

BROOKINGS

QUALITY. INDEPENDENCE. IMPACT.

Pricing Carbon in the US: A Model-Based Analysis of Power- Sector-Only Approaches

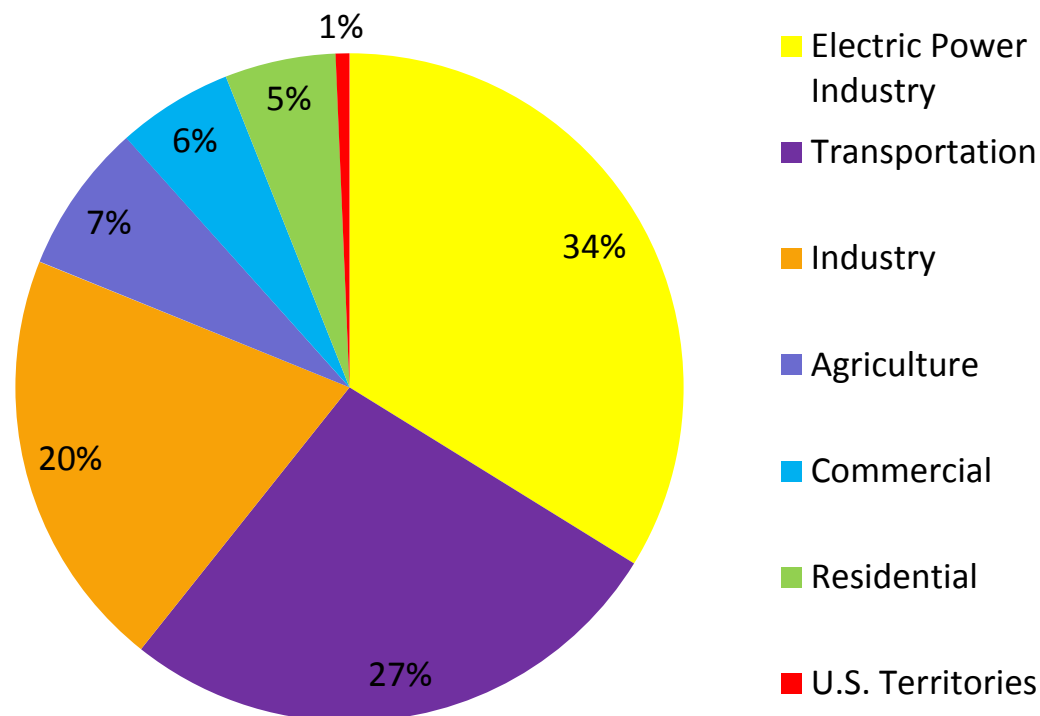
Warwick J. McKibbin, Adele C. Morris, and Peter J. Wilcoxon
Power Generation Conference
October 2, 2012

Policy background

- 2009
 - » US House of Representatives passed Waxman-Markey Bill
 - » Would have created a national carbon market
 - » 17% below 2005 emissions by 2020; 83% below by 2050
- 2010
 - » Senate abandoned its parallel bill
 - » Interest in more limited approaches
- Alternative offered by Senator Bingaman
 - » Electricity sector only
 - » Targets 17% below 2005 by 2020; 42% below by 2030

Key considerations of Power Sector Approach

Sector Shares of Gross US GHG Emissions in 2010



- Advantages:

- » Fewer regulated entities
- » Less industry opposition

- Disadvantages:

- » Does not minimize costs
- » Only 1/3 of US emissions

- Effects on fuels:

- » Large effect on coal
- » Little effect on petroleum

Policy questions in our study

- What carbon price would be needed to hit targets?
- What would the effect be on the economy?
- How would the results differ from a broader policy?
- Evaluate using the G-Cubed model
 - » Intertemporal general equilibrium model of the world economy

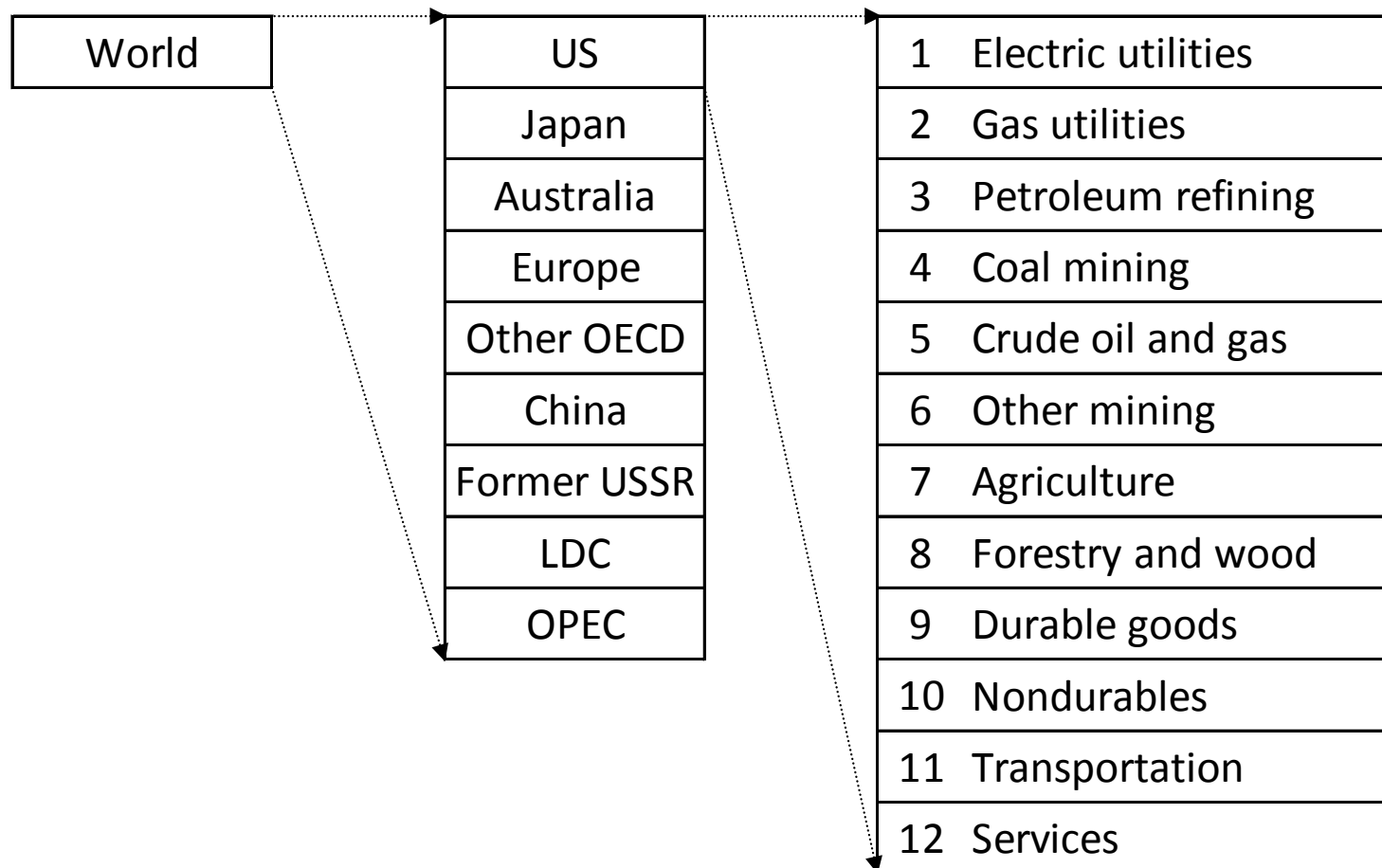
Overview of G-Cubed

- **Intertemporal optimization** by households and firms
 - » Forward-looking savings, investment and financial arbitrage
 - » A fraction of households and firms are myopic
- Extensive **econometric parameterization**
 - » Behavior consistent with historical demands and supplies
 - » Technical change from historical productivity growth
- Full **bilateral trade**
 - » Agents in each region can buy goods from all other regions
 - » Financial assets can also be traded
 - » International trade and financial flows drive exchange rates

