+ 18)	145 (+ 16)	287 (+ 14)
2010-2049	430-530 ppm CO ₂ -eq	827 (+ 304)	226 (+ 78)	627 (+ 253)
	530-650 ppm CO ₂ -eq	661 (+ 138)	190 (+ 43)	466 (+ 194)
2050-2099	430-530 ppm CO ₂ -eq	2,725 (+ 1,511)	480 (+ 215)	2,253 (+ 1,264)
	530-650 ppm CO ₂ -eq	1,637 (+ 422)	393 (+ 128)	1,336 (+ 346)

Revenues from Carbon Pricing

- Rough estimate: carbon tax multiplied by level of CO₂ emissions
- Time profile depends on elasticity of carbon emissions to carbon pricing
- Evidence suggests a hill-shaped pattern
 - Max flow around 2040-2050
 - Negative flows (subsidies) after 2070 in 430-530 ppm CO₂-eq

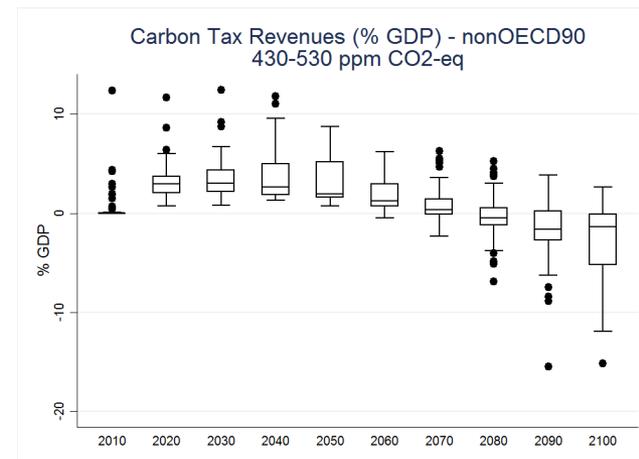
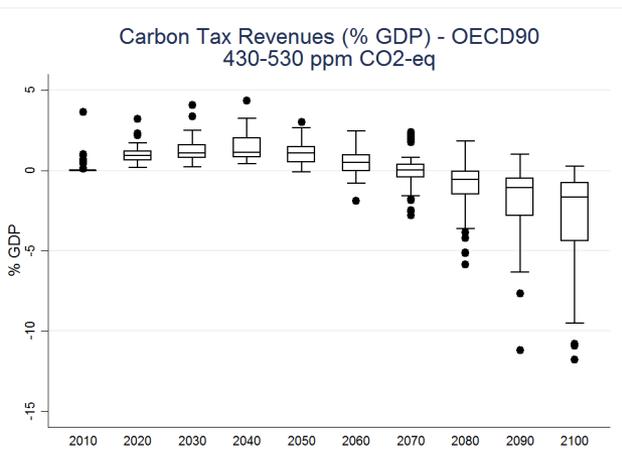
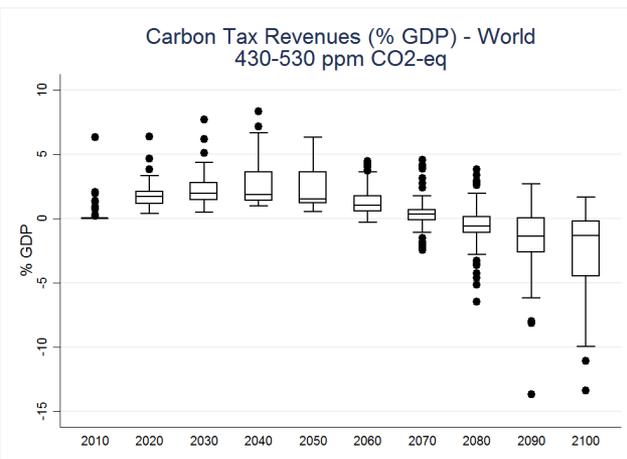
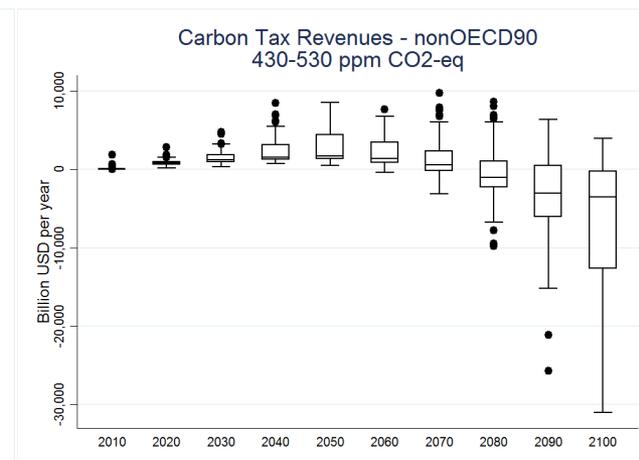
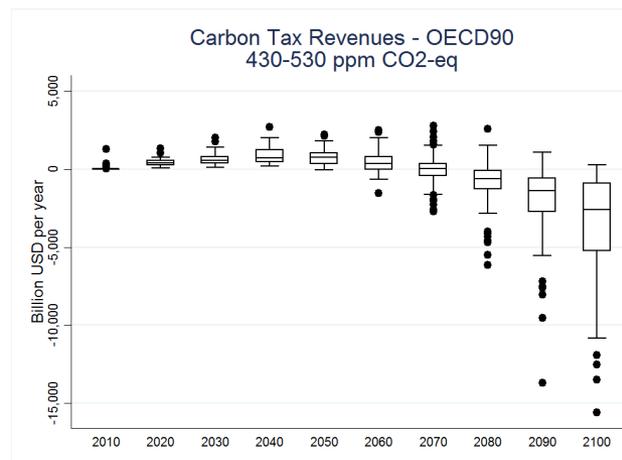
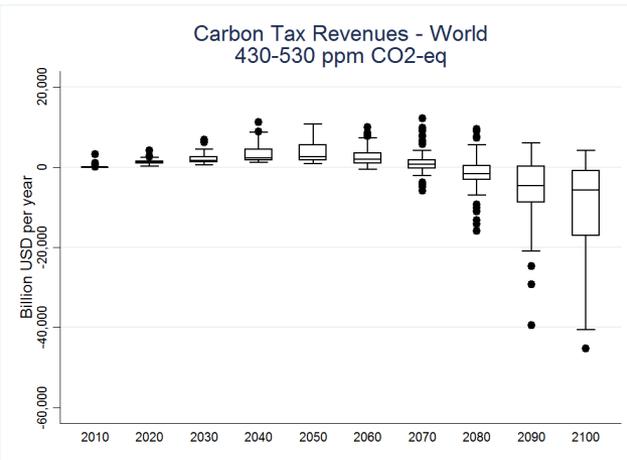
Carbon Tax Revenues

