Center for Policy Research on Energy and the Environment
PRINCETON UNIVERSITY

EPRI Energy and Climate Research Seminar

POLICY SEQUENCING TOWARDS LONG-TERM, DEEP DECARBONIZATION

WEI PENG

Assistant Professor
School of Public and International Affairs and
Andlinger Center for Energy and the Environment,
Princeton University

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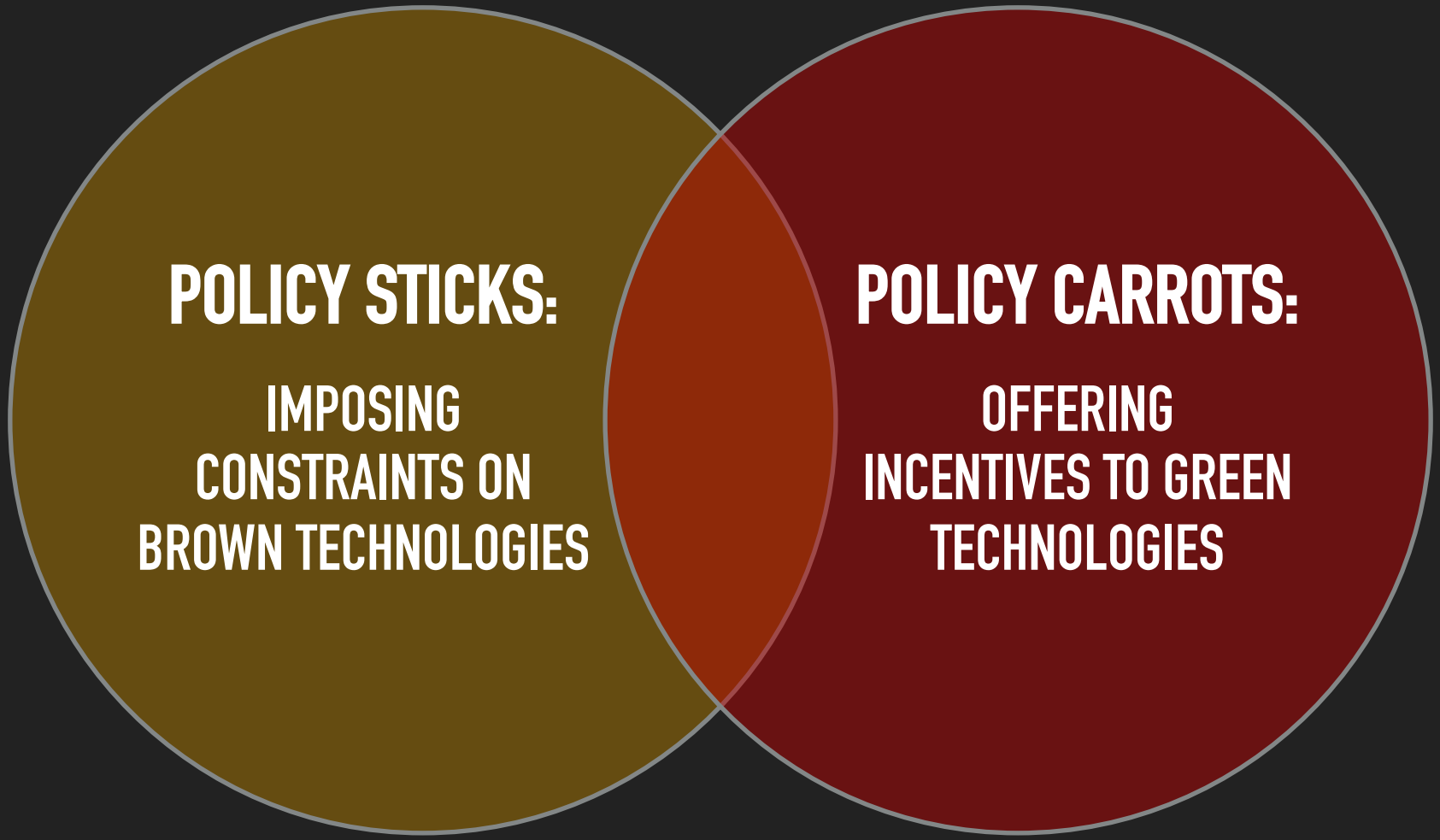
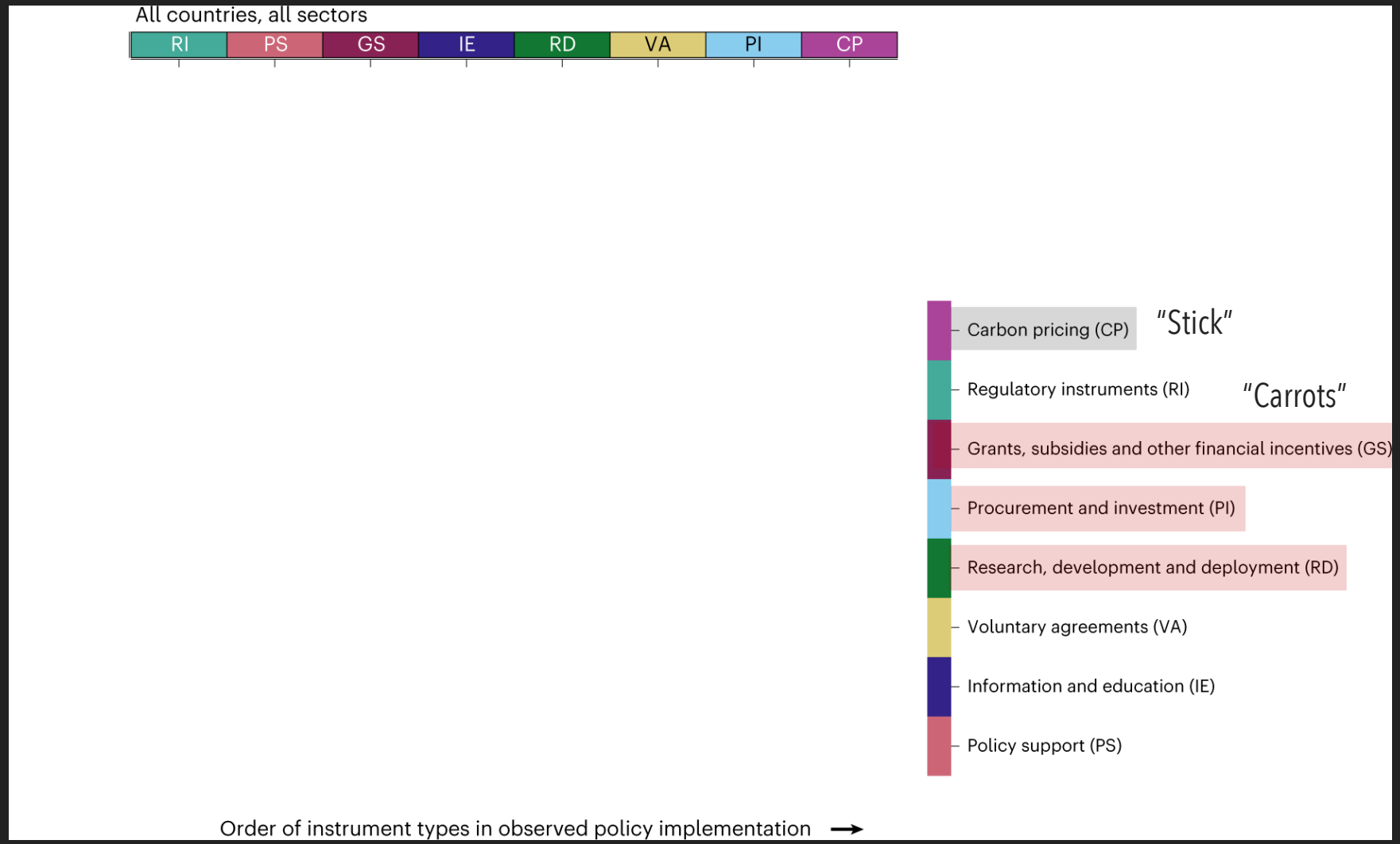
TWO FLAVORS OF POLICY INSTRUMENTS



EMPIRICAL EVIDENCE OF STARTING WITH POLICY "CARROTS" BEFORE INTRODUCING "STICKS"



Linsenmeier, M., Mohommad, A. & Schwerhoff, G. Policy sequencing towards carbon pricing among the world's largest emitters. *Nat. Clim. Chang.* **12**, 1107–1110 (2022).