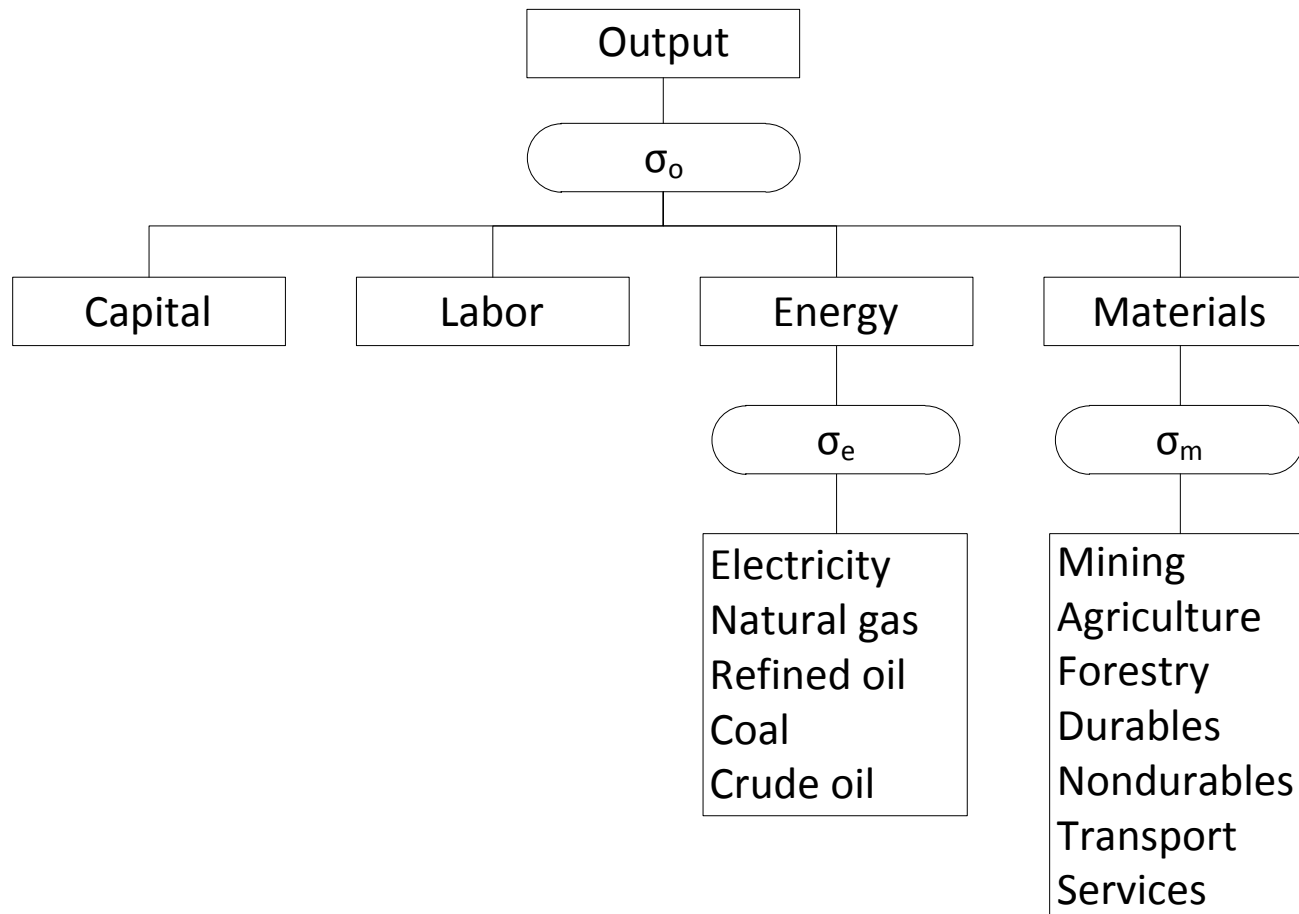
Regions and sectors in G-Cubed

Regions

Sectors per Region



Production model for each sector



Baseline data

- Population
 - » UN medium-variant population growth projections
- Productivity
 - » Labor-augmenting productivity growth
 - » Varies by sector by region
 - US rates based on recent history
 - Other regions converge to the US over time
- Energy efficiency
 - » Based on recent historical data
- Government spending held to baseline levels, even as prices shift

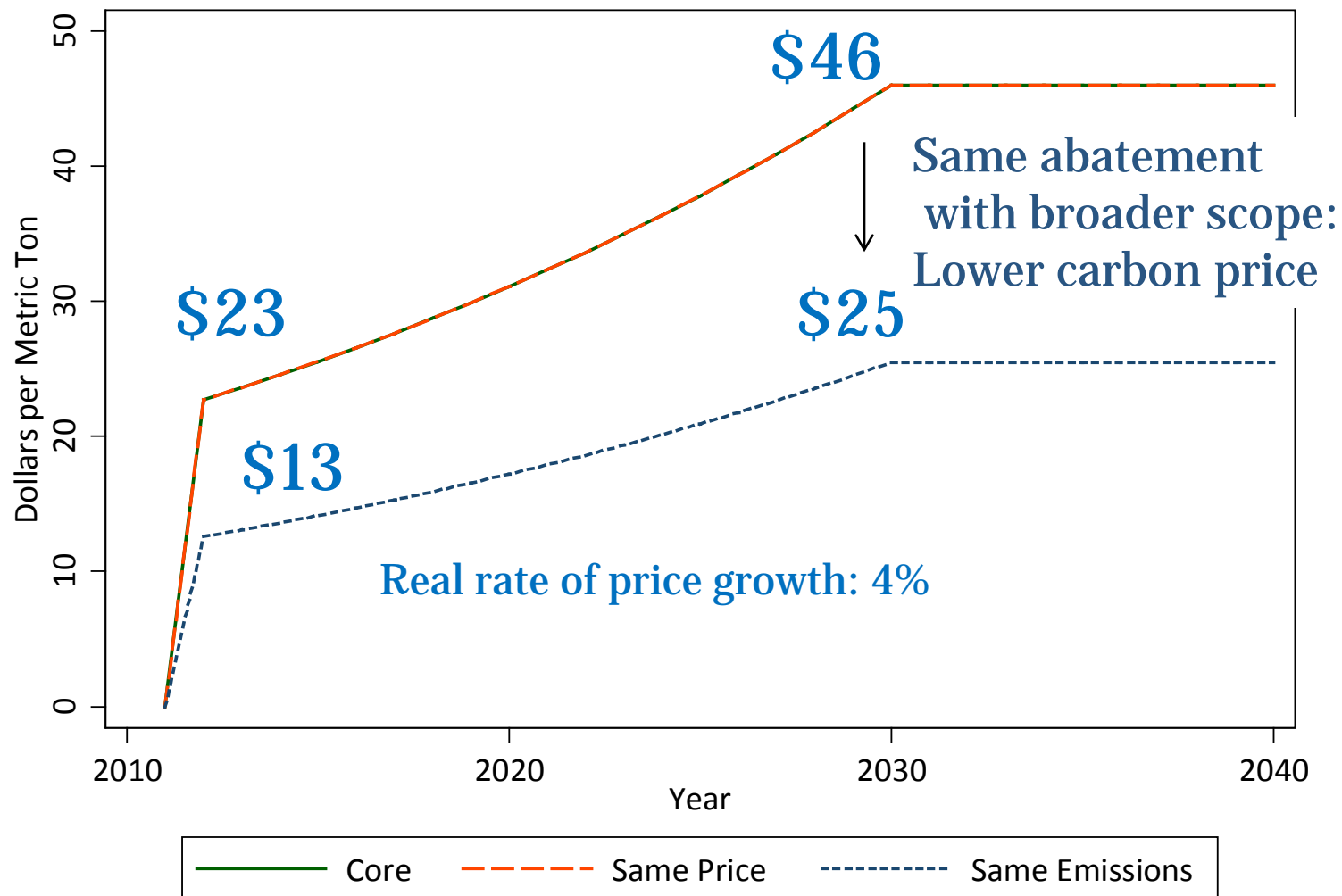
Core policy scenario

- Targets similar to Bingaman 2010 proposal
- Declining emissions targets for U.S. electricity generation
 - » 17 percent below 2005 levels in 2020
 - » 42 percent below 2005 levels in 2030
- Achieve with 4% rising real carbon price path
 - » Carbon price rises to 2030, then constant
 - » Achieves same cumulative emissions as sum of the targets
 - » Revenues are distributed via **lump sum rebates** to households