530-650 ppm CO₂-eq



Carbon Tax Revenues

430-530 ppm CO₂-eq



Challenges and Opportunities

- Large potential for tax reform programs
- Extremely large revenues in developing countries
 - Carbon taxes higher than all current tax revenues in many developing countries (Tol, 2012)
- Possible net negative flow at the end of the century
 - If public subsidy, financed by other taxes
 - "Double Cost" rather than "Double Dividend"?

Emission Trading

- Financial implications of large allocation schemes often overlooked, with few exceptions (e.g. McKibbin et al. 1998)
- IAMs generally do not model trade, balance of payments, exchange rates
- In some regions financial flows may be a large fraction of GDP (e.g. McCollum et al., 2013)
- Financial and macroeconomic limitations to implement these transfers

New and Old Commodities

- Coal consumption greatly reduced, zero without CCS
- Natural gas consumption may act as bridge but reduced in the long run
- Oil consumption in transport sharply reduced in second half of the century
- Biomass use greatly increased

- New global trade patterns
- Not a major issue per se, but meaningful impact on balance of payments, exchange rates and overall macroeconomic stability of entire regions

Ideas for IA Modelers

- Easy
 - Provide data on investments or at least detailed information on costs and other assumptions to allow off-line calculations
- Harder
 - Develop public sector to study public finance implications of carbon pricing
 - Determine macroeconomic impacts of international financial flows
 - Use empirical evidence to constrain financial flows

Ideas for Policy Makers

- The "finance gap" is the result of weak climate policies
- Fill the "policy gap" and the "financial gap" will automatically close
- If "climate finance" is the new buzz-word for subsidies/international cooperation, use (also) insights from IAMs to estimate size of subsidies
- Next IPCC report:
 - Large fraction of AR5 WGIII Ch 16 on barriers to investments and innovative financial schemes
 - But nothing really special about mitigation investments
 - Focus on
 - incremental investments
 - financial flows
 - public finance
 - global macro issues

Thank you for your attention

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Change of investments wrt BaU (430-530 ppm)

	2010-2029					2030-2049				
	number of studies	median	min	mean	max	number of studies	median	min	mean	max
World										
Electricity Generation	5	126.3	16.5	104.1	205.2	2	249.9	132.9	249.9	367.0
Renewables	5	85.4	-3.2	86.0	175.6	2	115.6	19.1	115.6	212.1
Nuclear	5	31.6	27.7	43.1	66.8	2	86.8	61.1	86.8	112.6
Power Plants with CCS	5	29.8	6.3	40.7	117.2	2	250.1	180.4	250.1	319.9
Total Fossil Power Plants	5	-29.7	-165.8	-65.6	-2.1	2	-202.6	-267.2	-202.6	-138.0
Extraction of Fossil Fuels	5	-55.9	-368.9	-115.7	8.3	2	-495.7	-724.6	-495.7	-266.8
Energy Efficiency	4	335.7	0.8	328.3	641.0	1	458.0	458.0	458.0	458.0
R&D in energy sector*	3		4.5		78.0	2		115.0		126.0

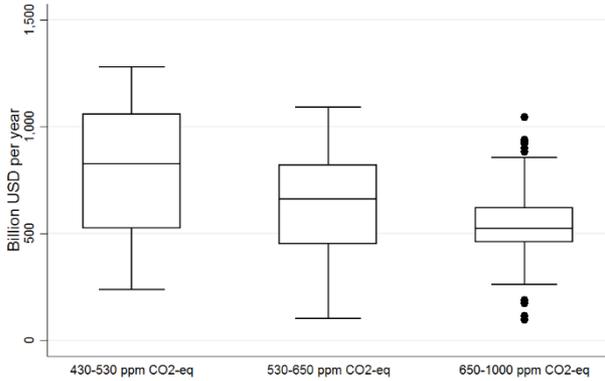
Source: Massetti (2015)

Notes: Data used to draw Figure 16.3 and 16.4 in Gupta et al. (2014). Mitigation scenarios that stabilize concentrations within the range of 430 – 530 ppm CO₂-eq by 2100. Change relative to respective average baseline investments. For a complete list of references see notes to Figures 16.3 and 16.4 in Gupta et al. (2014). * R&D investments are from UNFCCC (2007), Carraro et al. (2012) and McCollum et al. (2013) for 2010-2029 and from Carraro et al. (2012), Marangoni and Tavoni (2013), McCollum et al. (2013), Bosetti et al. (2009) and IEA (2010).

