Investments and Financial Flows for Climate Change Mitigation

Emanuele Massetti
Georgia Institute of Technology, FEEM, CESIfo

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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 constitues "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

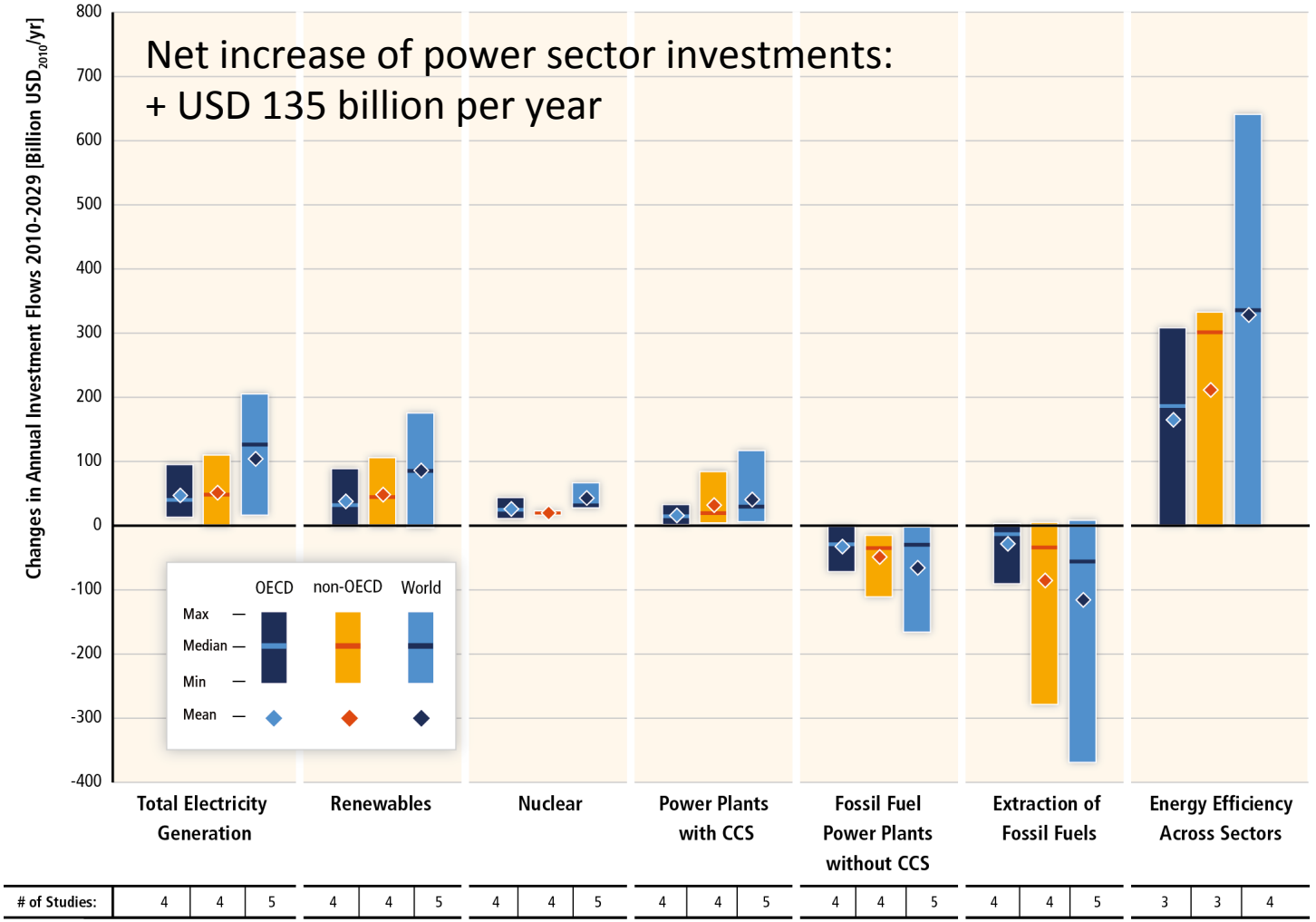
- Incremental investment:

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

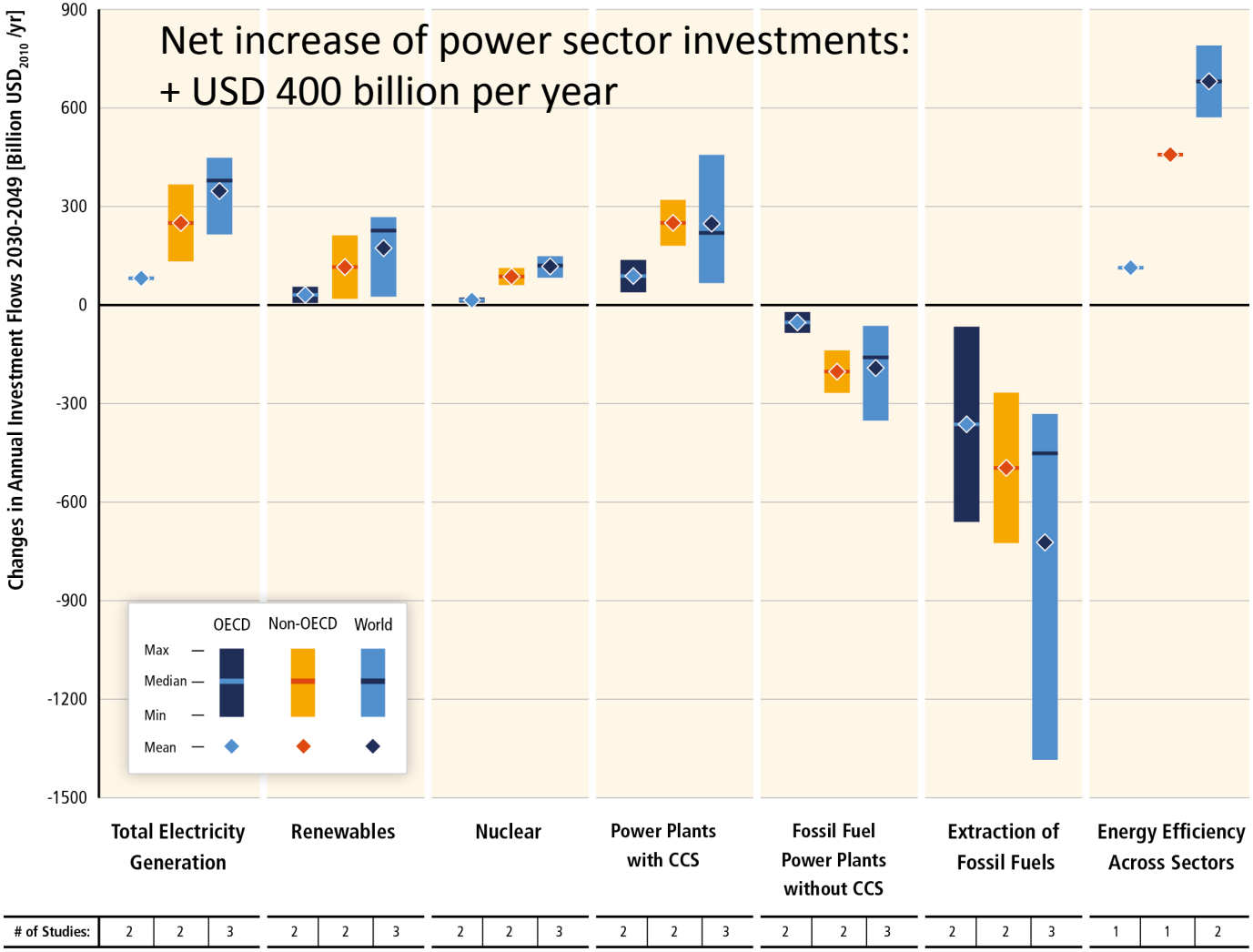
- Need models/reference scenarios

- 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

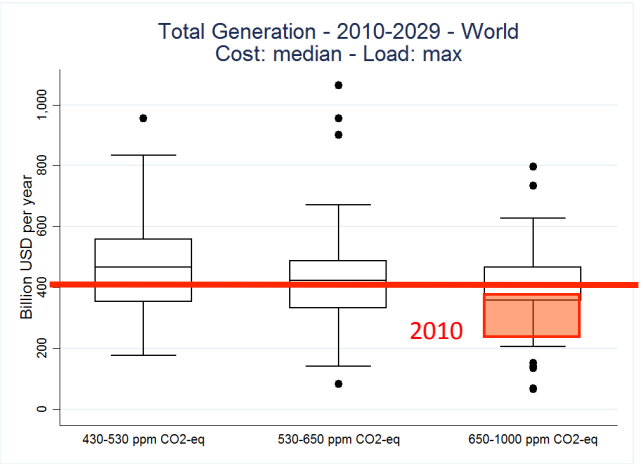
Models (24) and Projects (9)

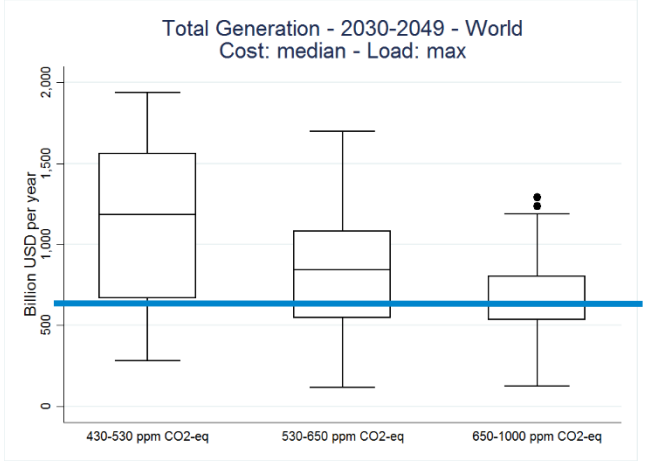
	AME	AMPERE	EMF27	GEA	LIMITS	N/A	POEM	RCP	RECIPE	ROSE	Total
AIM-Enduse			3		3						**6**
BET 1.5			3								**3**
DNE21	6	6									**12**
EC-IAM			2								**2**
ENV-Linkages			3								**3**
FARM			2								**2**
GCAM	6	10	3		3						**22**
GEM-E3		3									**3**
GRAPE	5		2								**7**
GTEM	4										**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**

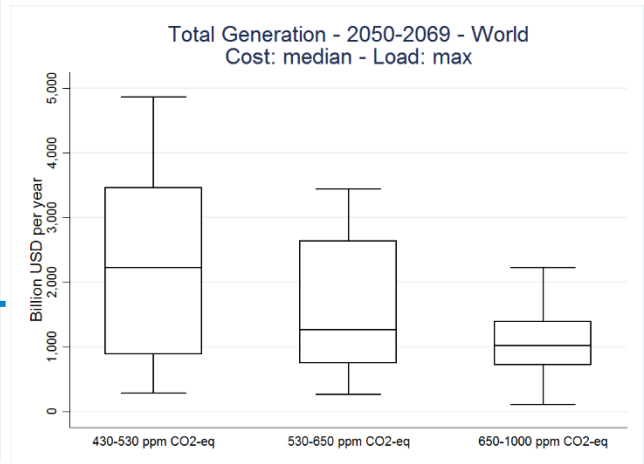
Investments in Power Generation

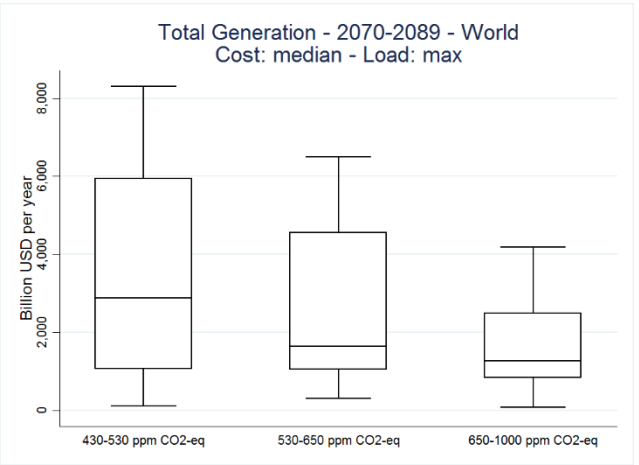
+61B USD wrt to BaU – IPCC: +135B USD wrt BaU

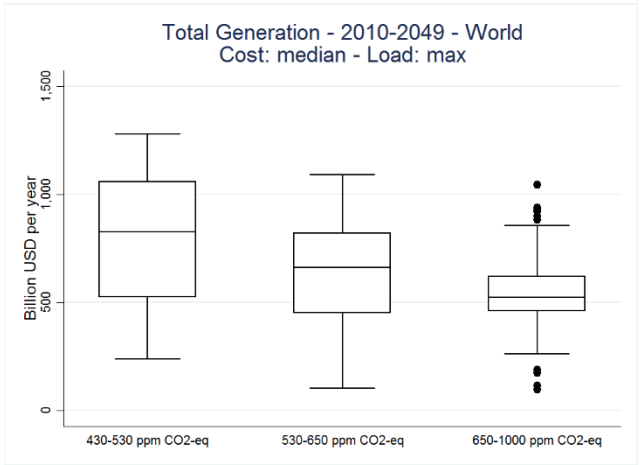
+561B USD wrt to BaU – IPCC: +400B USD wrt BaU