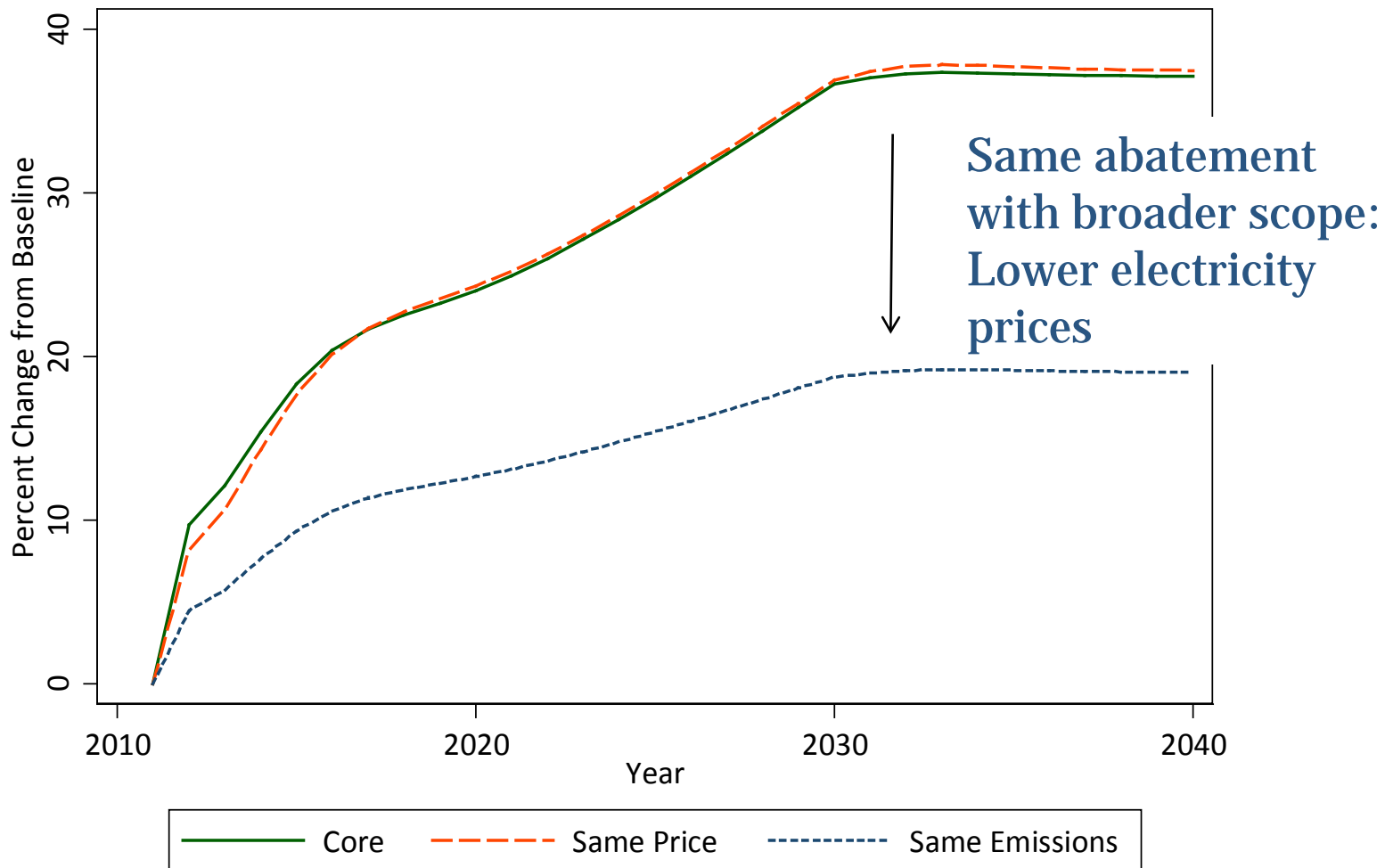
Two comparison scenarios

- **Same Price** scenario
 - » Same carbon price as in Core
 - » Applied economy-wide to fossil carbon in energy
 - Emissions reductions will be larger
- **Same Emissions** scenario
 - » Same U.S. emissions reduction as Core
 - » Uniform economy-wide price on fossil carbon in energy
 - Carbon price will be smaller