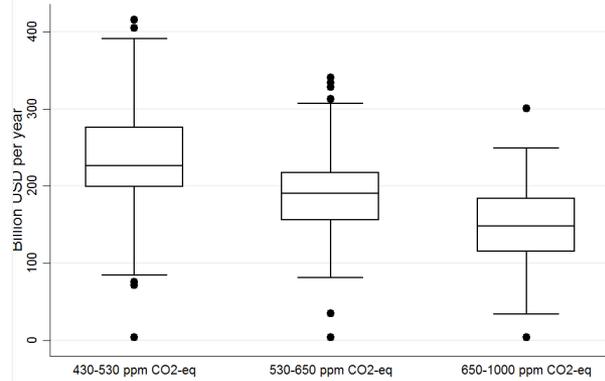
	2010-2029					2030-2049				
	number of studies	median	min	mean	max	number of studies	median	min	mean	max
<u>Non-OECD</u>										
Electricity Generation	4	48.3	-1.1	51.4	110.1	3	378.9	215.0	347.3	448.1
Renewables	4	44.5	-1.5	48.4	105.9	3	226.8	25.7	173.4	267.6
Nuclear	4	20.0	16.4	19.8	23.1	3	120.4	83.6	117.6	148.8
Power Plants with CCS	4	19.7	4.4	32.0	84.4	3	219.6	66.9	247.9	457.2
Total Fossil Power Plants	4	-34.8	-110.8	-48.8	-14.9	3	-159.5	-351.5	-191.5	-63.6
Extraction of Fossil Fuels	4	-33.9	-278.5	-85.4	4.9	3	-451.3	-1384.5	-722.5	-331.8
Energy Efficiency	3	301.3	0.4	211.5	332.7	2	681.0	571.8	681.0	790.1
<u>OECD</u>										
Electricity Generation	4	40.1	13.3	47.2	95.1	2	81.6	81.1	81.6	82.1
Renewables	4	32.0	-1.7	37.8	88.7	2	31.1	6.6	31.1	55.5
Nuclear	4	24.7	11.3	26.1	43.7	2	15.2	7.9	15.2	22.5
Power Plants with CCS	4	14.6	1.9	16.0	32.8	2	88.3	39.2	88.3	137.3
Total Fossil Power Plants	4	-28.9	-71.6	-32.6	-1.1	2	-52.9	-84.3	-52.9	-21.5
Extraction of Fossil Fuels	4	-13.2	-90.4	-28.3	3.4	2	-363.0	-659.9	-363.0	-66.1
Energy Efficiency	3	186.4	0.4	165.0	308.3	1	113.8	113.8	113.8	113.8

Regional Differences

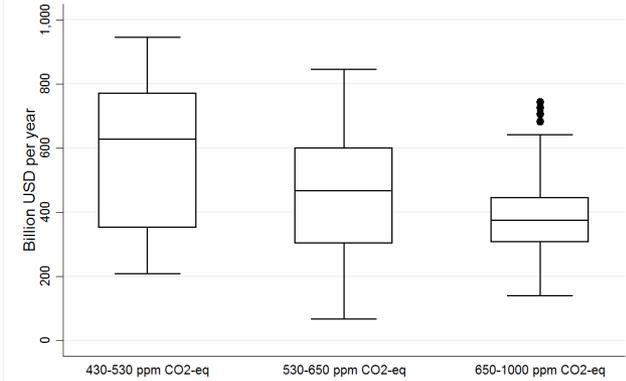
Total Generation - 2010-2049 - World
Cost: median - Load: max



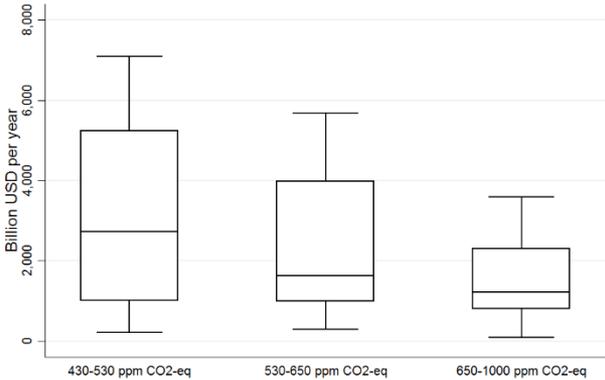
Total Generation - 2010-2049 - OECD90
Cost: median - Load: max