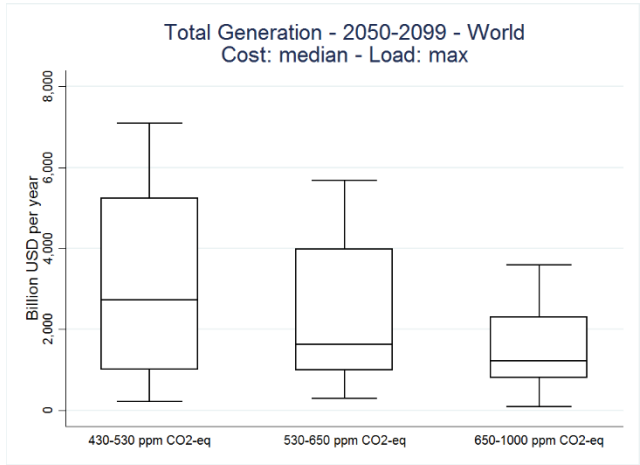




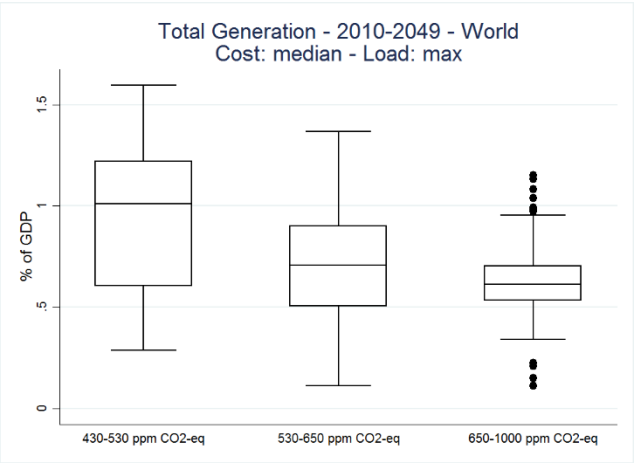


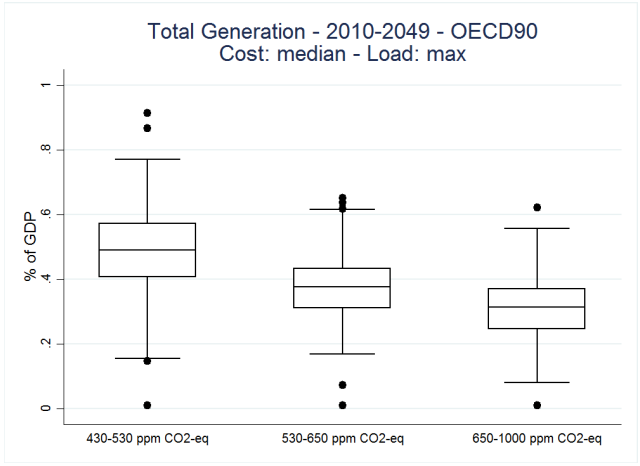


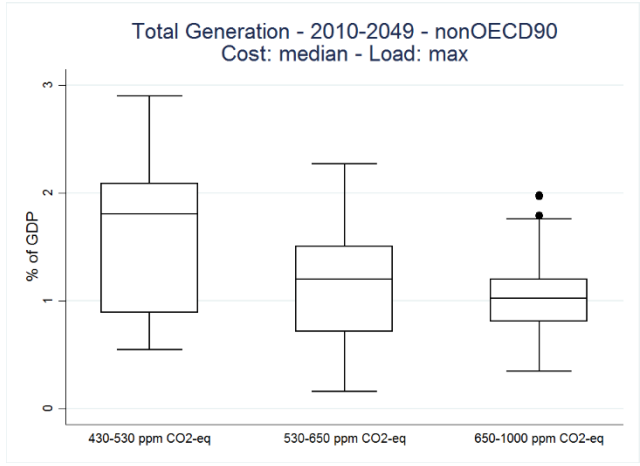


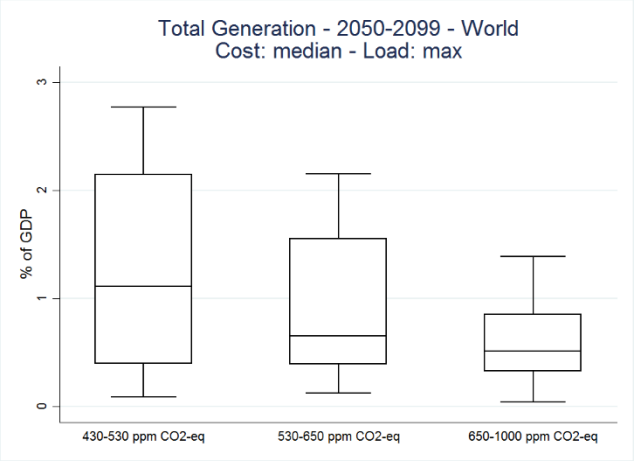


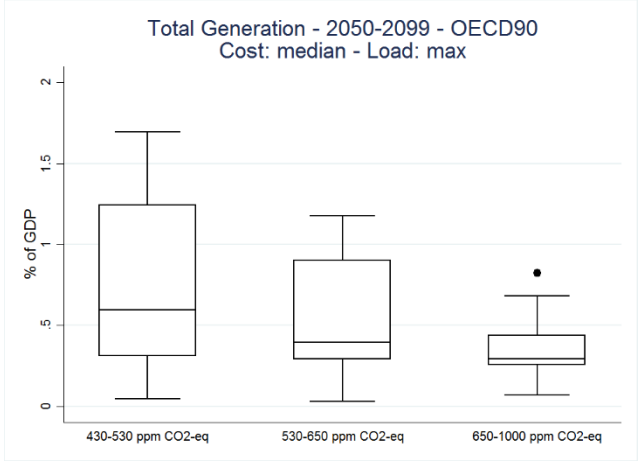
Investments as % of GDP

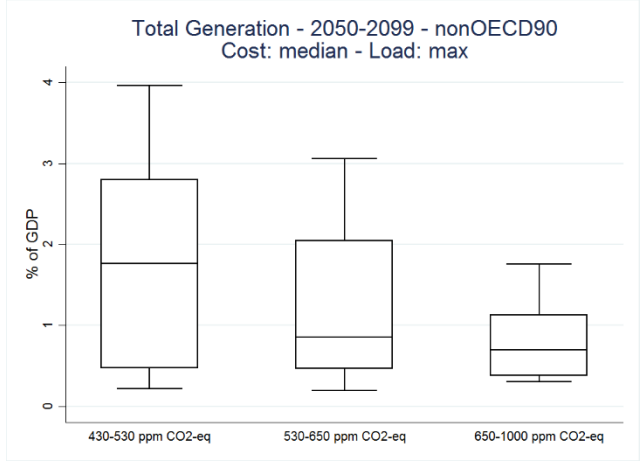






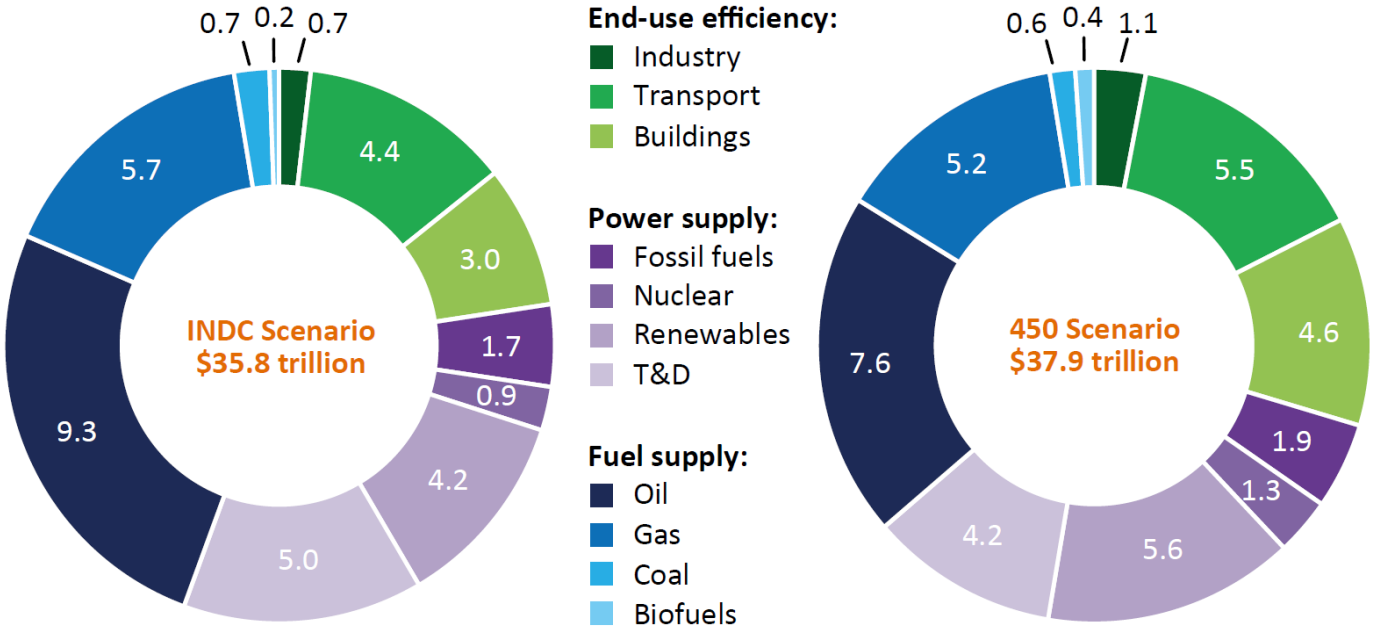






IEA Investment Scenarios

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

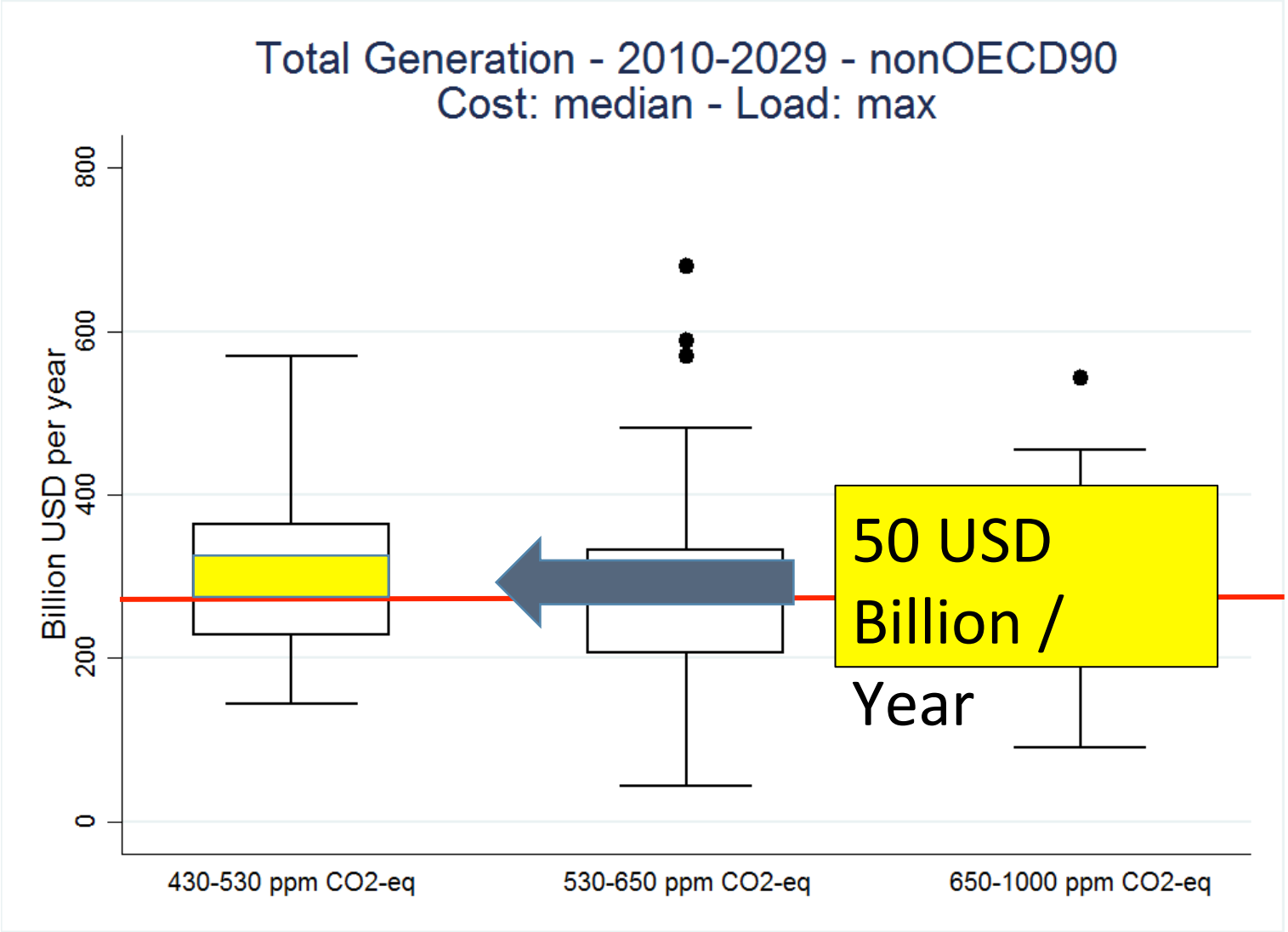


Note: T&D is transmission and distribution.

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.

IEA. World Energy Outlook. Special Report on Energy and Climate Change. International Energy Agency, Paris, 2015. Figure 2.4

"Climate Mitigation Fund"



Summary

- Investment needs (median estimate, central case)