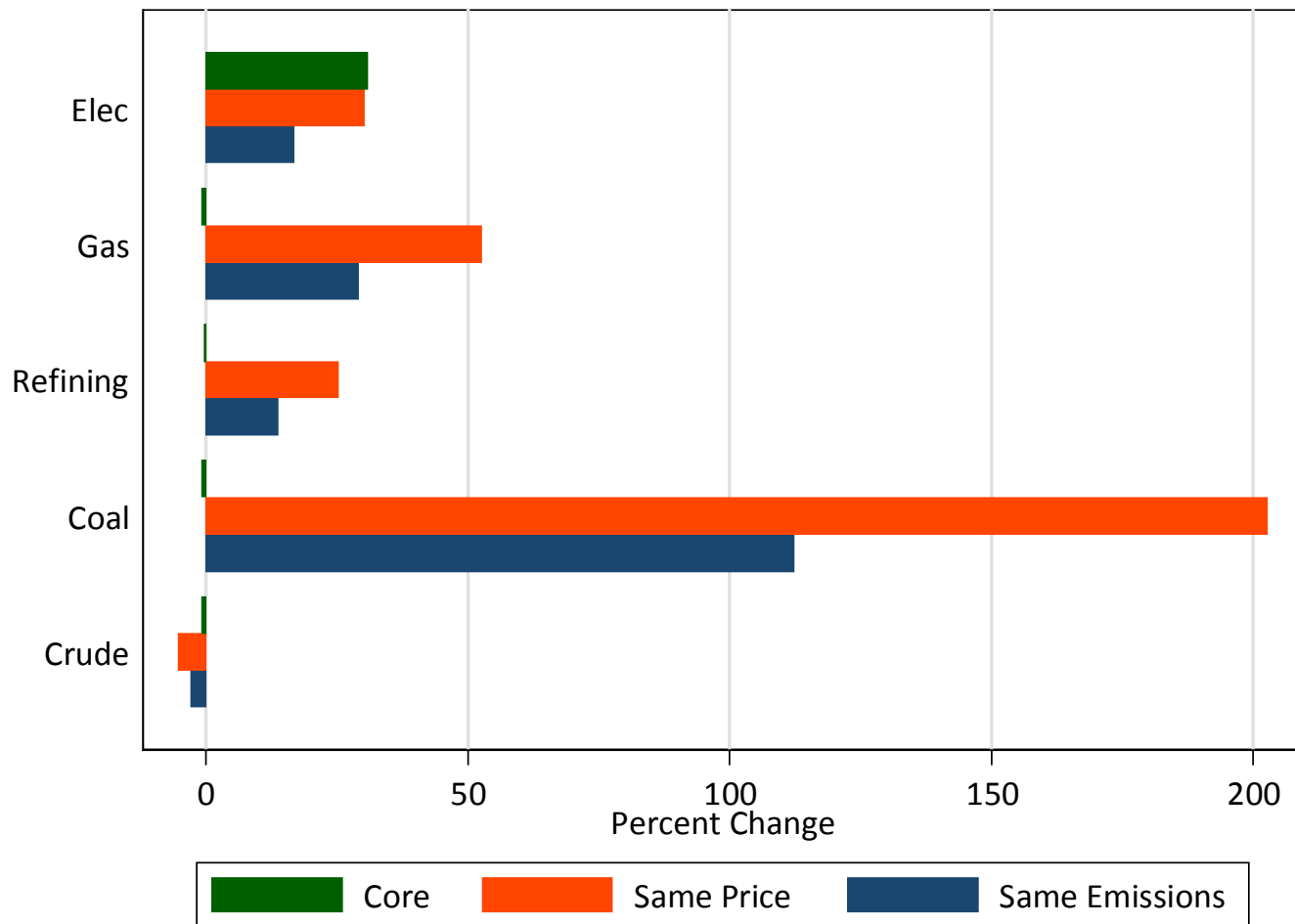
Carbon dioxide prices



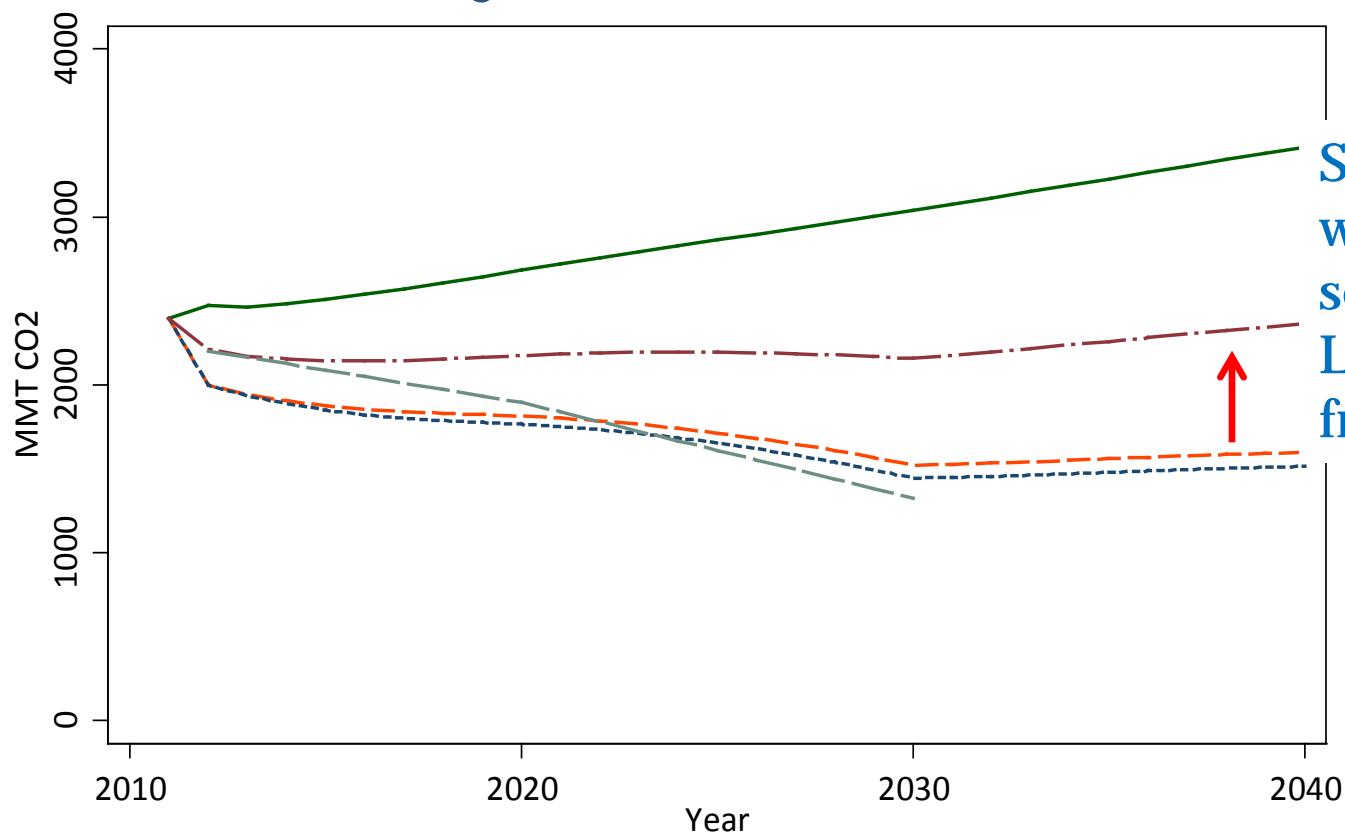
Electricity prices



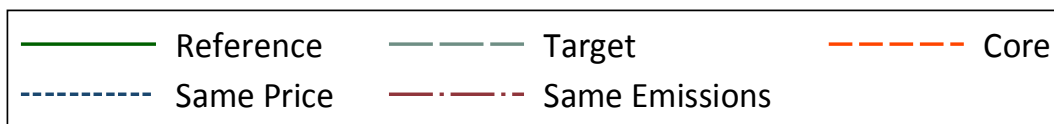
Energy prices in 2030



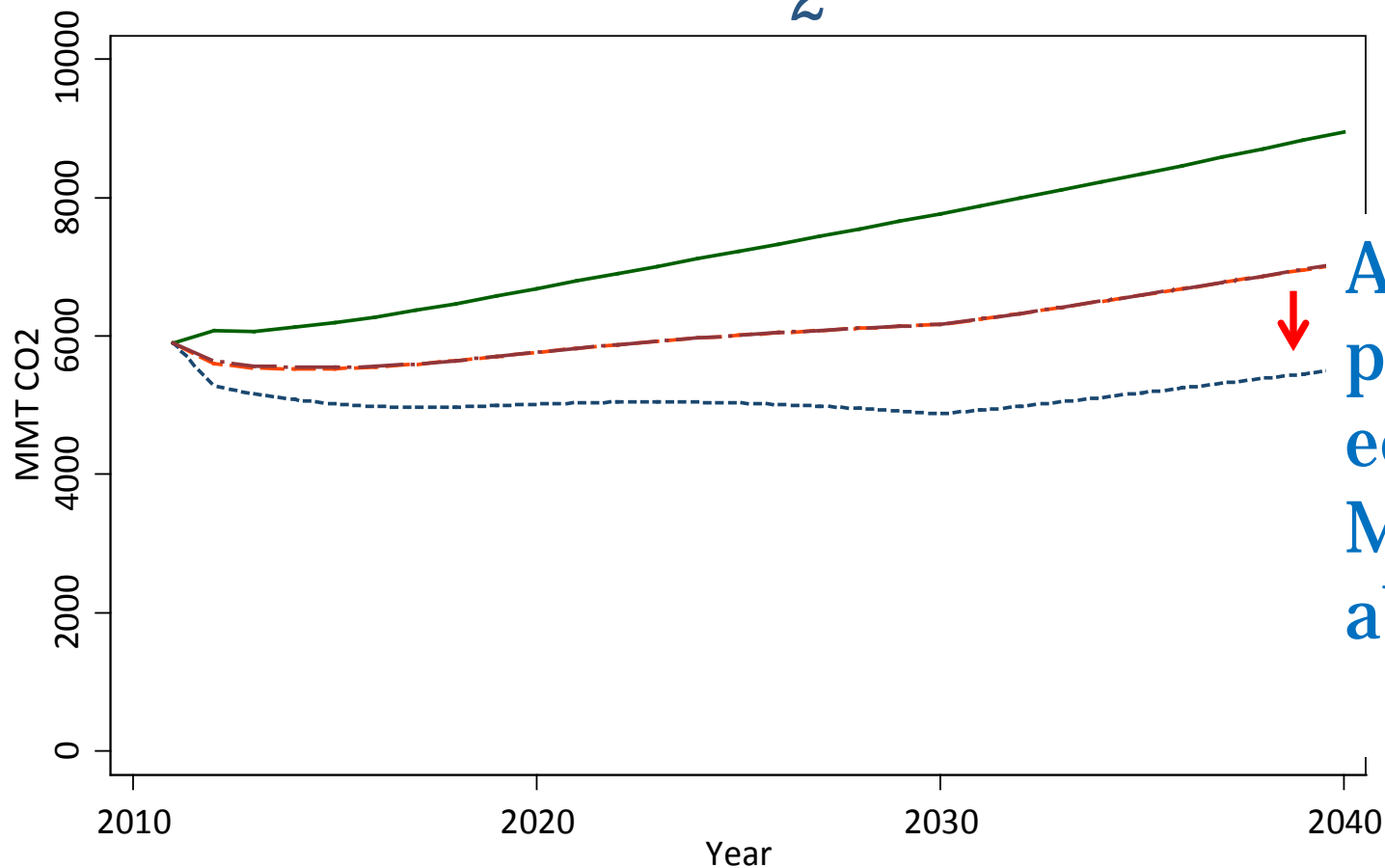
Electricity sector emissions



Same abatement
with broader
scope:
Less abatement
from electricity



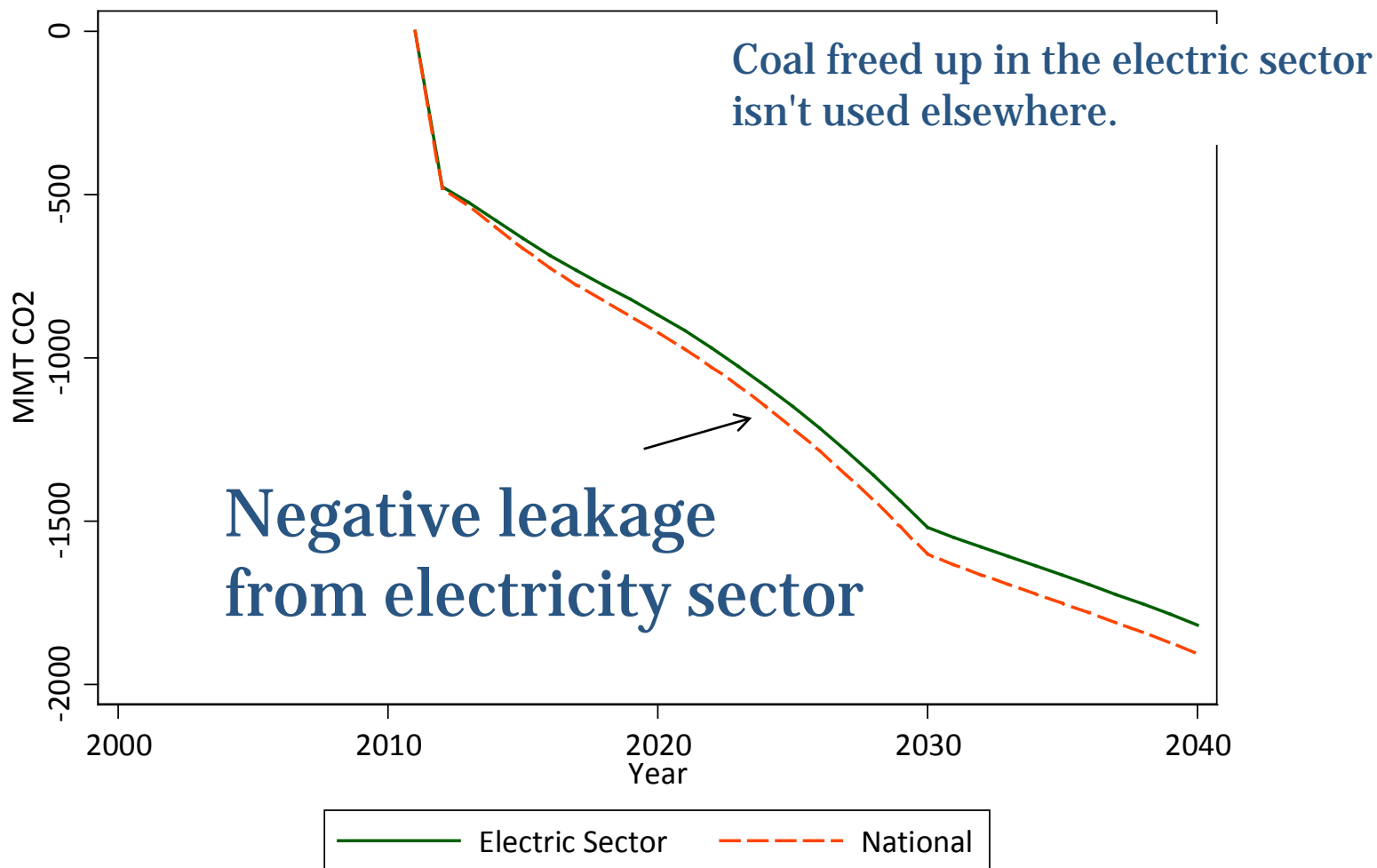
U.S. Fossil CO₂ Emissions



Apply same price across economy:
More abatement



Fossil Energy CO₂ Emissions Relative to Baseline: Core Scenario



U.S. Annual and Cumulative Emissions (Billions of metric tons of CO₂ and % declines from reference)

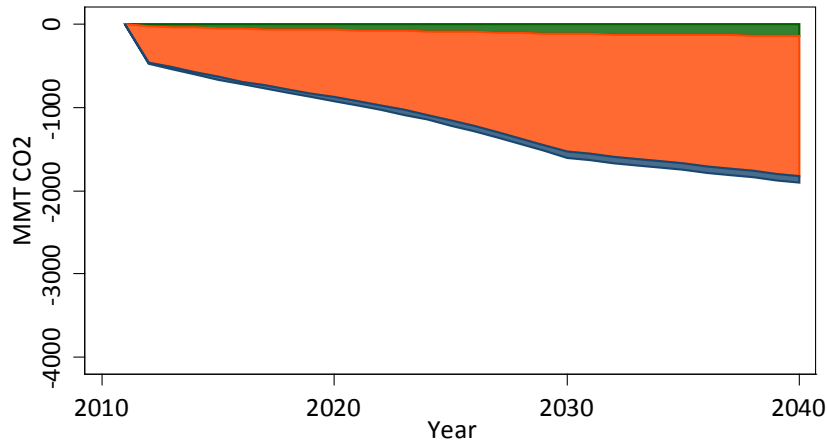
	Reductions Relative to the Reference Case			
	2020	2030	2040	Cumulative 2008 to 2040
Core	0.9 (14%)	1.6 (21%)	1.9 (21%)	37 (17%)
Same Price	1.7 (25%)	2.9 (37%)	3.4 (38%)	66 (30%)
Same Emissions	0.9 (14%)	1.6 (21%)	1.9 (21%)	37 (17%)