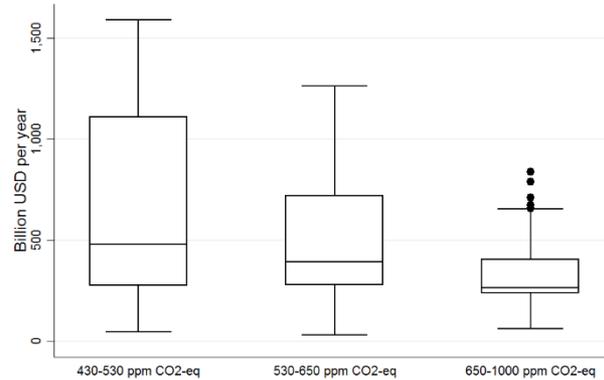
Total Generation - 2010-2049 - nonOECD90
Cost: median - Load: max



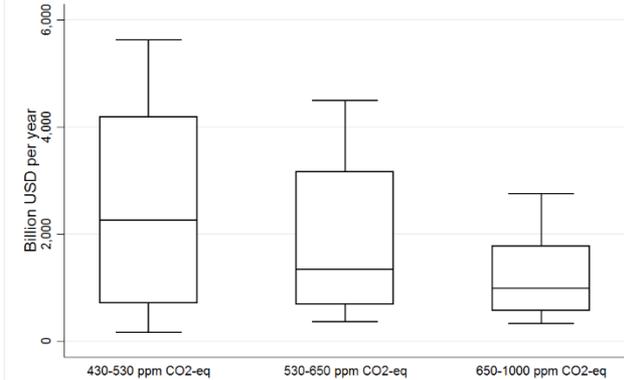
Total Generation - 2050-2099 - World
Cost: median - Load: max