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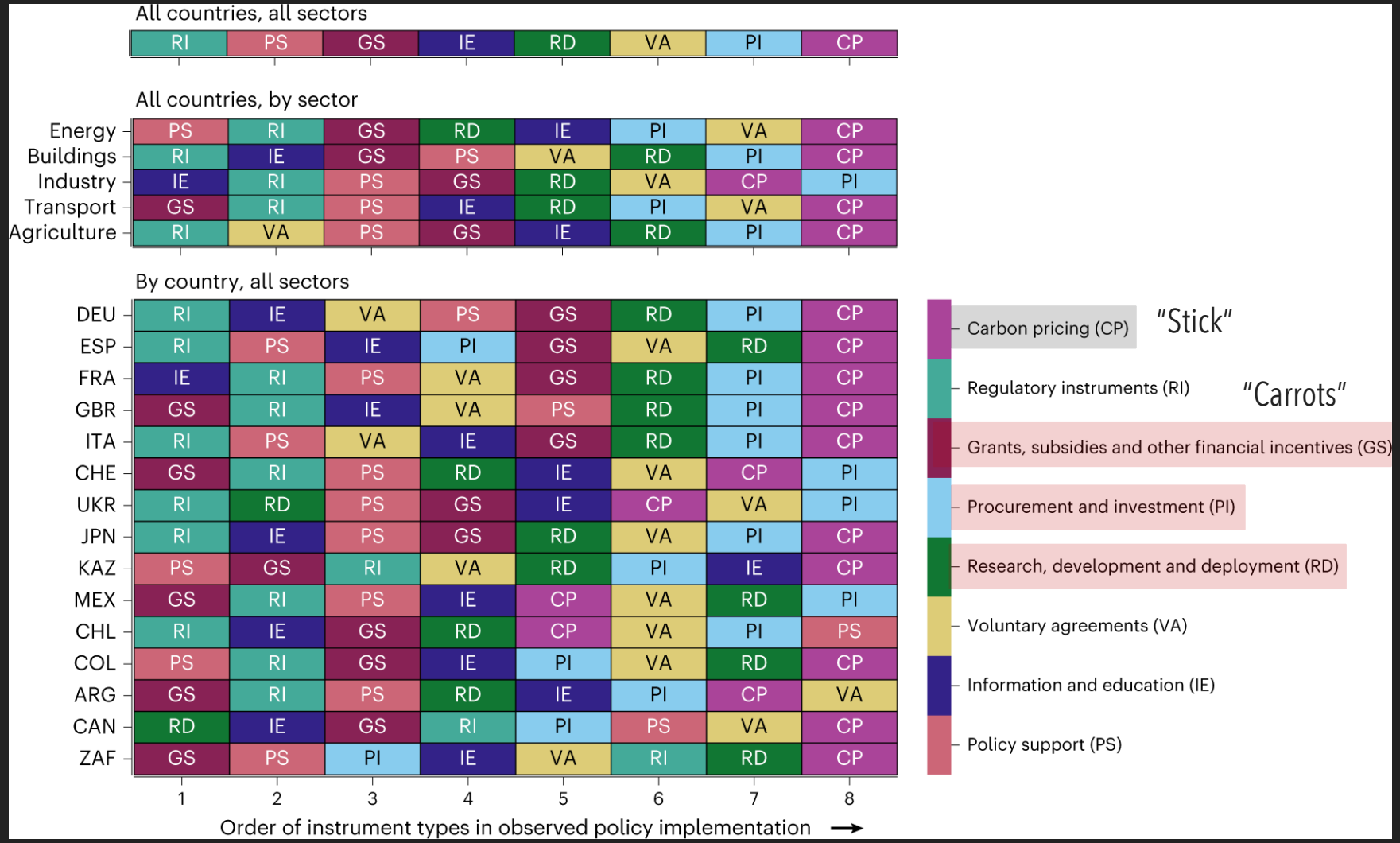

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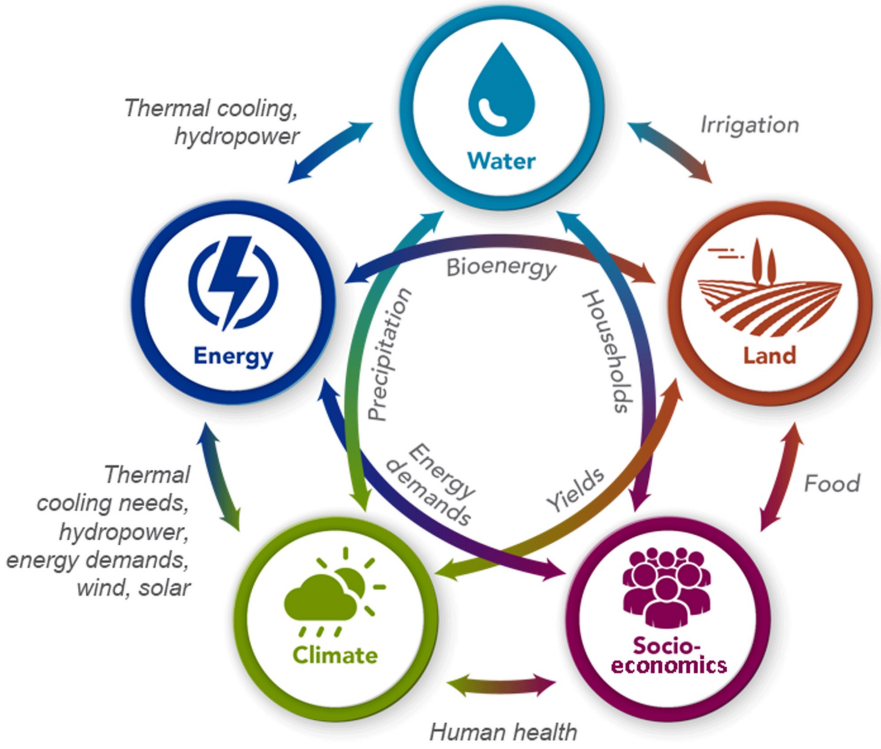
POLITICAL ECONOMY LOGIC OF POLICY SEQUENCING

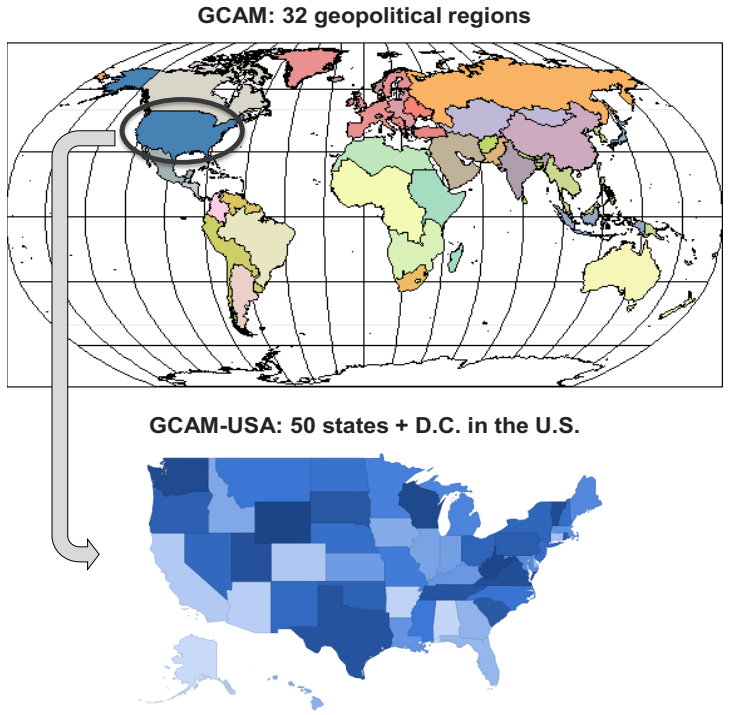
Meckling et al. *Nat Energy* 2, 921–922 (2017)

HOW DOES POLICY SEQUENCE INFLUENCE THE SYSTEM-WIDE COST OF LONG-TERM DECARBONIZATION?

A TEST CASE USING A STATE-LEVEL MULTI-SECTORAL MODEL

Global Change Analysis Model (GCAM) - USA





Key model structures:

- Market equilibrium model
- Dynamic recursive
- 5-yr time step
- State-level representation of the energy and socioeconomic system

Calvin, K., et al, Geosci. Model Dev., 20219

COMPARISON OF STYLIZED POLICY PATHWAYS

Key elements of policy debates:

- Carrots vs. sticks

1. Stick Only

Economy-wide carbon price from 2025 to 2050

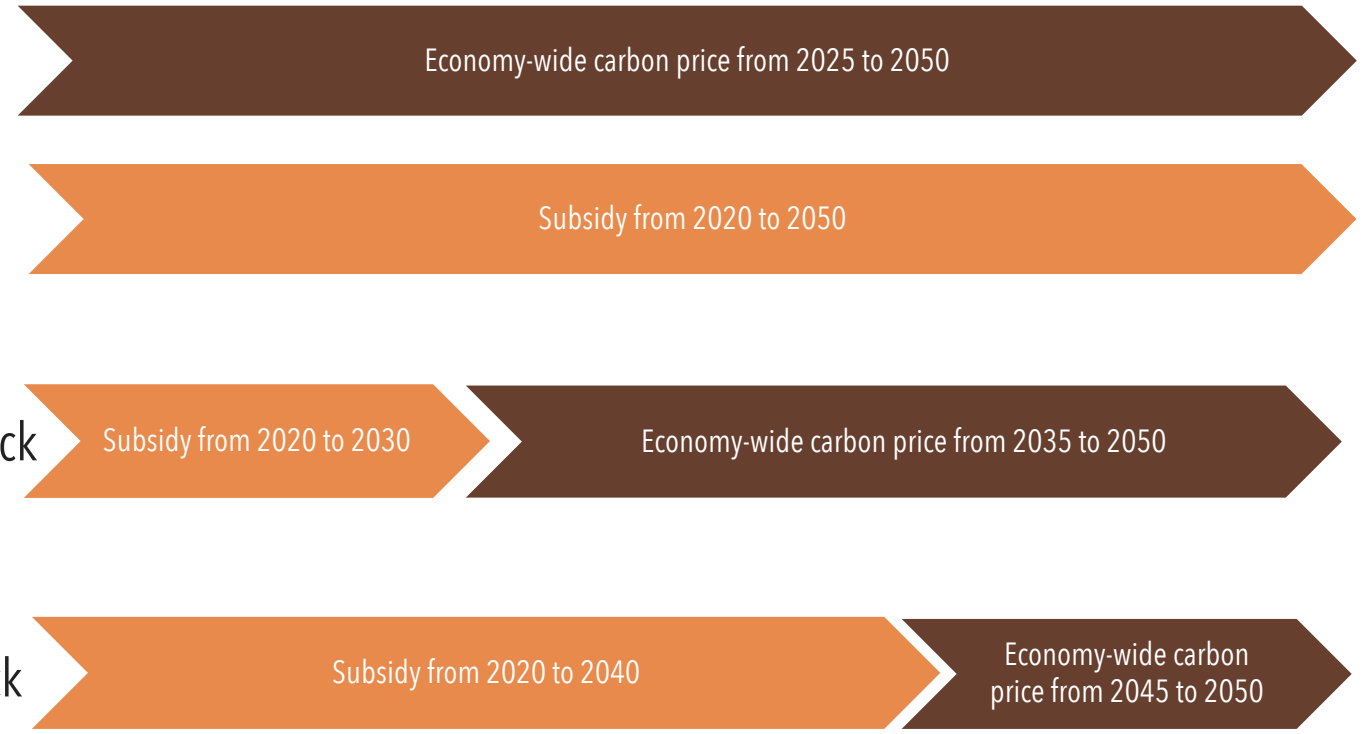
2. Carrots Only

Subsidy from 2020 to 2050

COMPARISON OF STYLIZED POLICY PATHWAYS

Key elements of policy debates:

- Carrots vs. sticks
- Timing of stick transition



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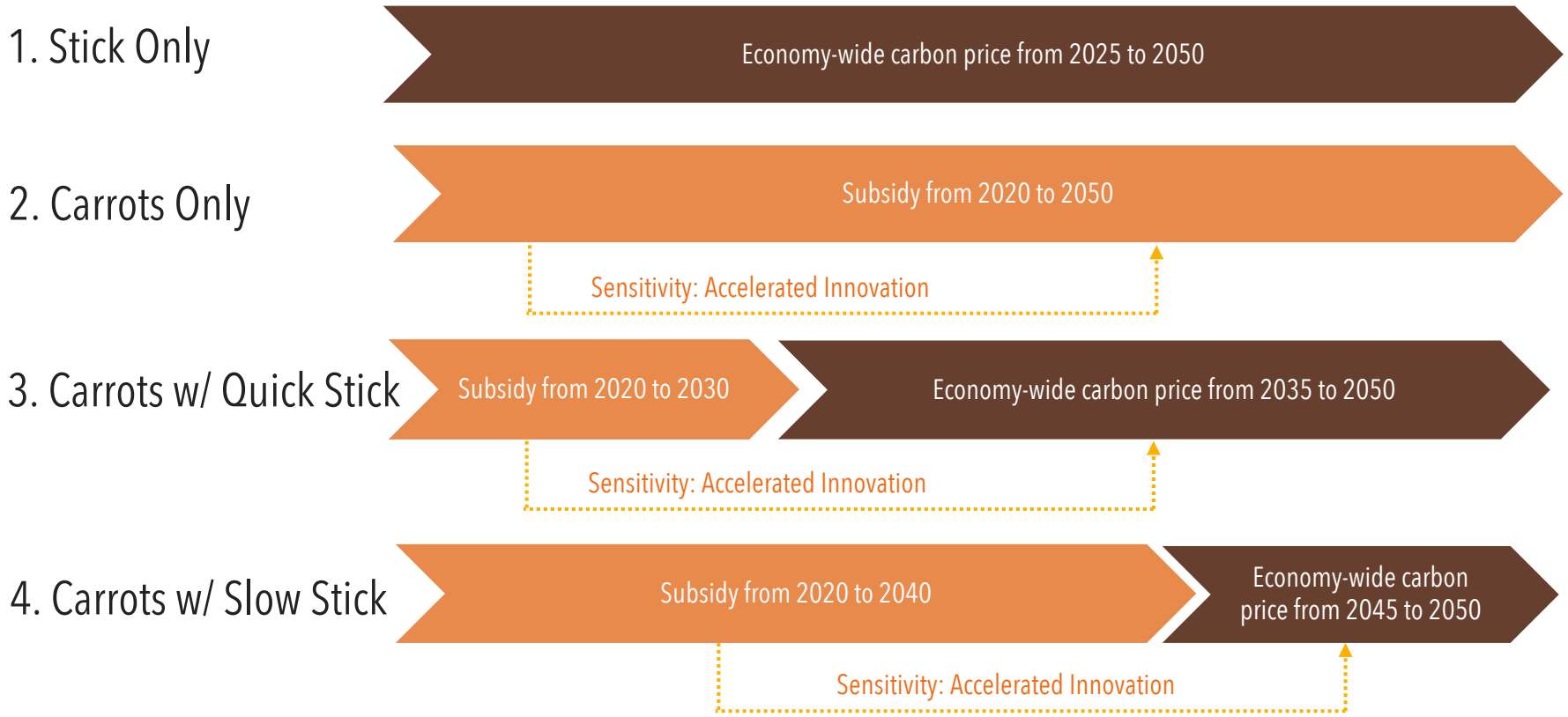

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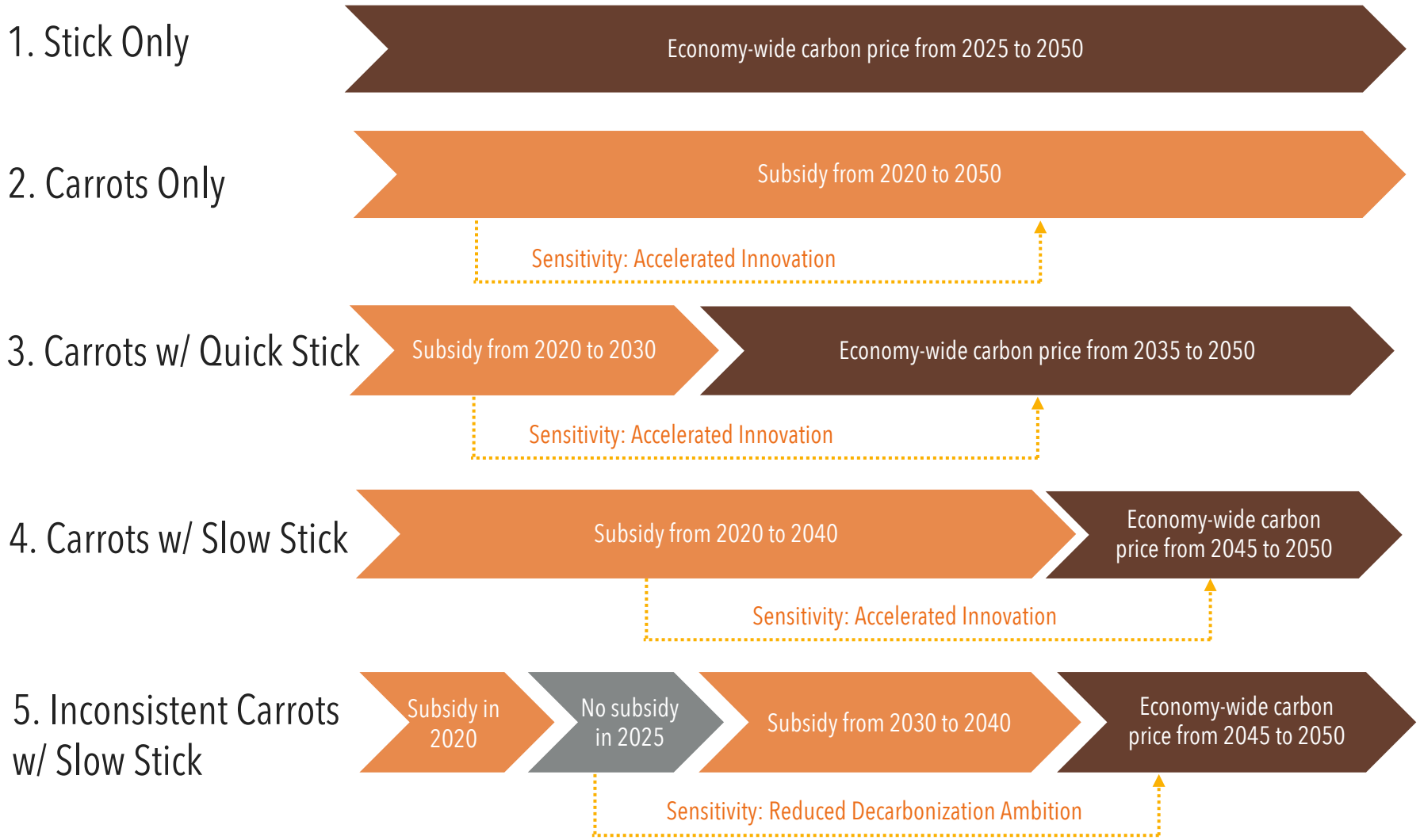
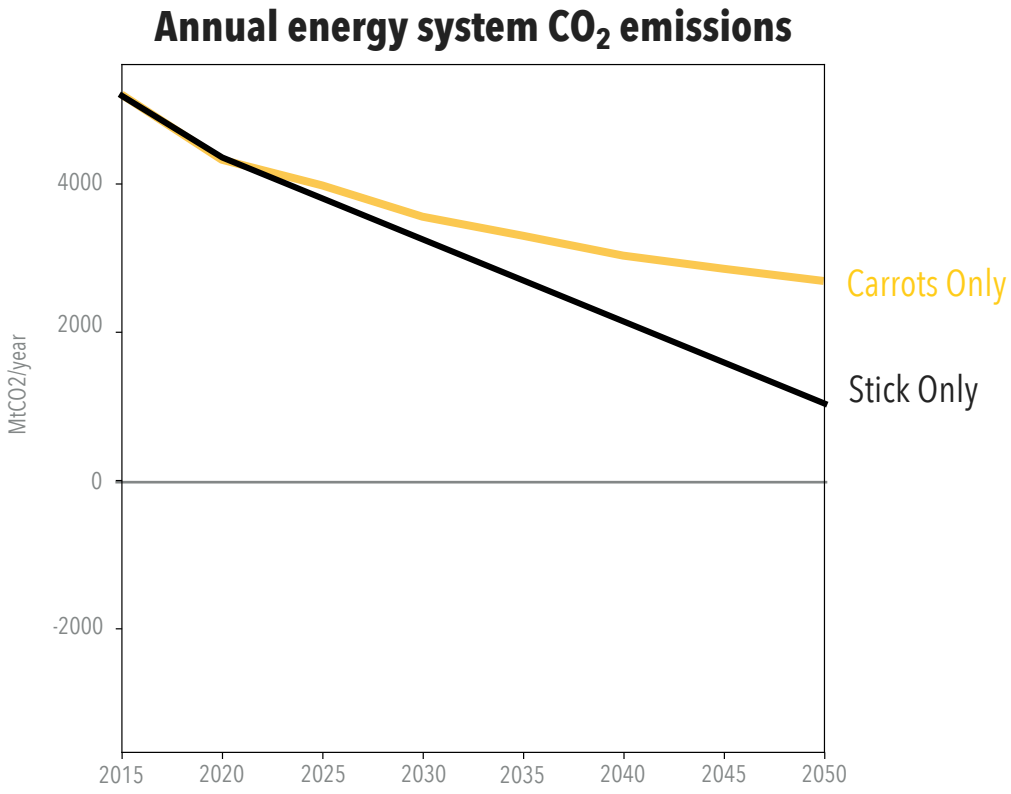
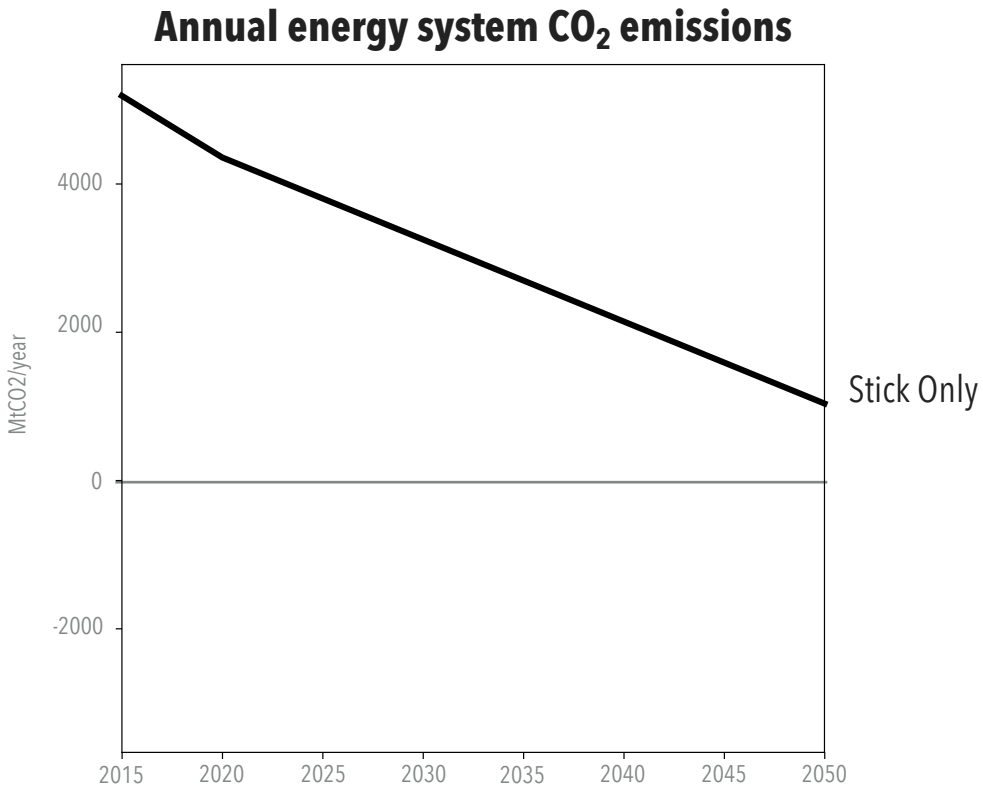
- Policy consistency