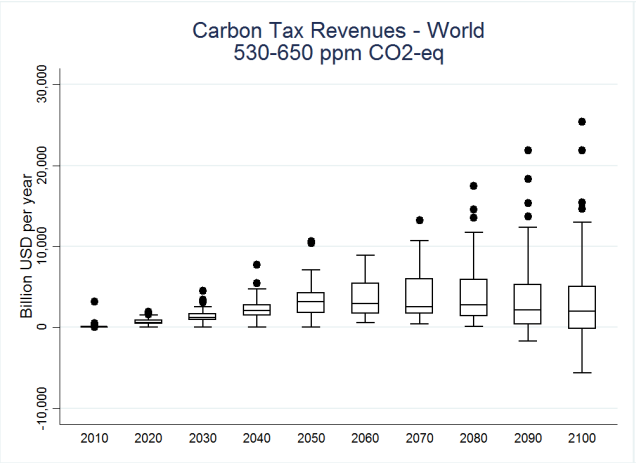
		World	OECD90	nonOECD90
2010-2029	430-530 ppm CO_2-eq	467 (+ 61)	163 (+ 30)	321 (+ 49)
	530-650 ppm CO_2-eq	423 (+ 18)	145 (+ 16)	287 (+ 14)
2010-2049	430-530 ppm CO_2-eq	827 (+ 304)	226 (+ 78)	627 (+ 253)
	530-650 ppm CO_2-eq	661 (+ 138)	190 (+ 43)	466 (+ 194)
2050-2099	430-530 ppm CO_2-eq	2,725 (+ 1,511)	480 (+ 215)	2,253 (+ 1,264)
	530-650 ppm CO_2-eq	1,637 (+ 422)	393 (+ 128)	1,336 (+ 346)

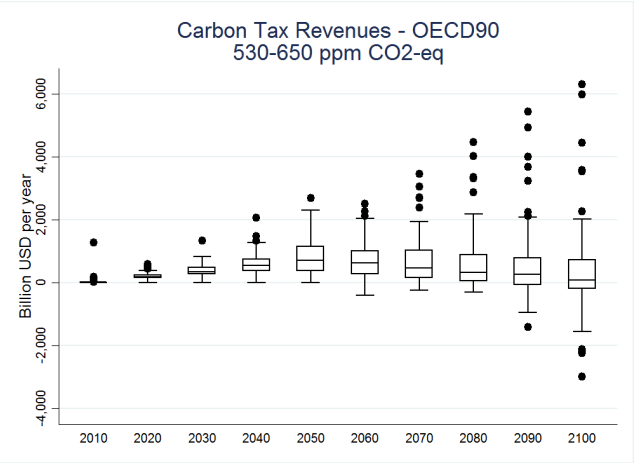
Revenues from Carbon Pricing

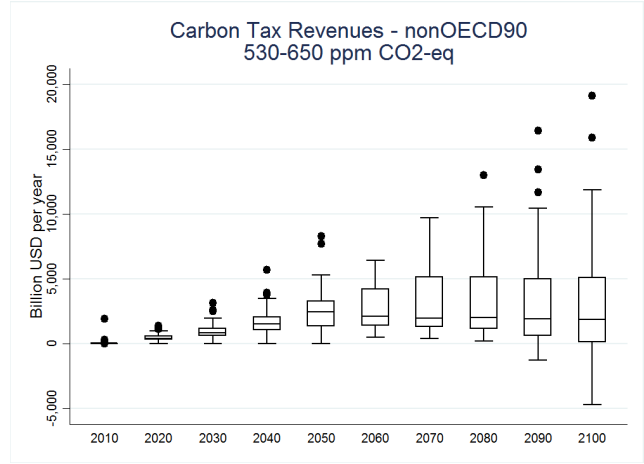
- Rough estimate: carbon tax multiplied by level of CO_2 emissions
- Time profile depends on elasticity of carbon emissions to carbon pricing
- Evidence suggests a hill-shaped pattern
  - Max flow around 2040-2050
  - Negative flows (subsidies) after 2070 in 430-530 ppm CO_2-eq