Same Price: Almost double the abatement

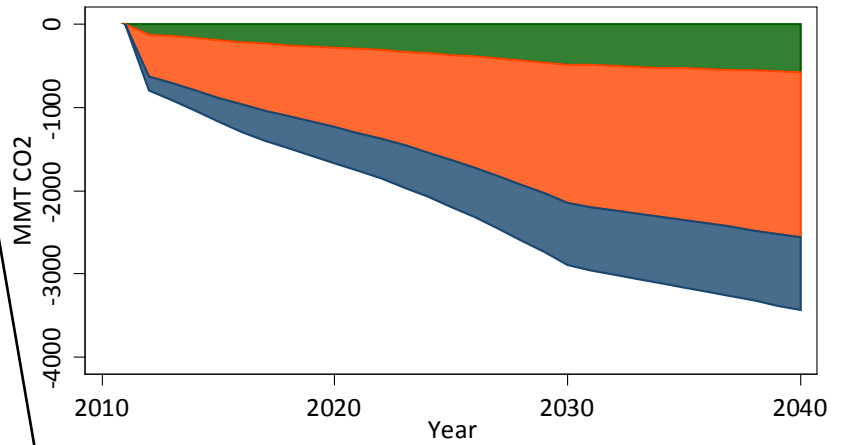
Same Emissions: Half the increase in electricity prices

Decomposition of U.S reduction by fuel

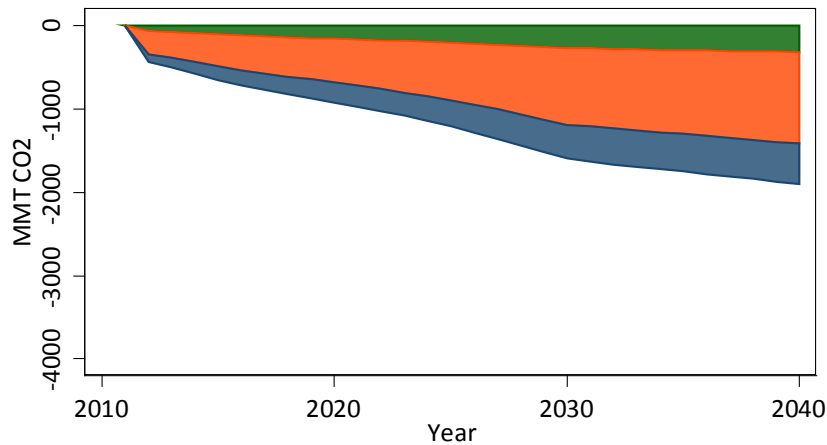
Panel A: Core



Panel B: Same Price



Panel C: Same Emissions

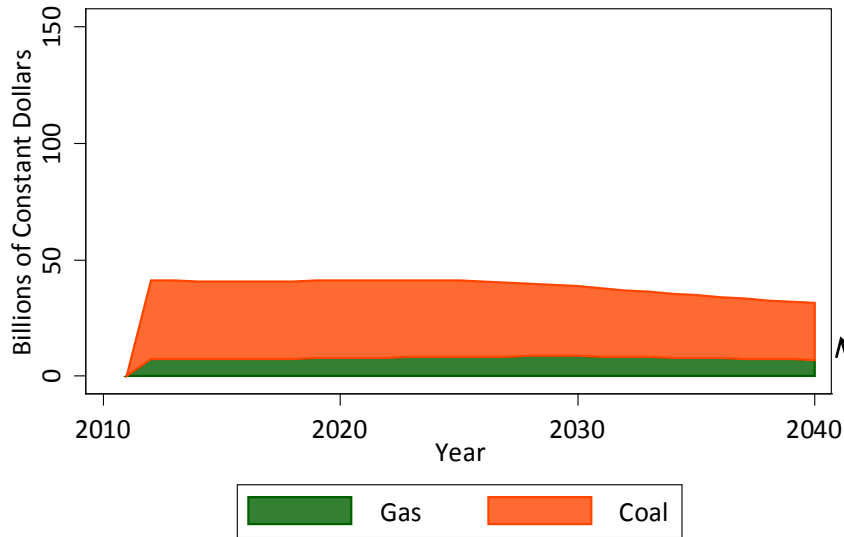


Power sector only policy falls almost entirely on coal.

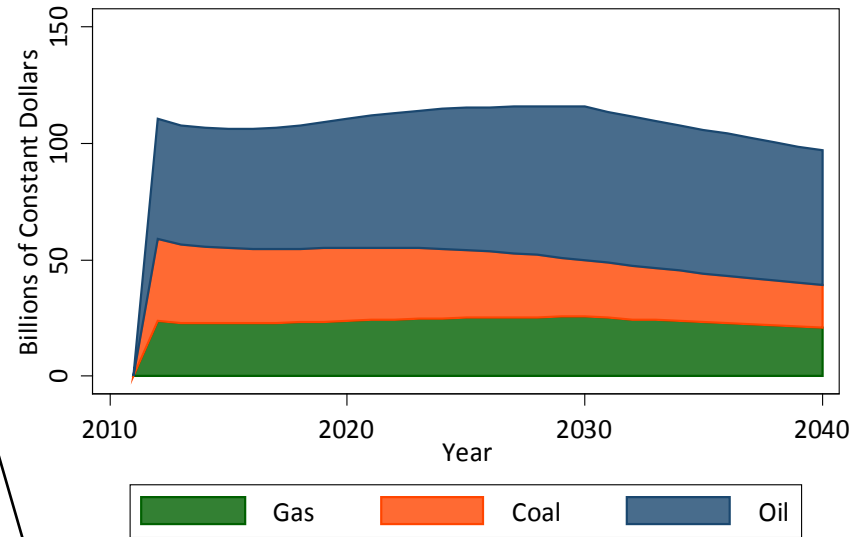
Broader policy brings in oil.

Revenue

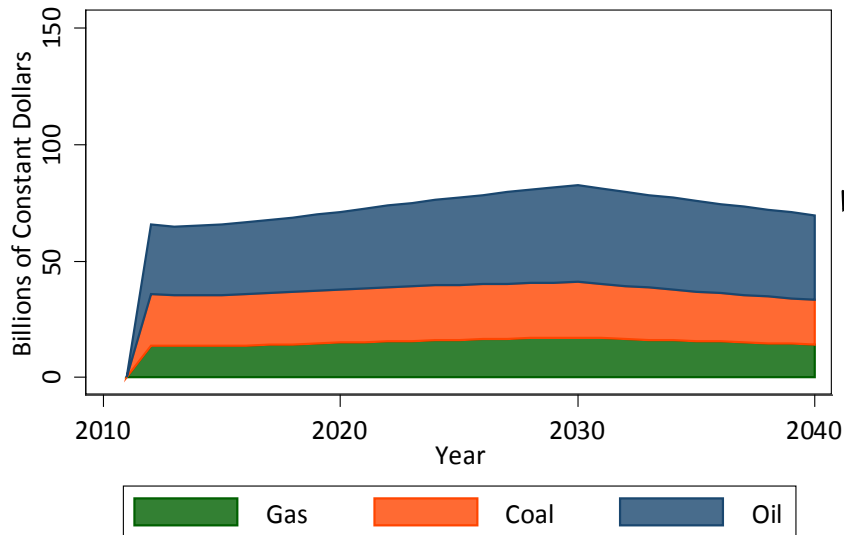
Panel A: Core



Panel B: Same Price



Panel C: Same Emissions

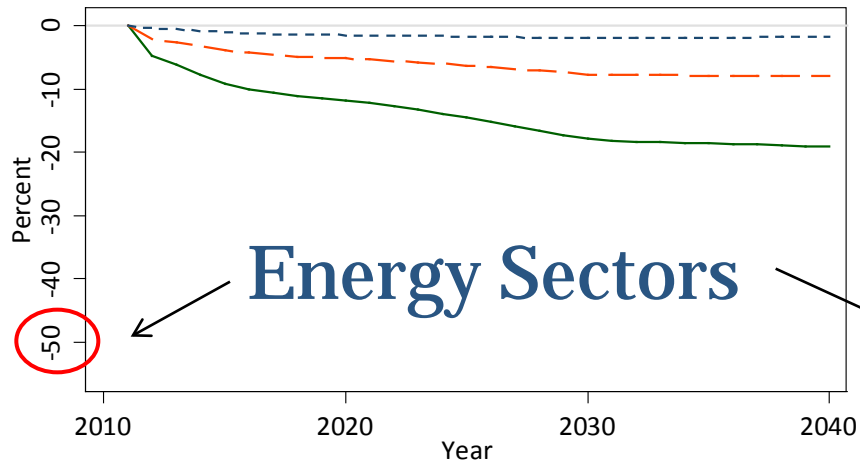


Broader policies generate much more revenue, even for same abatement.