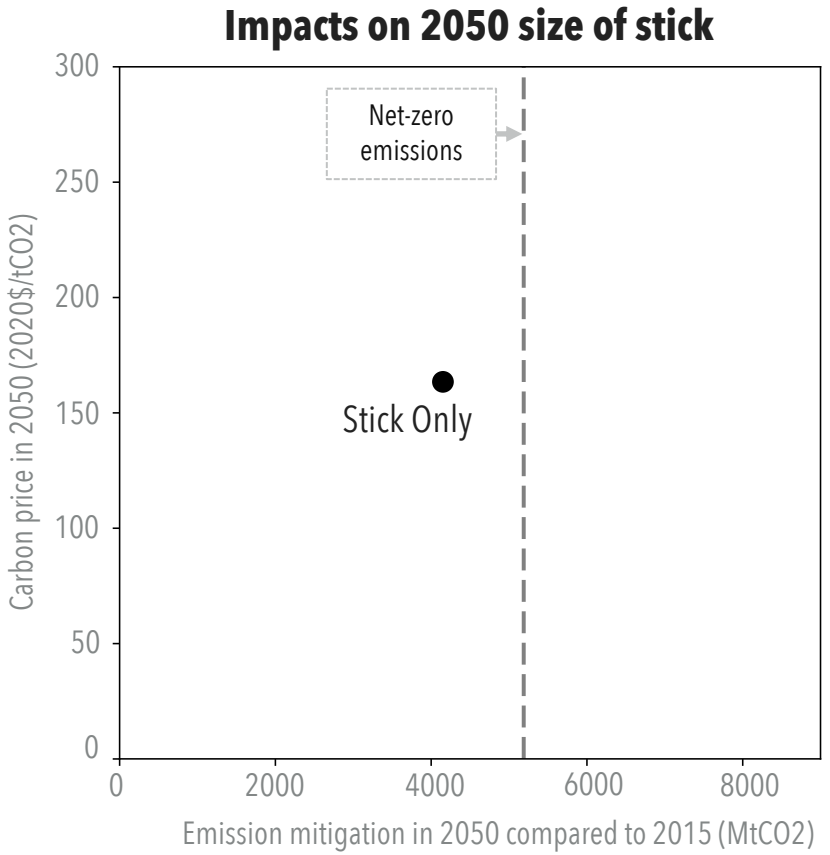


Insight #1: Industrial policy carrots can deliver early emission cuts, but not long-term deep decarbonization.



Insight #2: A carrots-first strategy can work, but only if the shift to sticks does not come too late.





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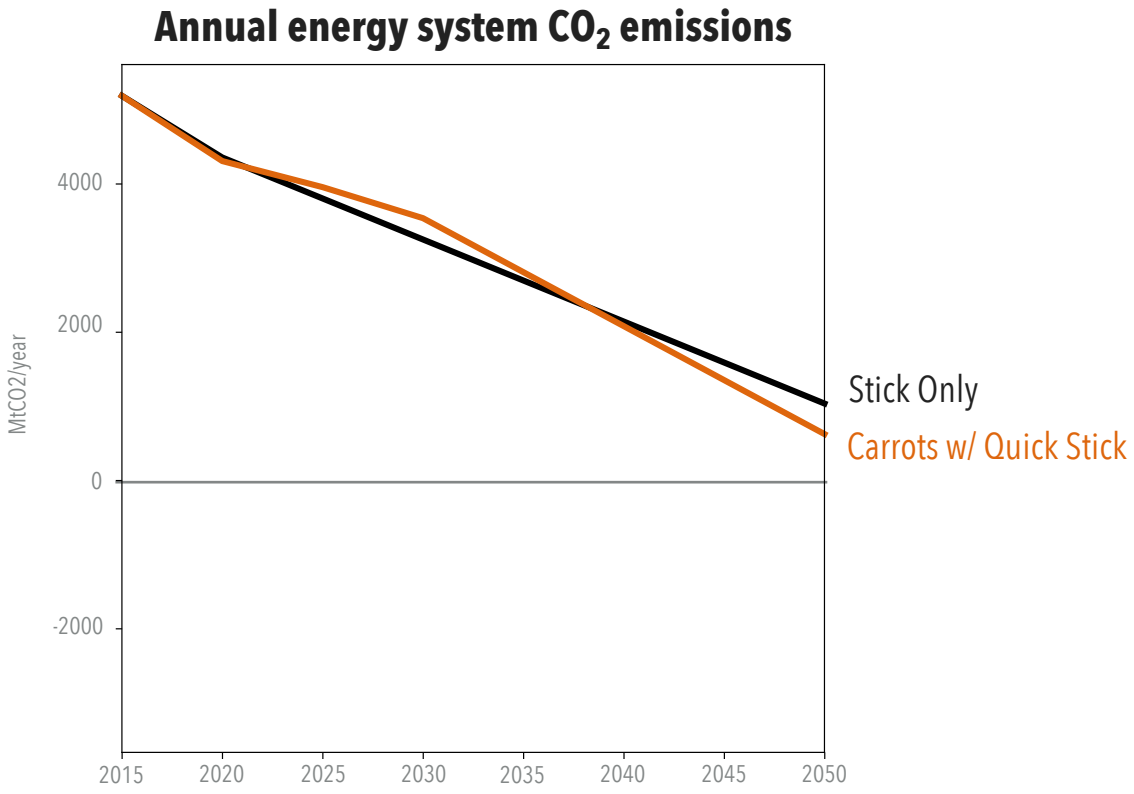