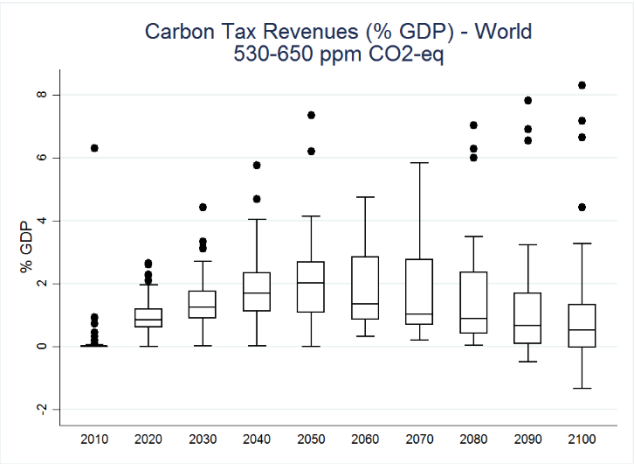
Carbon Tax Revenues

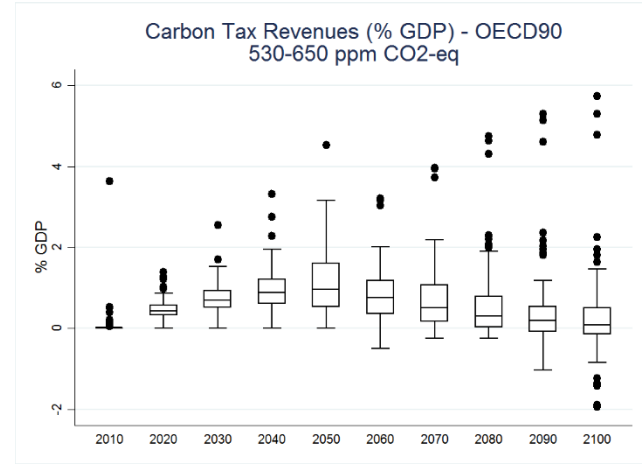
530-650 ppm CO_2-eq

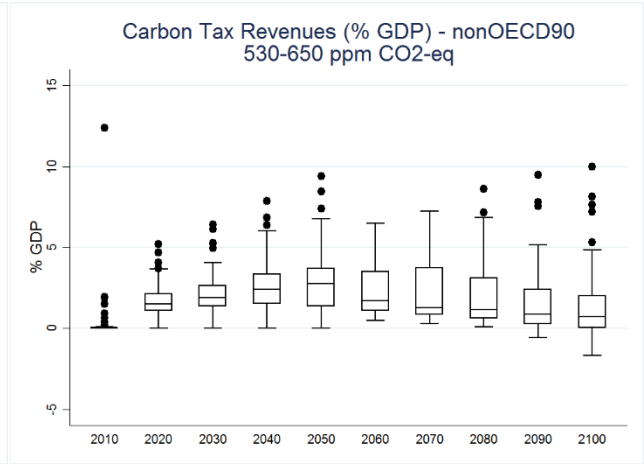






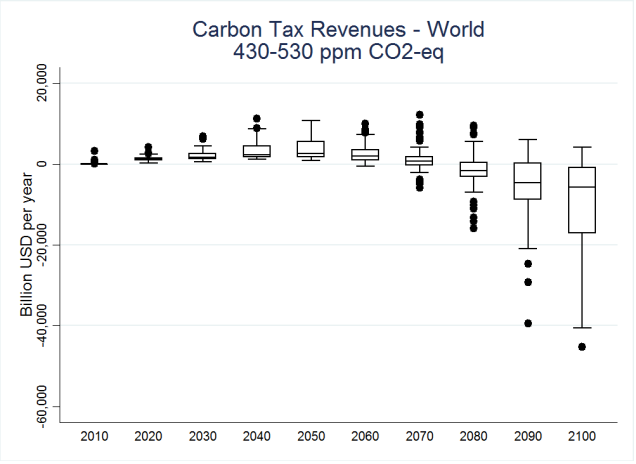


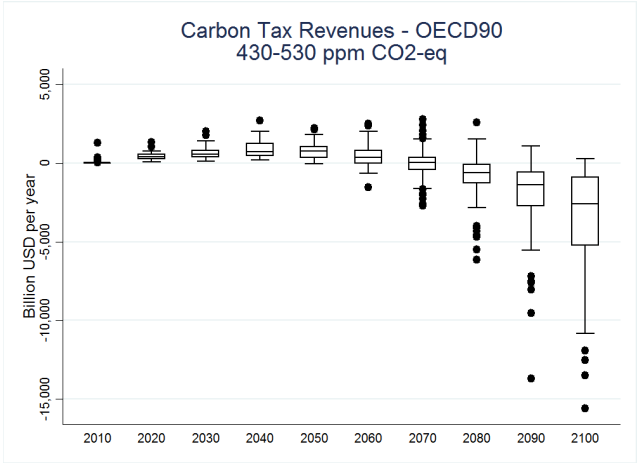


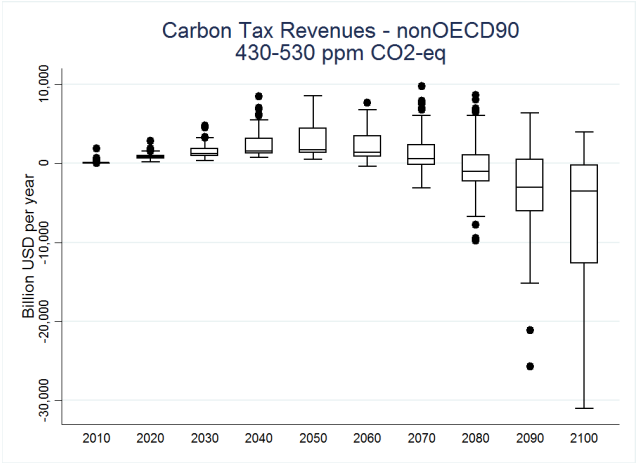


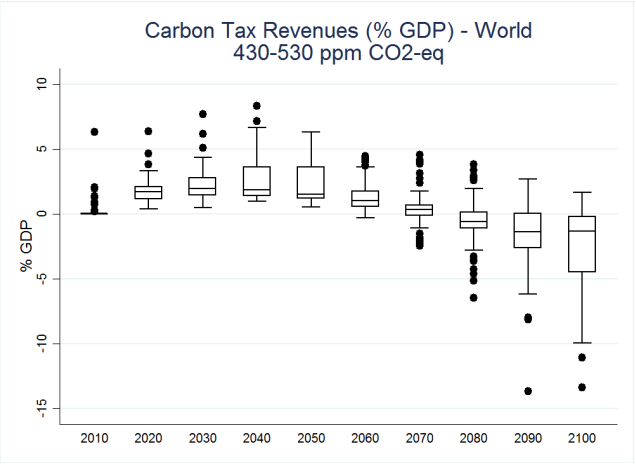
Carbon Tax Revenues

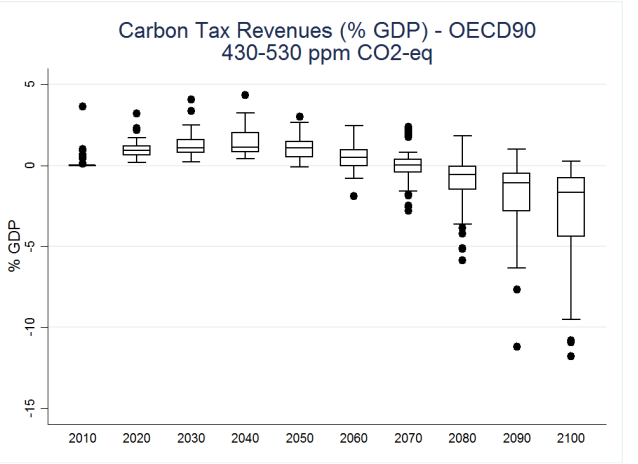
430-530 ppm CO_2-eq

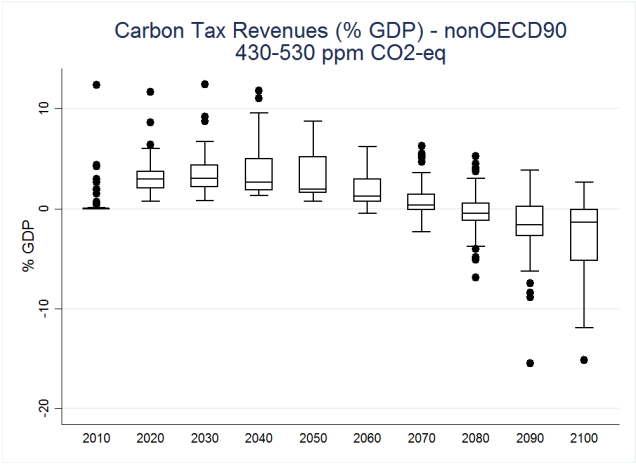












Challenges and Opportunities

- 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

emanuele.massetti@pubpolicy.gatech.edu

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Change of investments wrt BaU (430-530 ppm)

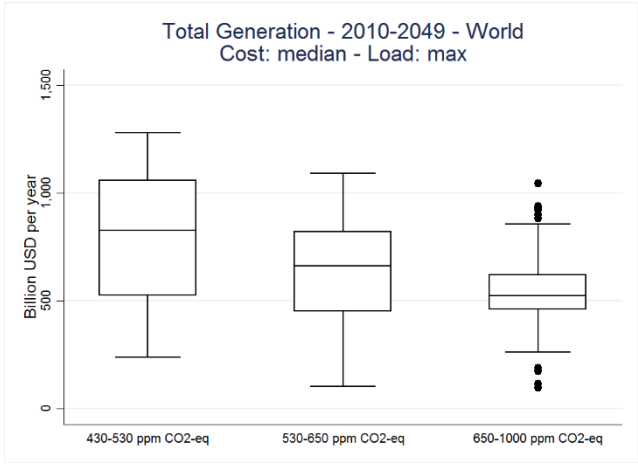
	2010-2029					2030-2049				
	number of studies	median	min	mean	max	number of studies	median	min	mean	max
World										
Electricity Generation	5	126.3	16.5	104.1	205.2	2	249.9	132.9	249.9	367.0
Renewables	5	85.4	-3.2	86.0	175.6	2	115.6	19.1	115.6	212.1