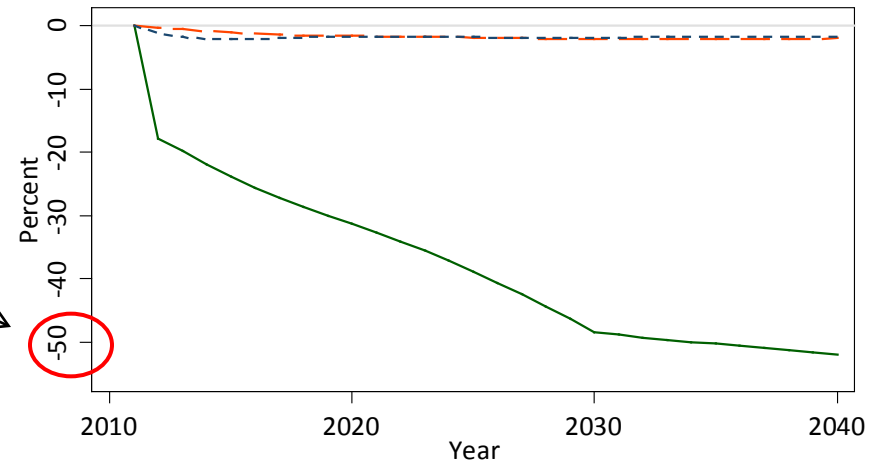
Oil demand is less elastic than coal.

Effect on industry output, Core Scenario

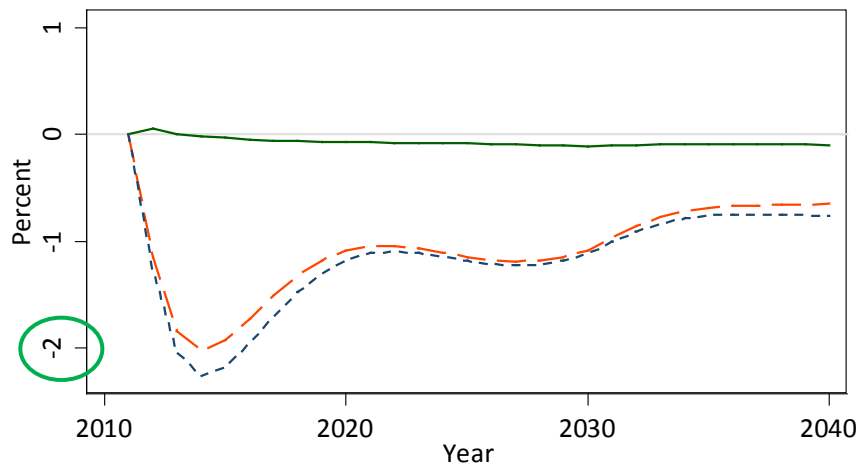
Panel A: Sectors 1-3



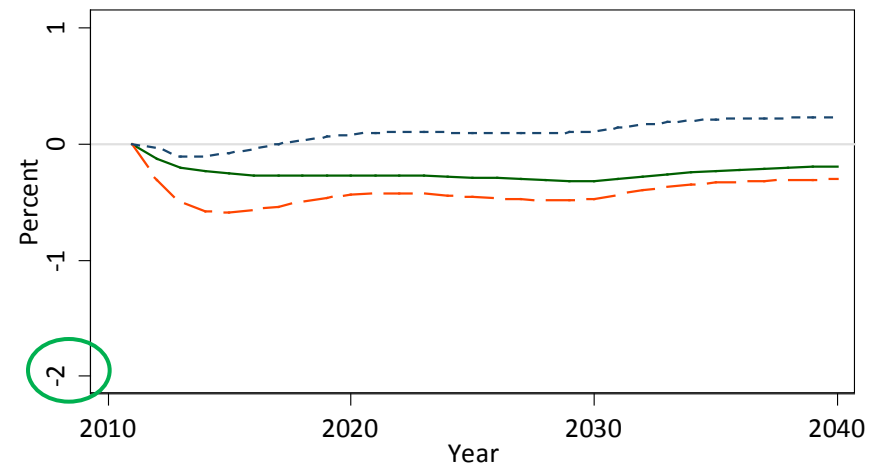
Panel B: Sectors 4-6



Panel C: Sectors 7-9

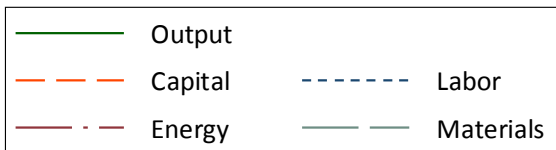
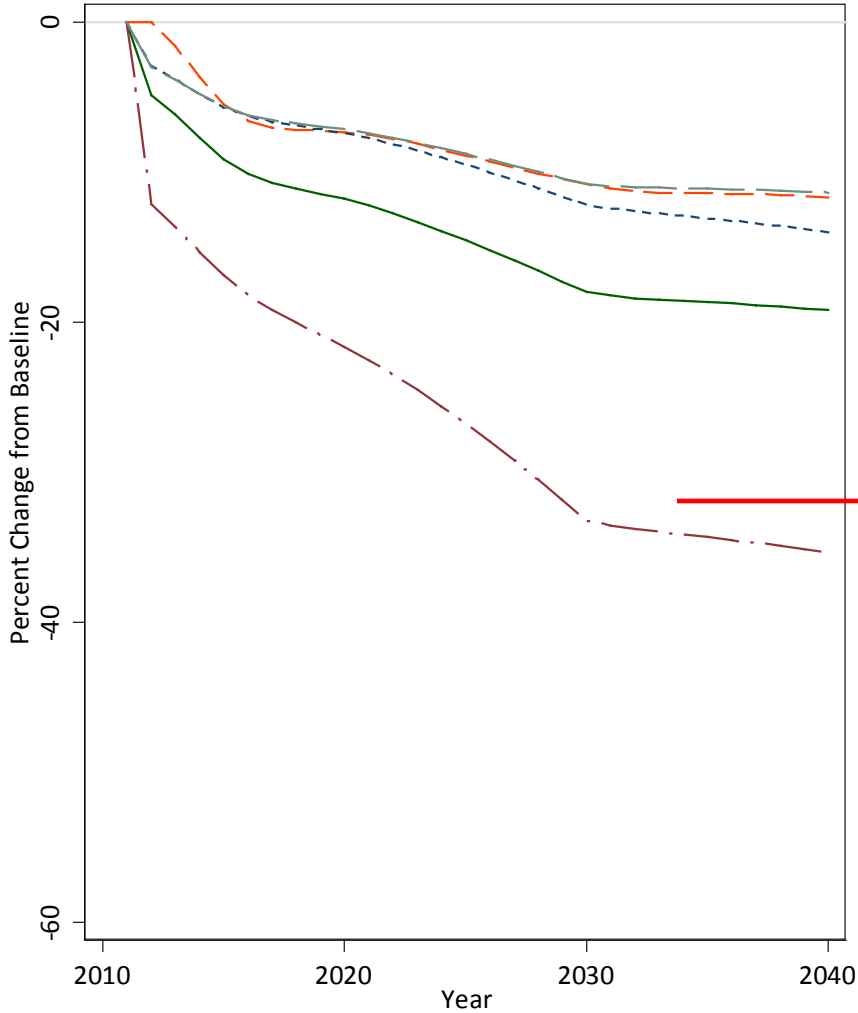