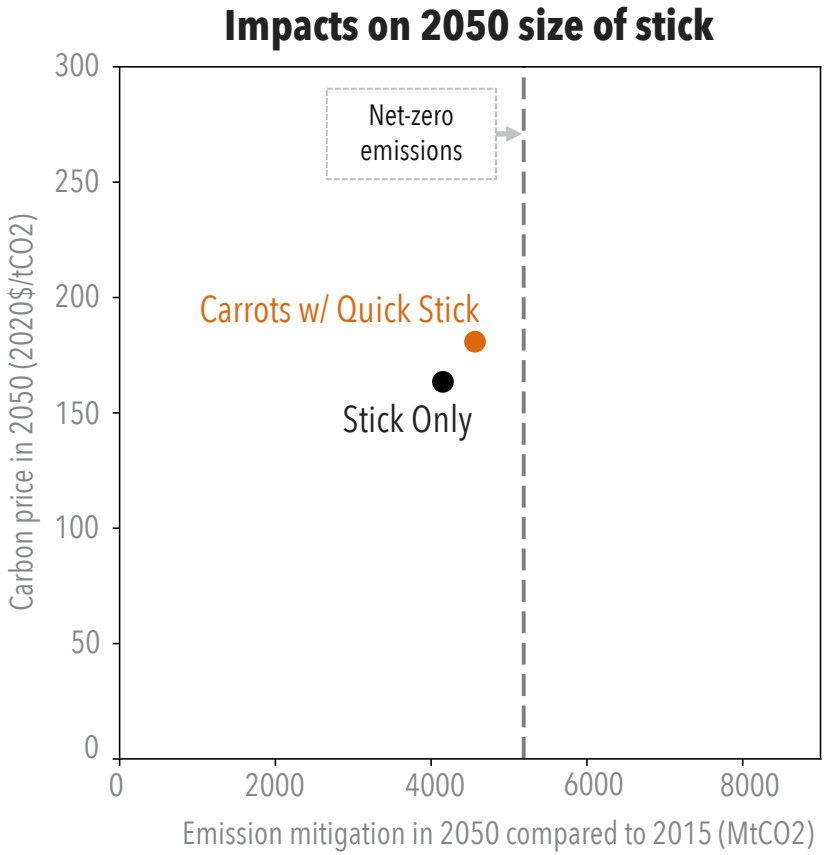

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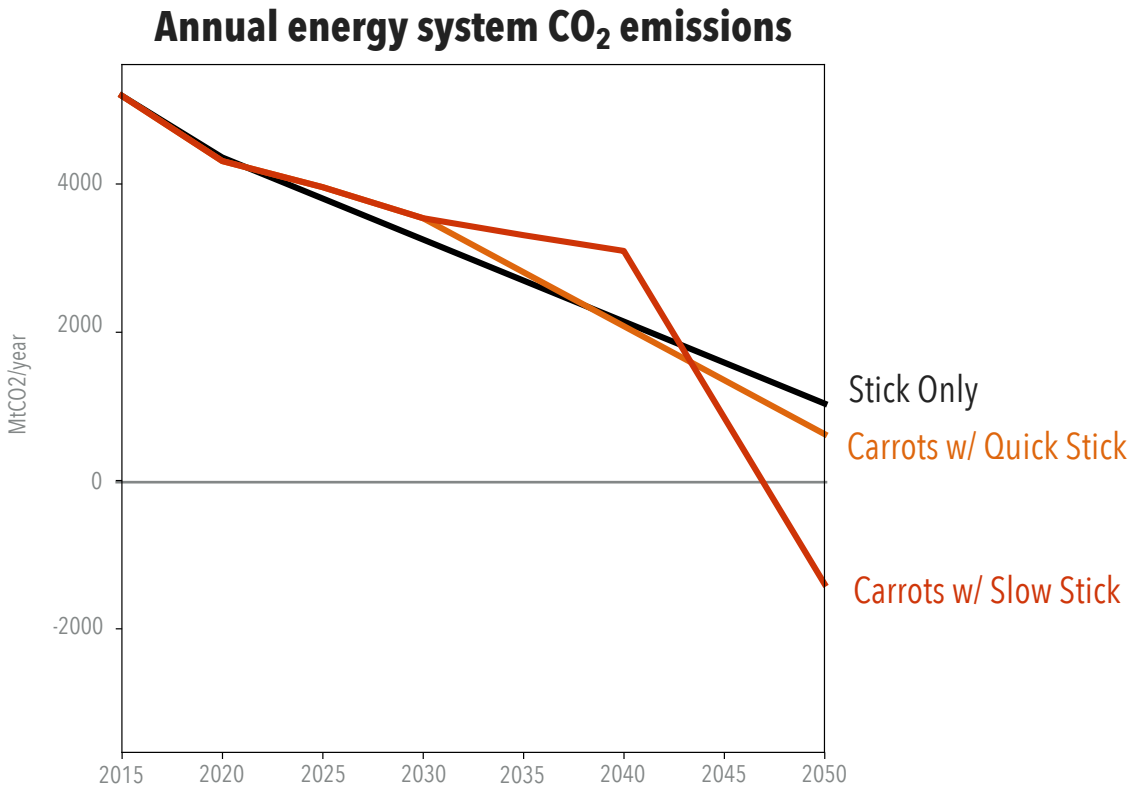
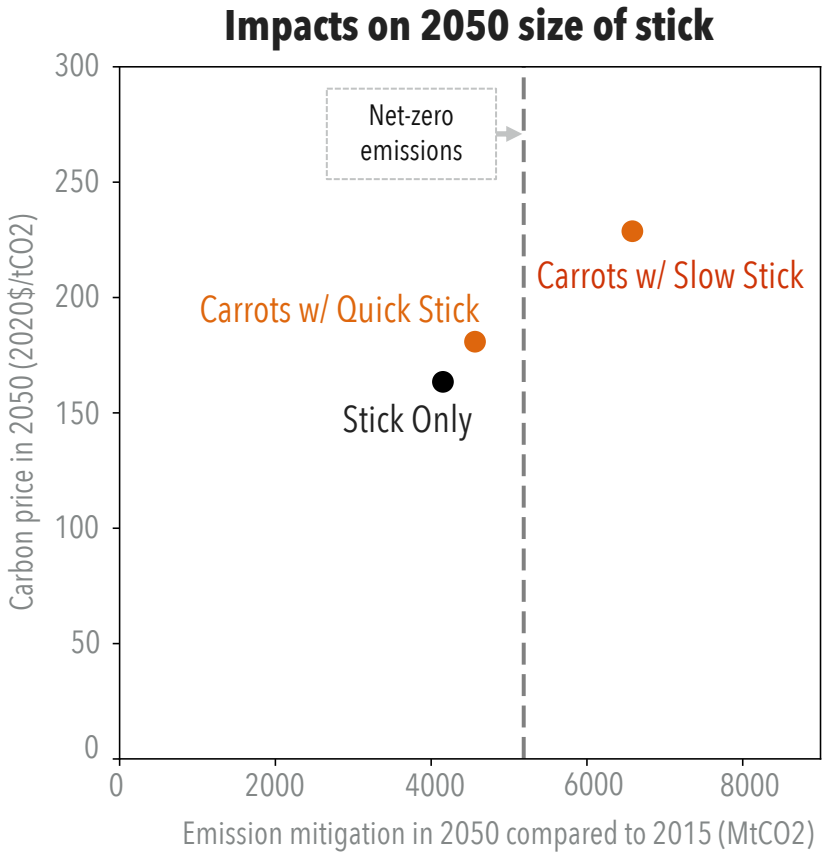
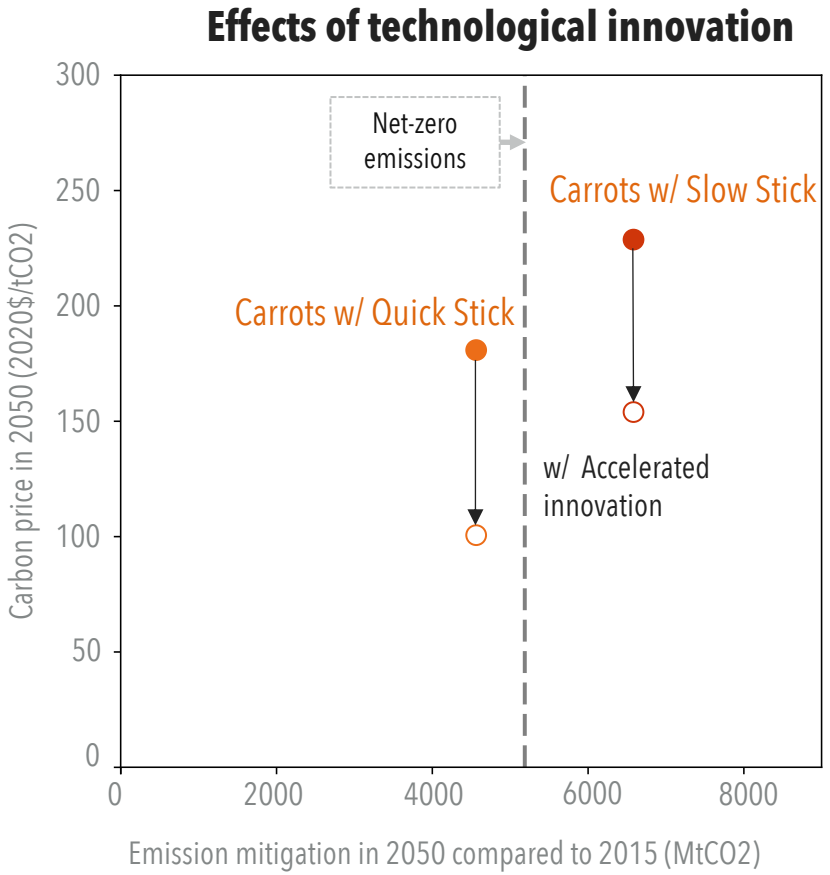
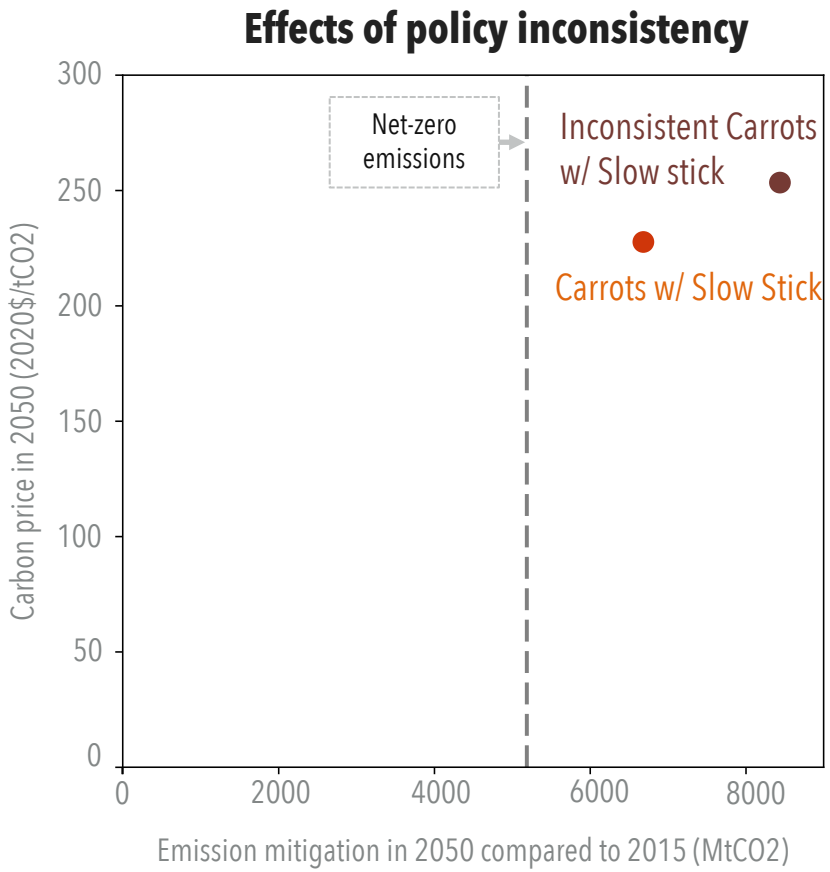