Nuclear	5	31.6	27.7	43.1	66.8	2	86.8	61.1	86.8	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

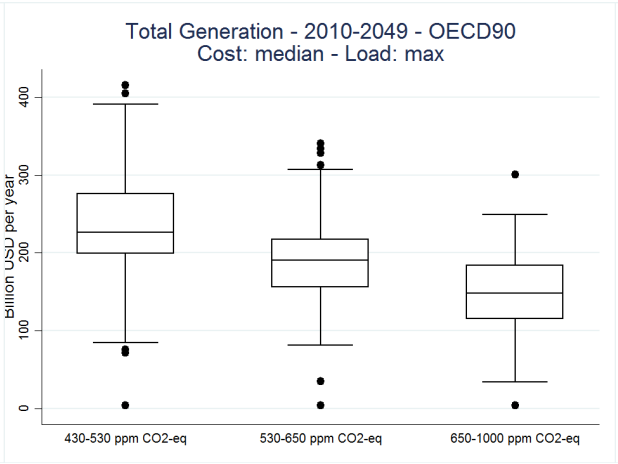
Source: Massetti (2015)

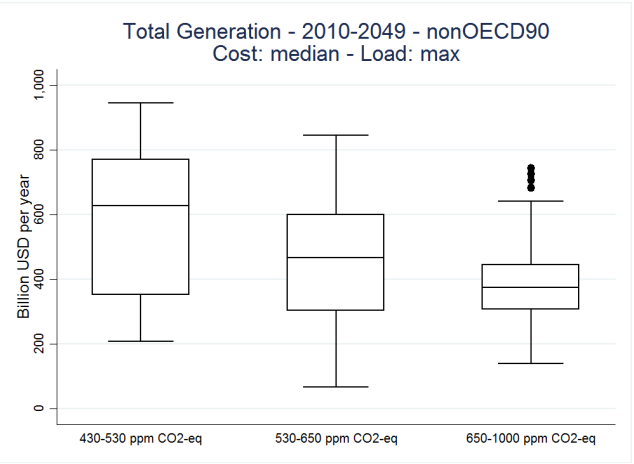
Notes: Data used to draw Figure 16.3 and 16.4 in Gupta et al. (2014). Mitigation scenarios that stabilize concentrations within the range of 430 – 530 ppm CO_2-eq by 2100. Change relative to respective average baseline investments. For a complete list of references see notes to Figures 16.3 and 16.4 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).

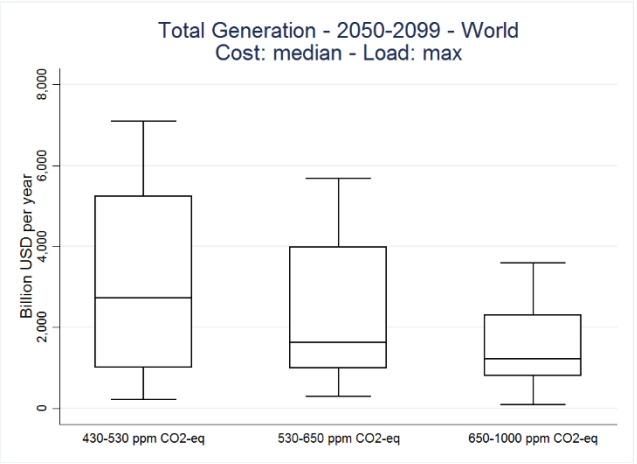
	2010-2029					2030-2049				
	number of studies	median	min	mean	max	number of studies	median	min	mean	max
Non-OECD										
Electricity Generation	4	48.3	-1.1	51.4	110.1	3	378.9	215.0	347.3	448.1
Renewables	4	44.5	-1.5	48.4	105.9	3	226.8	25.7	173.4	267.6
Nuclear	4	20.0	16.4	19.8	23.1	3	120.4	83.6	117.6	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
OECD										
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