Panel D: Sectors 10-12

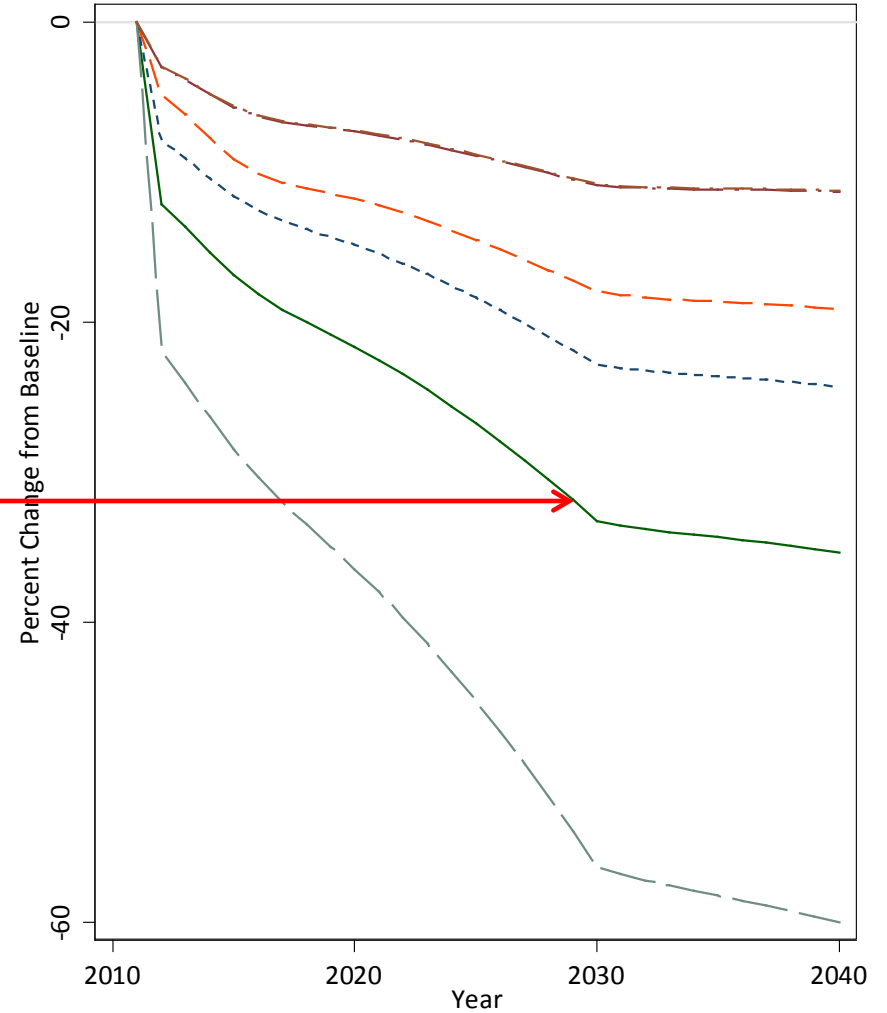


Effect of the Core Scenario on Output and Inputs to Electric Utilities

Panel A: Output and KLEM Inputs

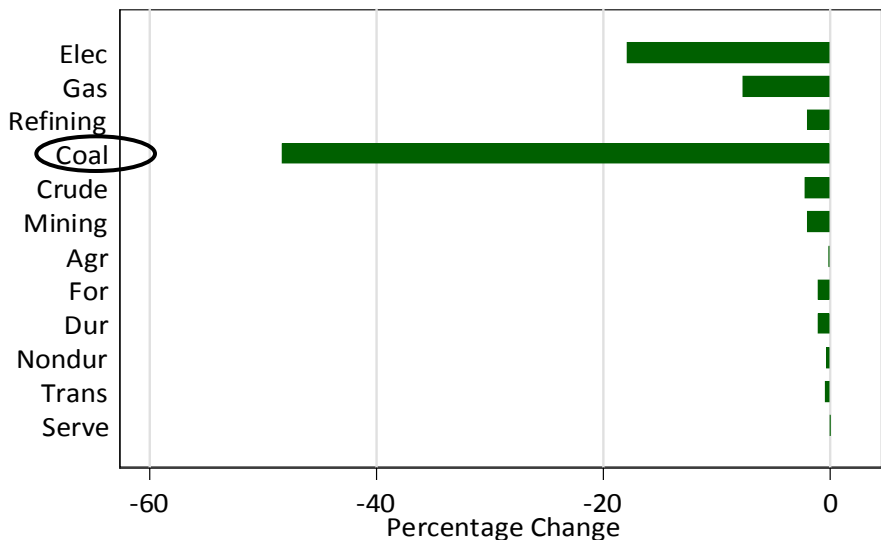


Panel B: Aggregate Energy and Inputs

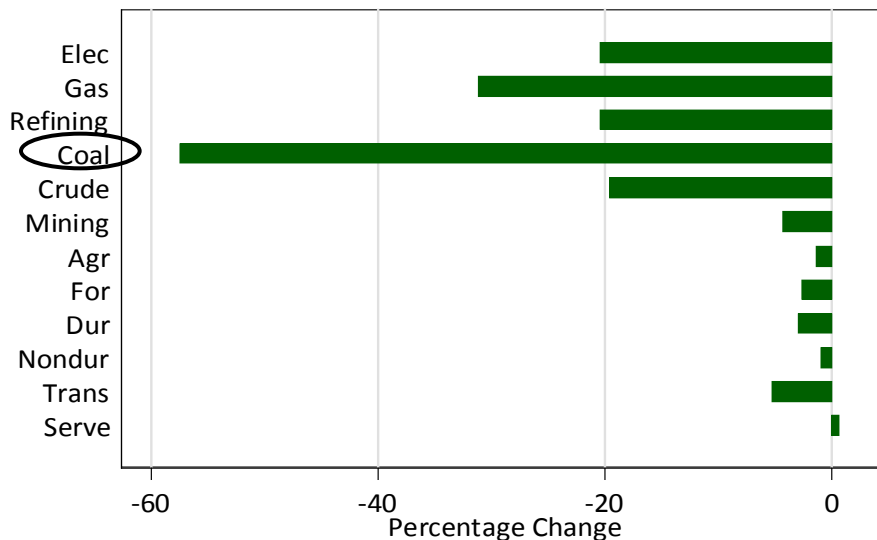


Change in industry output in 2030, all 3 policies

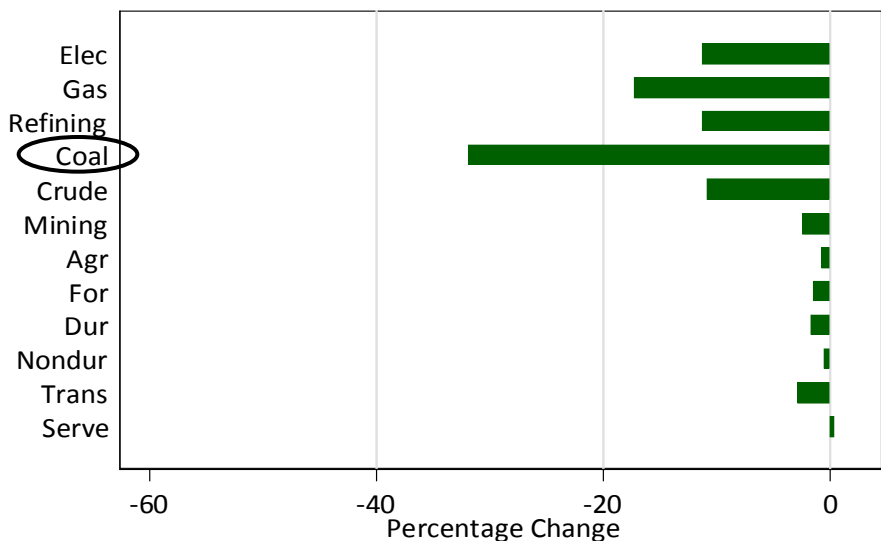
Panel A: Core



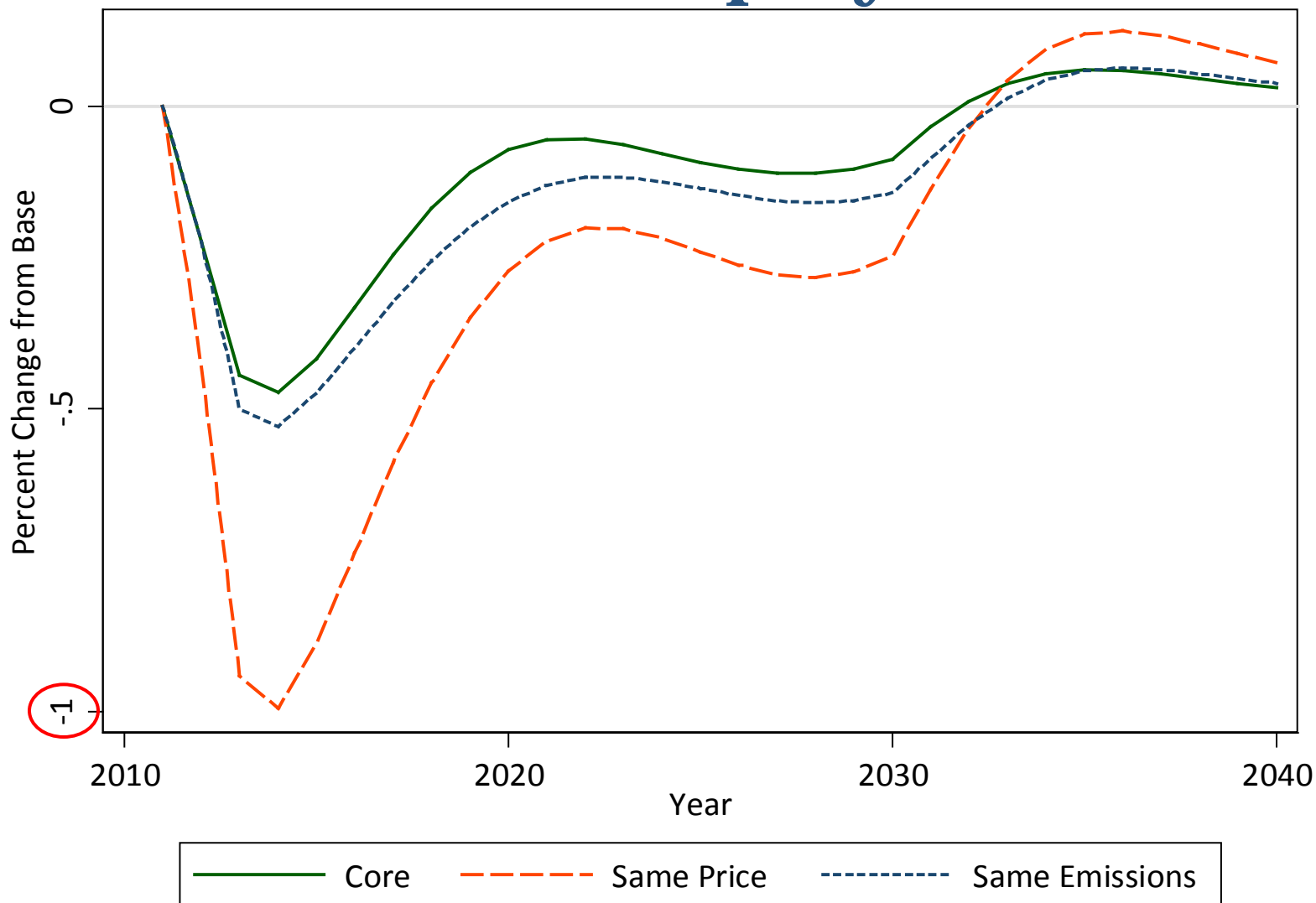
Panel B: Same Price



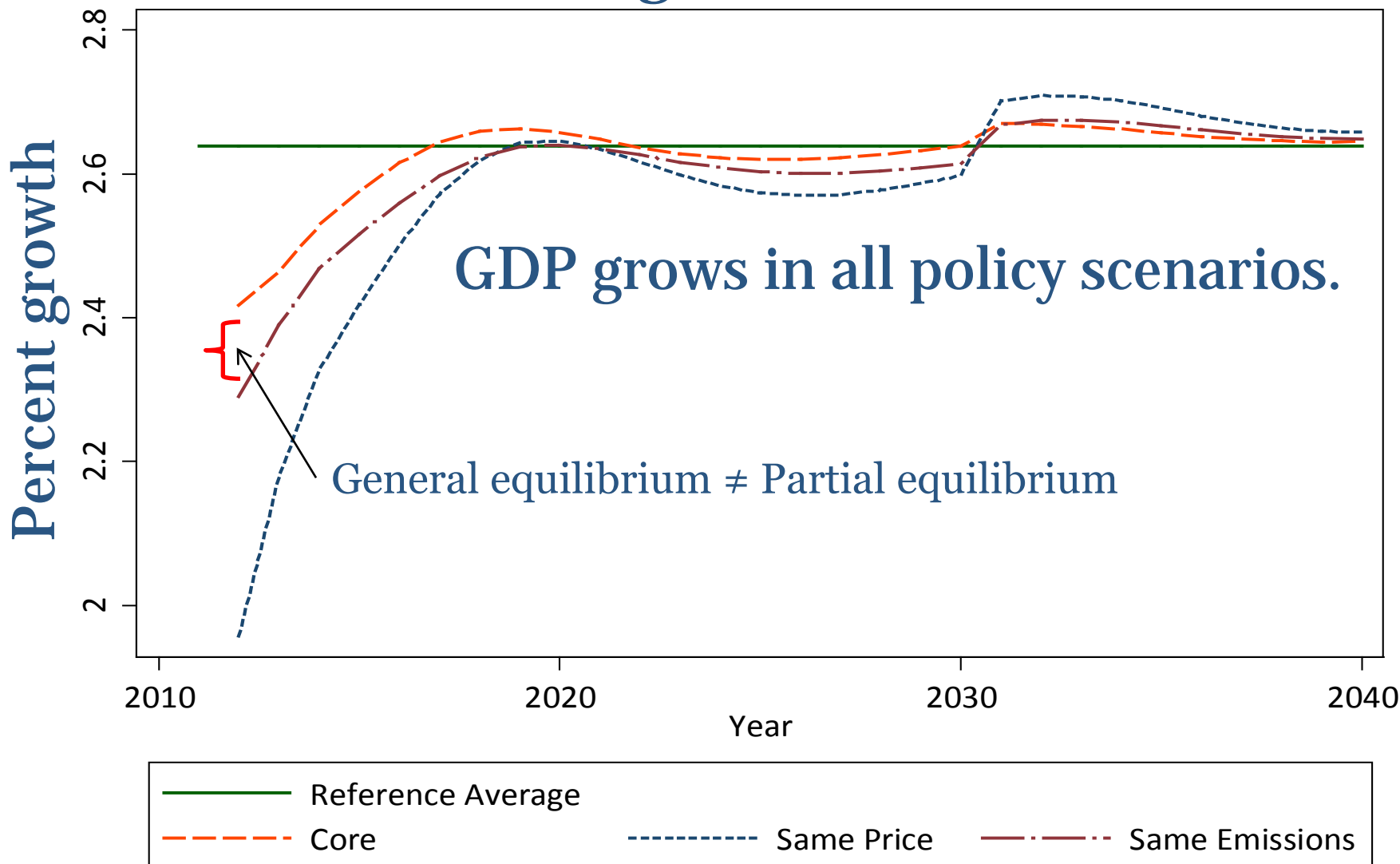
Panel C: Same Emissions



Effects on employment