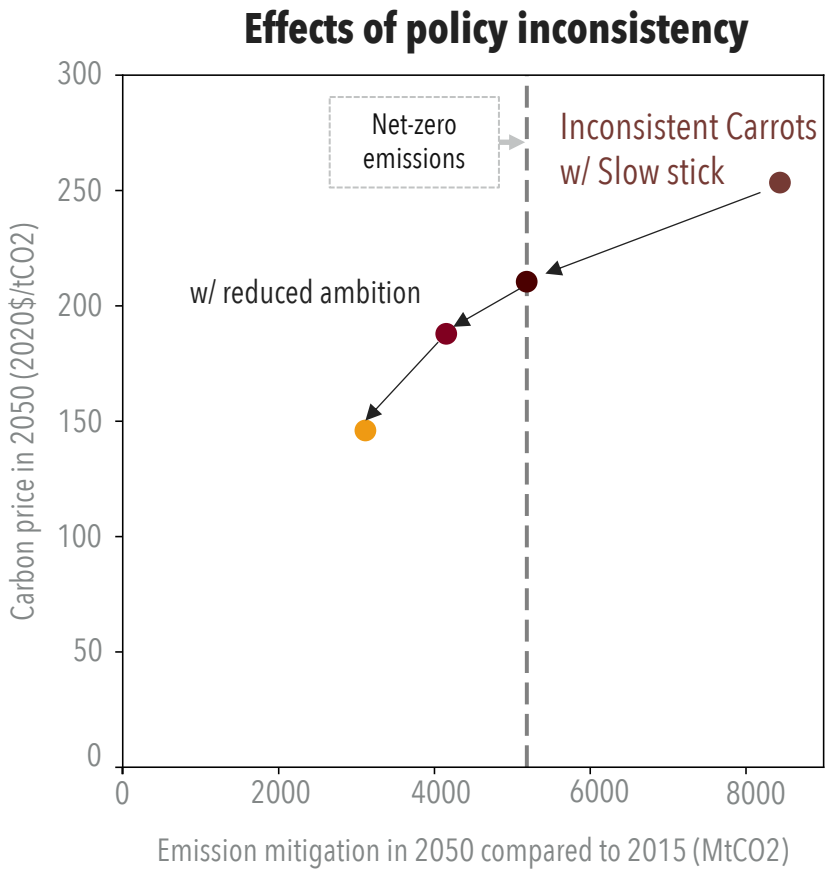
Insight #3: Accelerated technological innovation can reduce the size of stick.



Insight #4: Policy inconsistency either increases the stick size needed for deep decarbonization …



Insight #4: Policy inconsistency either increases the stick size needed for deep decarbonization or lowers the decarbonization ambition.



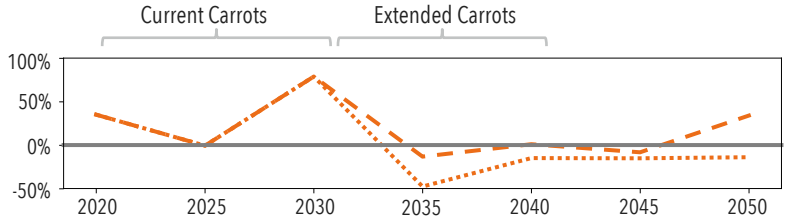
Insight #5: Carrots build green industries, but they do not automatically weaken fossil incumbents.

Changes in carrot-first scenarios compared to Stick only

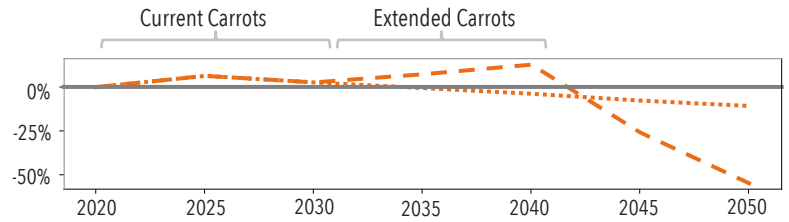
Green industries

Fossil industries

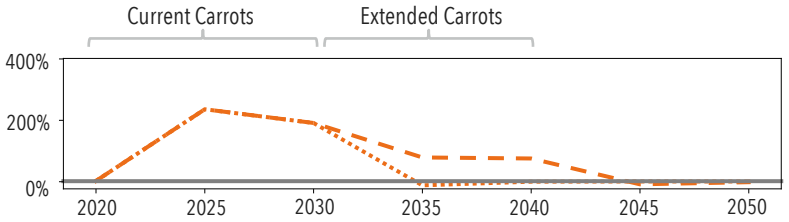
a) Wind and solar new installations



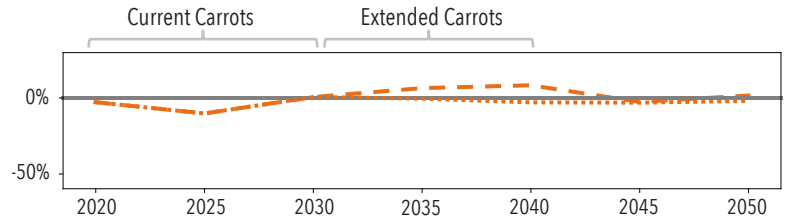
b) Oil consumption



c) EV new sales

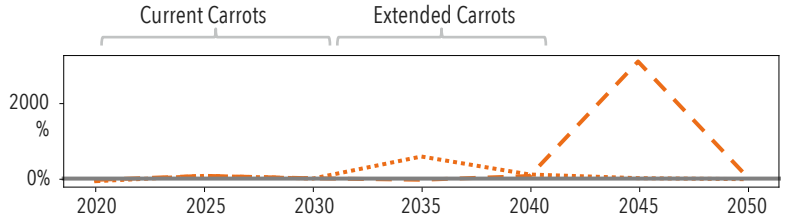


d) Natural gas consumption



Carrots w/ Quick Stick
Carrots w/ Slow Stick

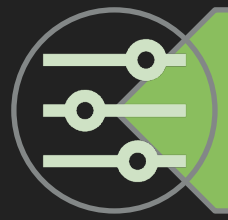
e) Premature retirement of fossil-based power plants



REFLECTION OF CURRENT POLICY LANDSCAPE:

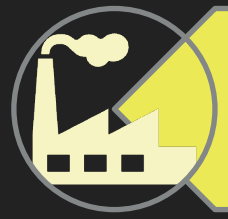
THE IRA IS PERHAPS BEST UNDERSTOOD AS AN INCOMPLETE SEQUENCE.

WHAT THE NEXT ROUND OF INDUSTRIAL POLICY SHOULD DO MORE (OR DIFFERENTLY)

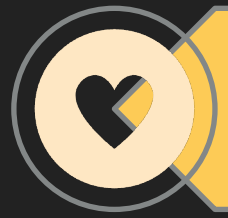


Build the sequencing logic in from the outset—industrial policy is just the start

Strengthen policy durability—stop-start incentives weaken investor confidence, slow deployment, and erode emissions outcomes



Do not assume that scaling clean industries will automatically shift the politics of incumbent activities



Build the political coalition for the next phase deliberately, by making the benefits of the incentive phase visible early.

MORE INFORMATION

nature climate change

Article

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Modelling the impacts of policy sequencing on energy decarbonization