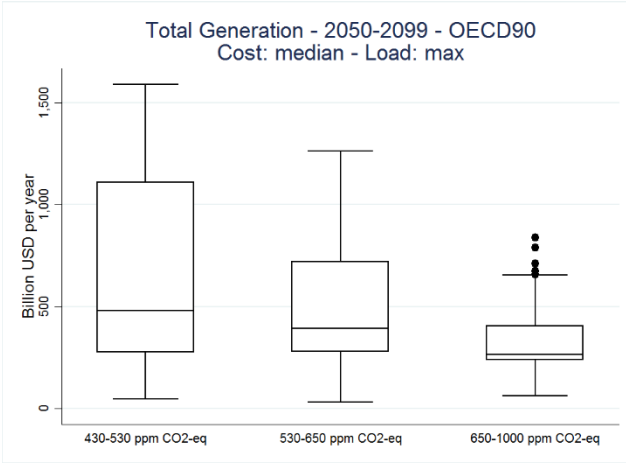
Regional Differences

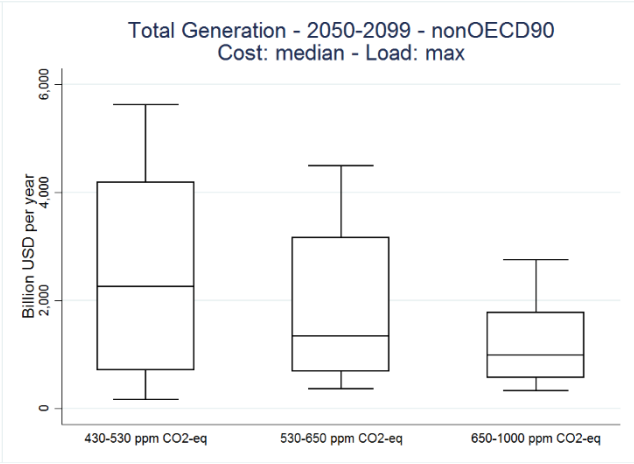




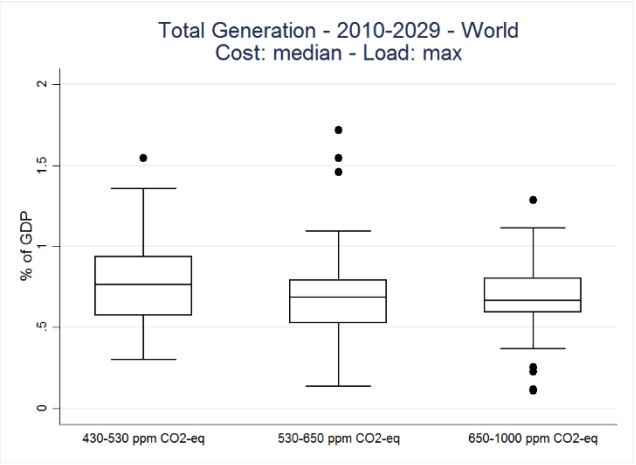


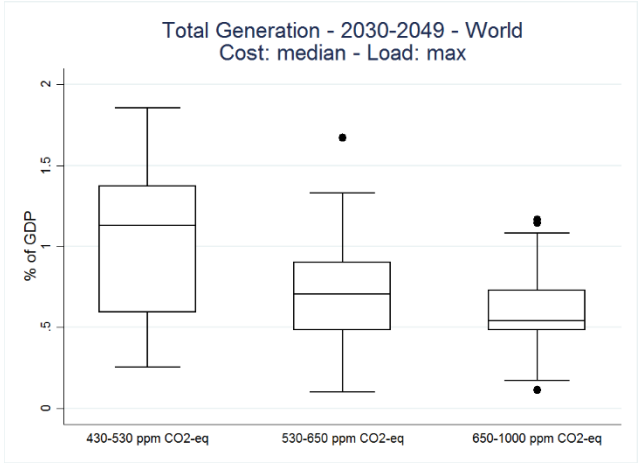


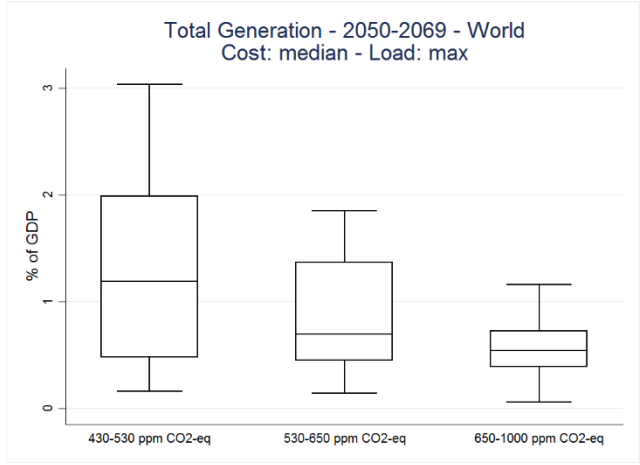


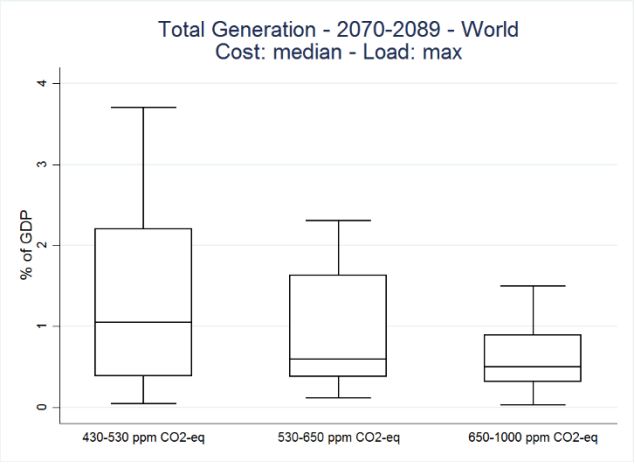


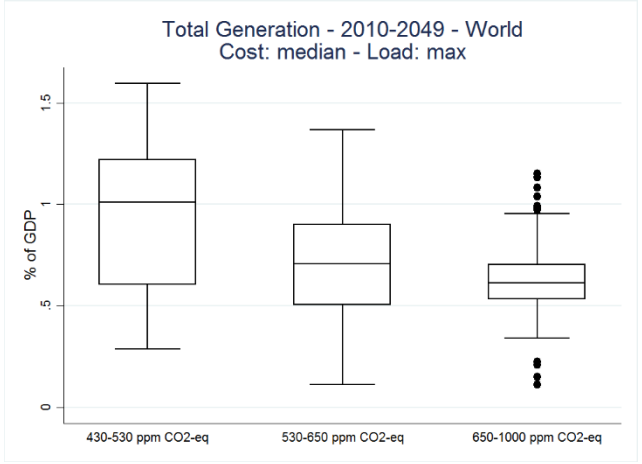