Total Generation - 2050-2099 - OECD90
Cost: median - Load: max

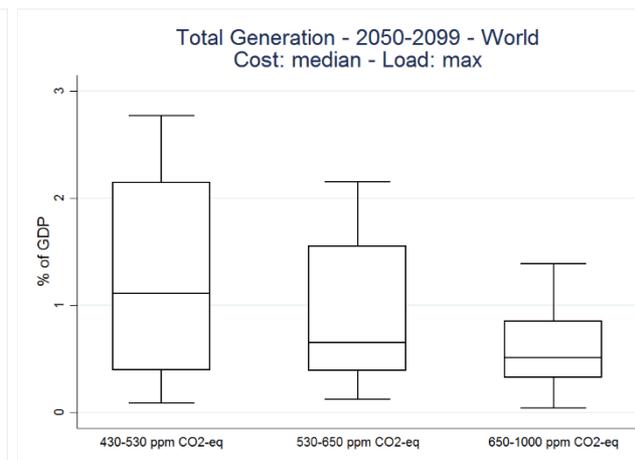
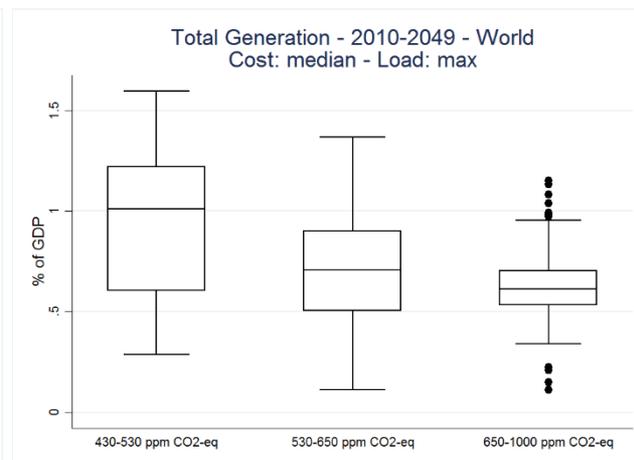
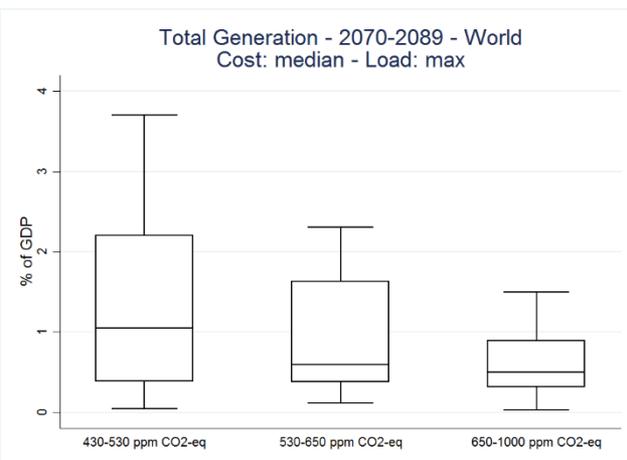
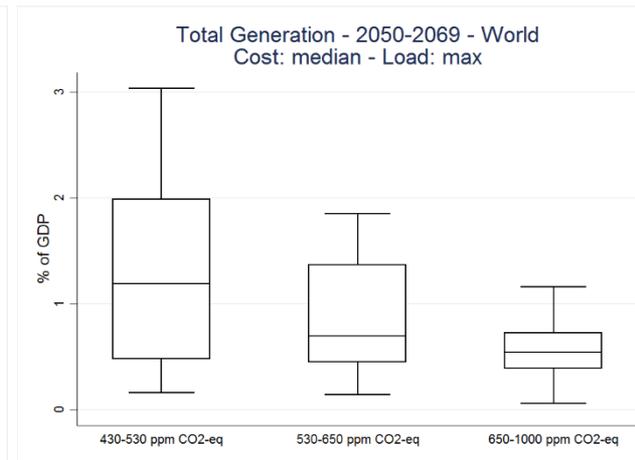
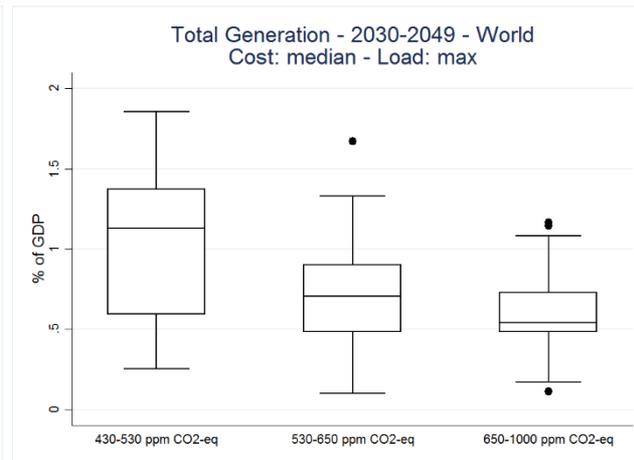
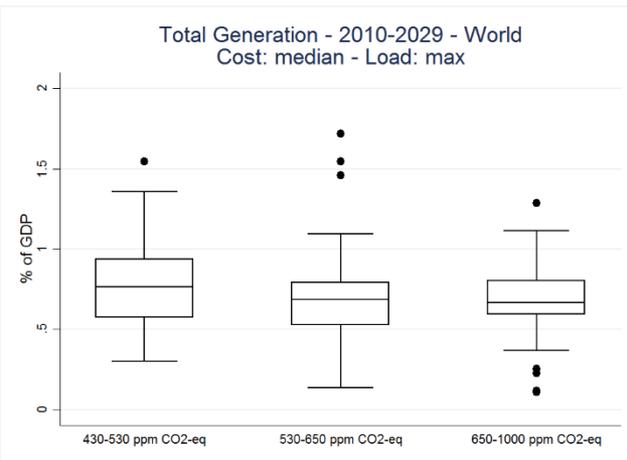