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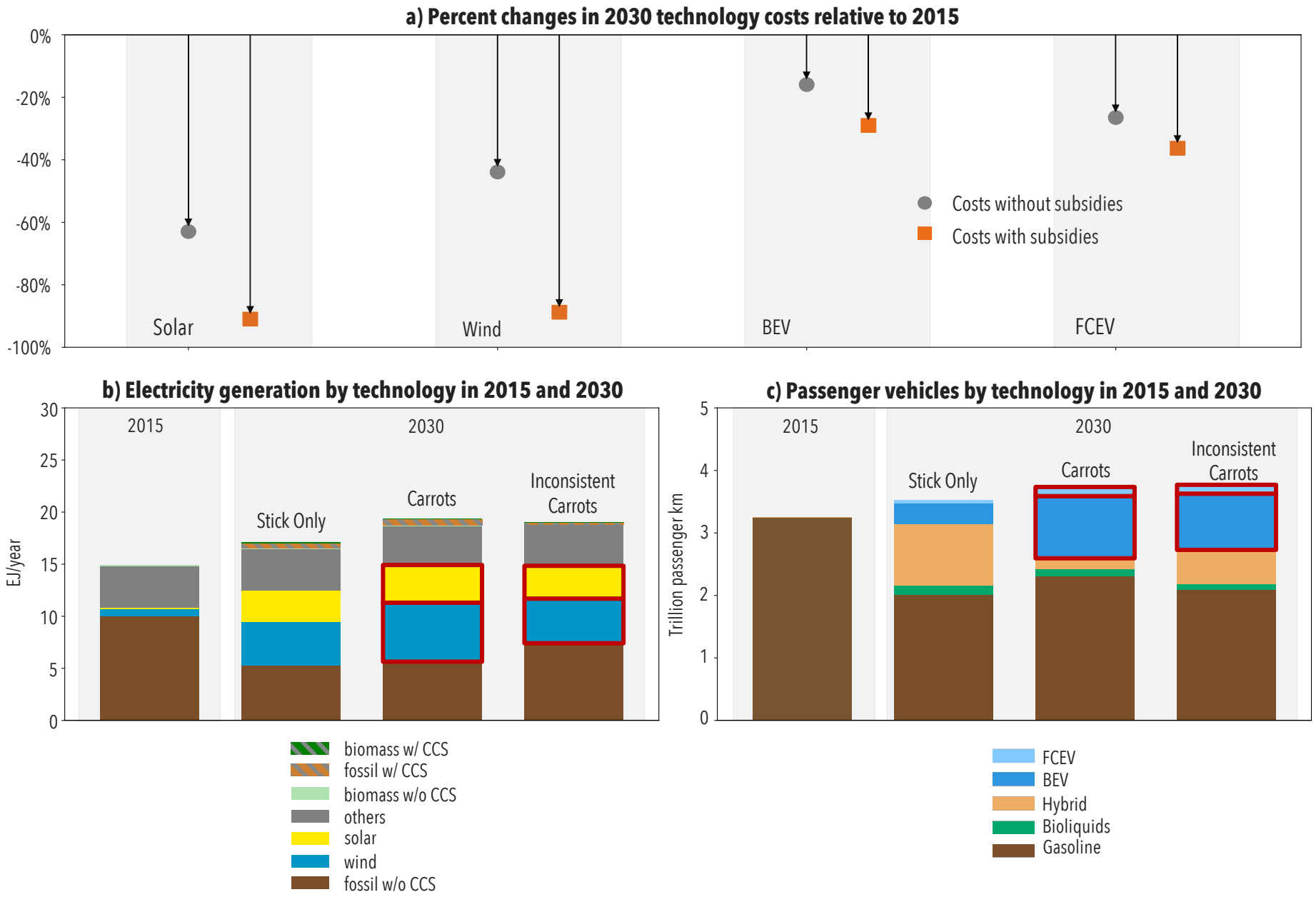
Huilin Luo[1,2,11], Wei Peng[2,11] ✉, Allen Fawcett[3], Jessica F. Green[4], Gokul Iyer[3], Jonas Meckling[5,6], Jonas Nahm[7] & David G. Victor[8,9,10]

Email: weipeng@princeton.edu; **Website:** weipengenergy.com

SUPPLEMENTARY SLIDES

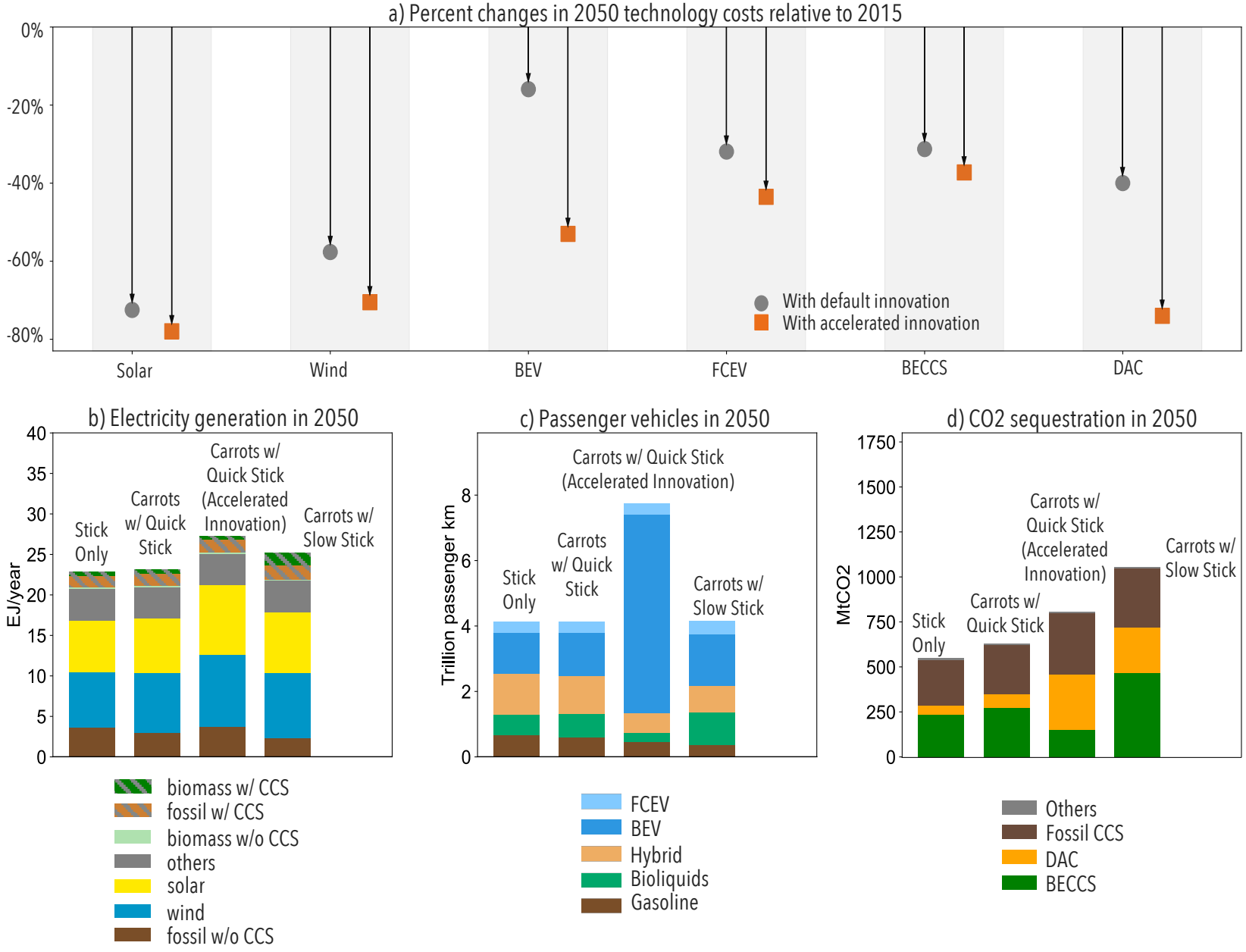
The near-term effectiveness of carrots depend on:

- Scale and scope of carrots
- Impacts on technology competition and adoption within relevant sectors



The long-term effectiveness of carrots depend on:

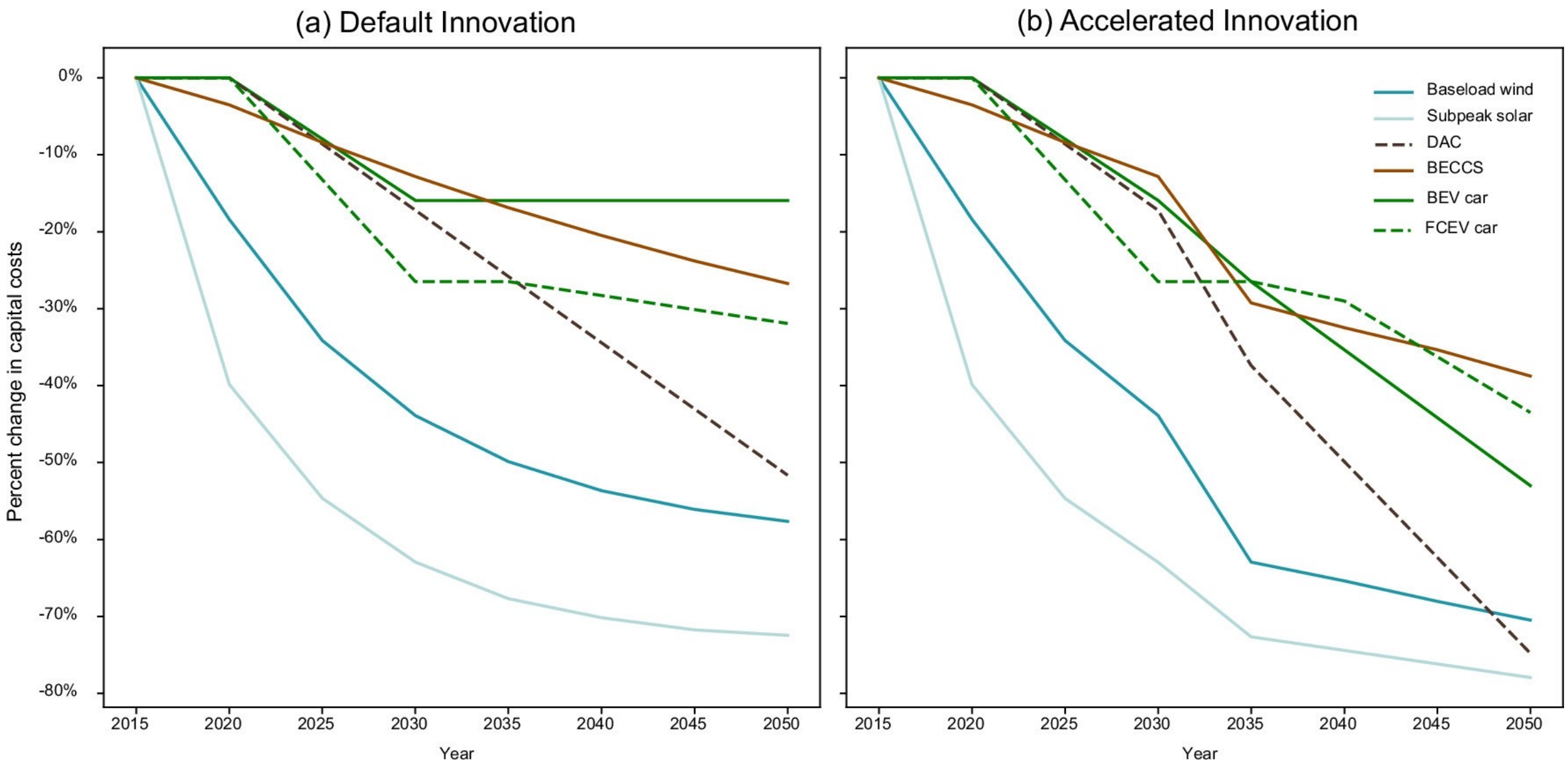
- Ability to enable a quick stick transition
- Ability to accelerate innovation