Investments as % of GDP Global

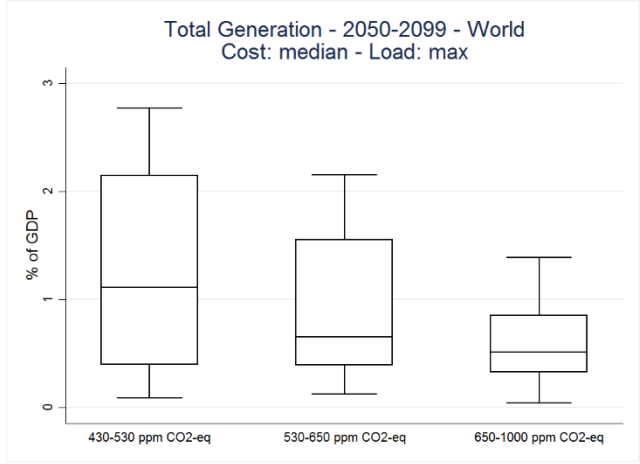




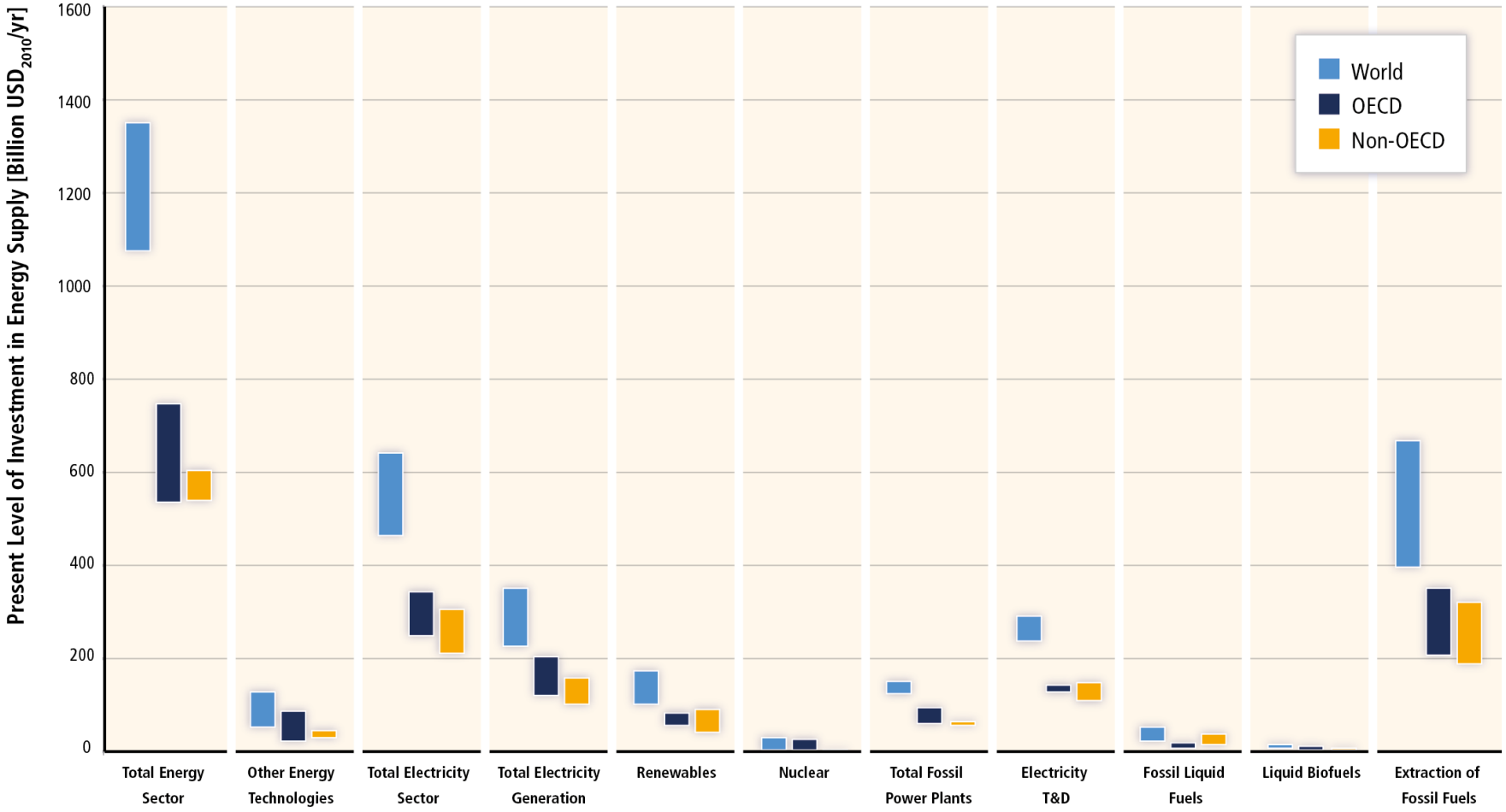
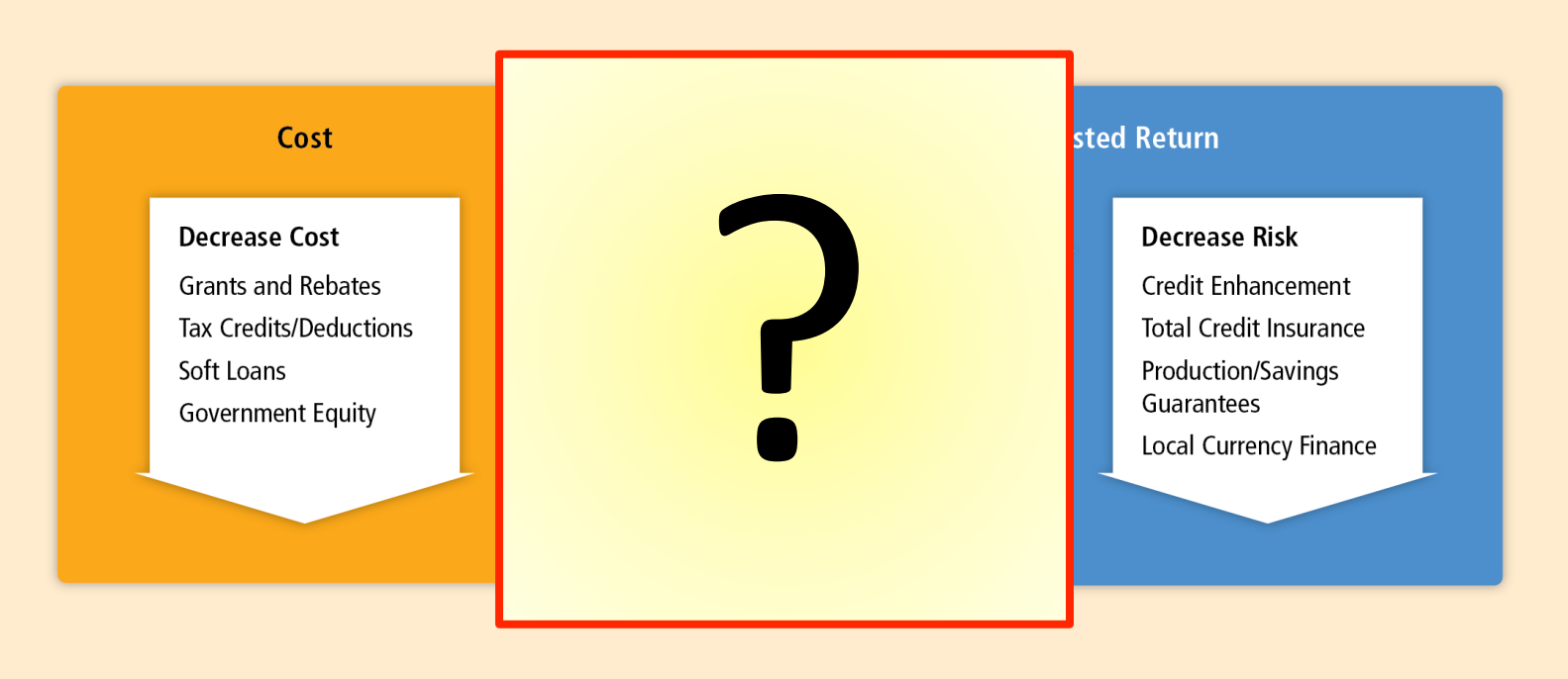








Current investment in the energy system: about 1,2 trillion USD / year



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