Total Generation - 2050-2099 - nonOECD90
Cost: median - Load: max

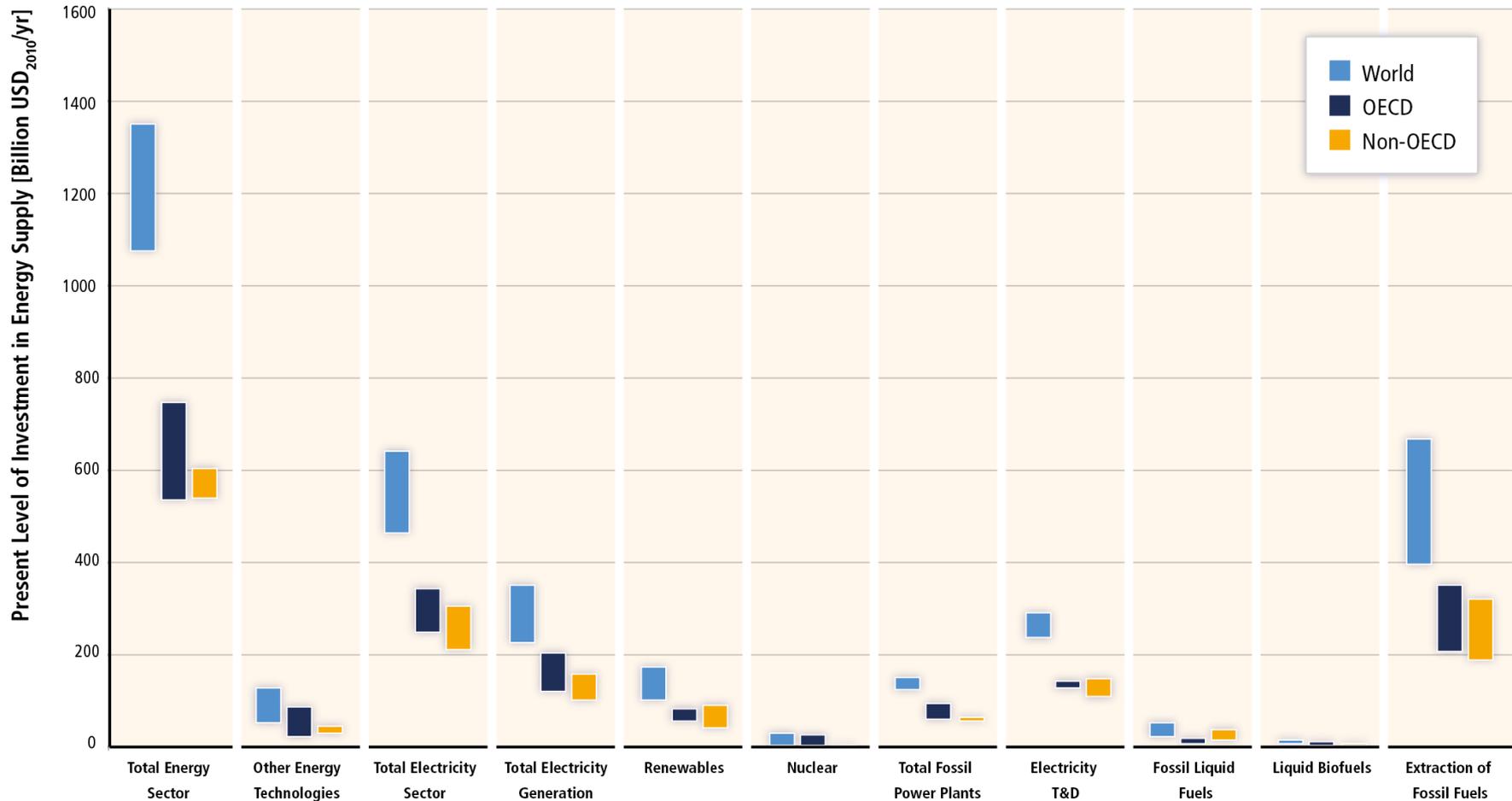


Investments as % of GDP

Global



Current investment in the energy system: about 1,2 trillion USD / year



Within an appropriate enabling environment, the private sector can help to mitigate climate change