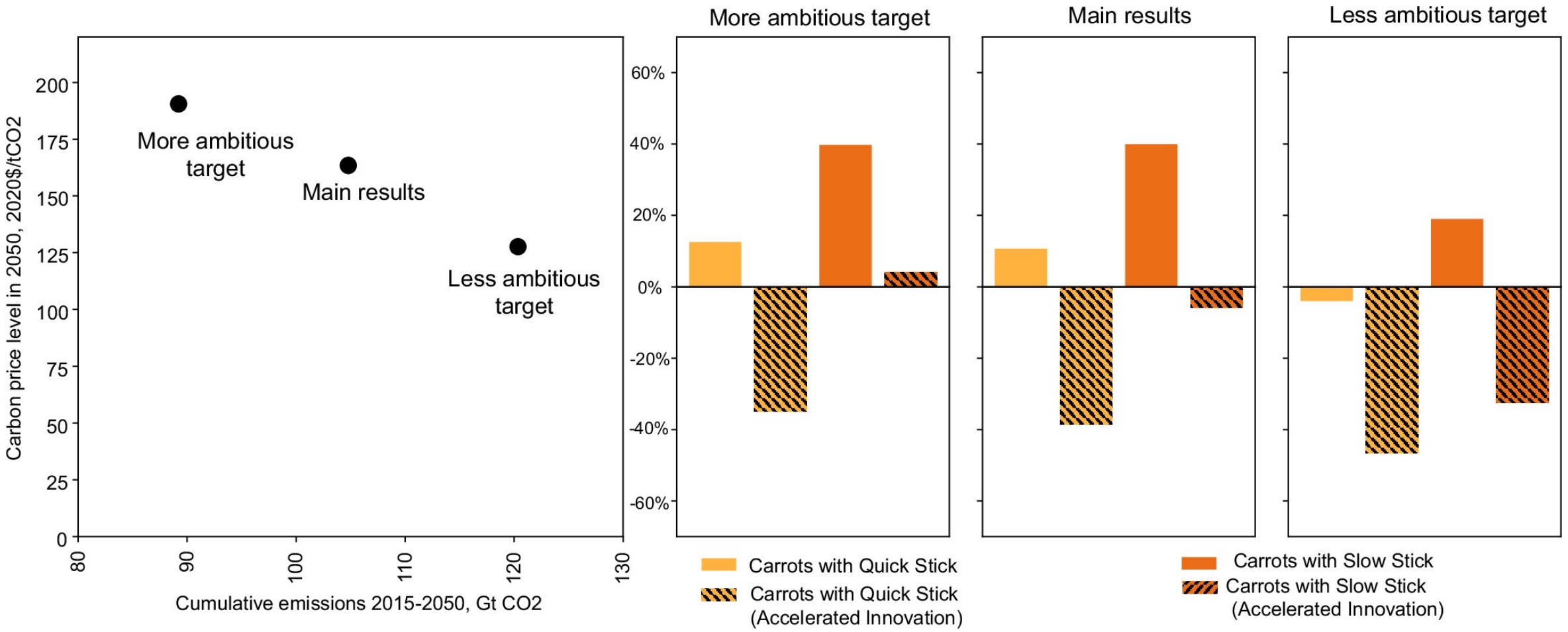


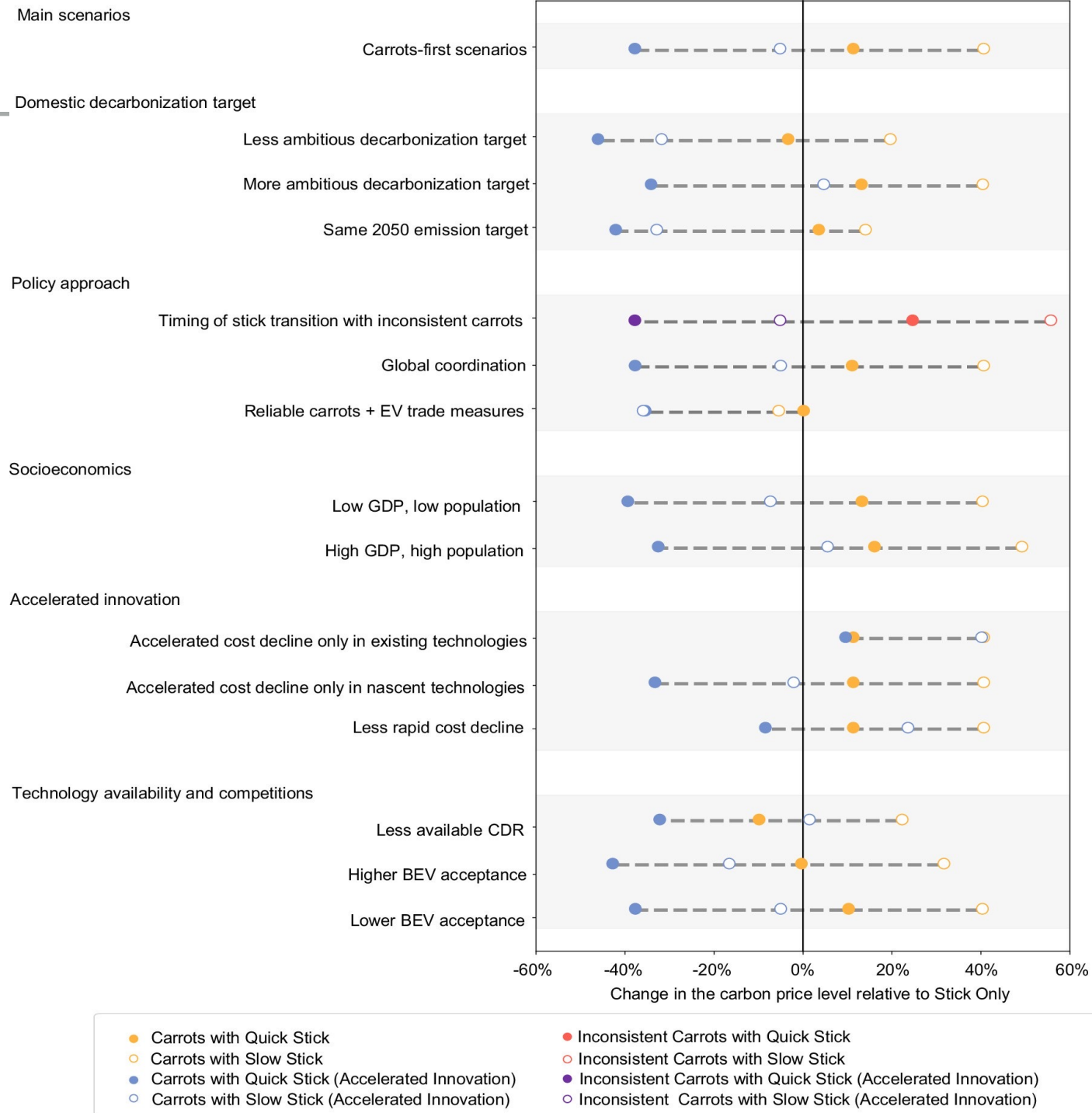
CLOSING THOUGHT #1: WITHIN IAM
THE NEXT FRONTIER IS TO ENDOGENIZE POLICY CHOICE

Deeper integration between modeling and social sciences

Modeling strategies	Model representations
1. Scenario design: Inform model inputs with political narratives	Design scenarios with "carrots" vs. "sticks" and different timing to shift from "carrots" to "sticks"
2. Ex-post assessment: Provide a political analysis based on model outputs	Assess winning vs losing sectors and states from "carrots" vs. "sticks"
3. Encode the process: Endogenize political processes and policy decisions	"Carrots" → *Impacts of technology innovation + Green coalition building* → Future "sticks"


(a) Default Innovation
(b) Accelerated Innovation
Percent change in capital costs
0%
-10%
-20%
-30%
-40%
-50%
-60%
-70%
-80%
2015
2020
2025
2030
2035
2040
2045
2050
Year
Baseload wind
Subpeak solar
DAC
BECCS
BEV car
FCEV car


Carbon price level in 2050, 2020$/tCO2
200
175
150
125
100
75
50
25
0
More ambitious target
Main results
Less ambitious target
80
90
100
110
120
130
Cumulative emissions 2015-2050, Gt CO2
More ambitious target
Main results
Less ambitious target
60%
40%
20%
0%
-20%
-40%
-60%
Carrots with Quick Stick
Carrots with Quick Stick (Accelerated Innovation)
Carrots with Slow Stick
Carrots with Slow Stick (Accelerated Innovation)


Main scenarios
Carrots-first scenarios
Domestic decarbonization target
Less ambitious decarbonization target
More ambitious decarbonization target
Same 2050 emission target
Policy approach
Timing of stick transition with inconsistent carrots
Global coordination
Reliable carrots + EV trade measures
Socioeconomics
Low GDP, low population
High GDP, high population
Accelerated innovation
Accelerated cost decline only in existing technologies
Accelerated cost decline only in nascent technologies
Less rapid cost decline
Technology availability and competitions
Less available CDR
Higher BEV acceptance
Lower BEV acceptance
-60%
-40%
-20%
0%
20%
40%
60%
Change in the carbon price level relative to Stick Only
Carrots with Quick Stick
Carrots with Slow Stick
Carrots with Quick Stick (Accelerated Innovation)
Carrots with Slow Stick (Accelerated Innovation)
Inconsistent Carrots with Quick Stick
Inconsistent Carrots with Slow Stick
Inconsistent Carrots with Quick Stick (Accelerated Innovation)
Inconsistent Carrots with Slow Stick (Accelerated Innovation)