Effects on GDP growth

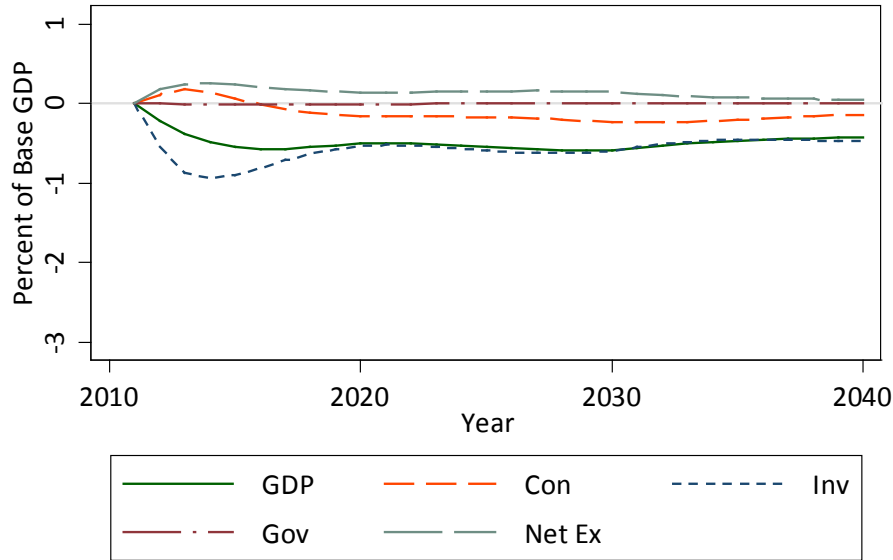


Why are GDP and employment losses greater in Same Emissions than Core?

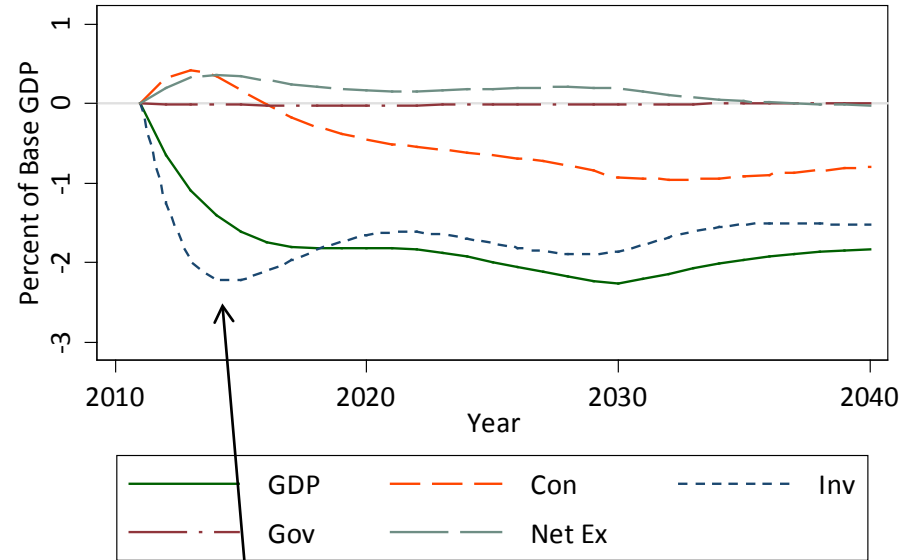
- Might expect lower cost to economy as marginal abatement cost equalizes across economy.
- Same Emissions scenario applies carbon price to oil.
- Oil demand is relatively less elastic.
- Adjustment costs are higher.
- Bigger hit to consumption and investment.

Effects on GDP Composition

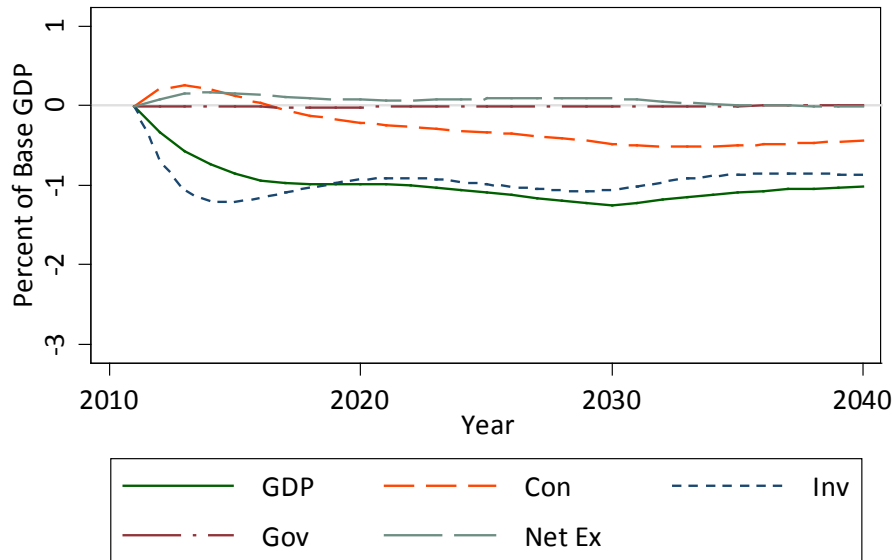
Panel A: Core



Panel B: Same Price



Panel C: Same Emissions

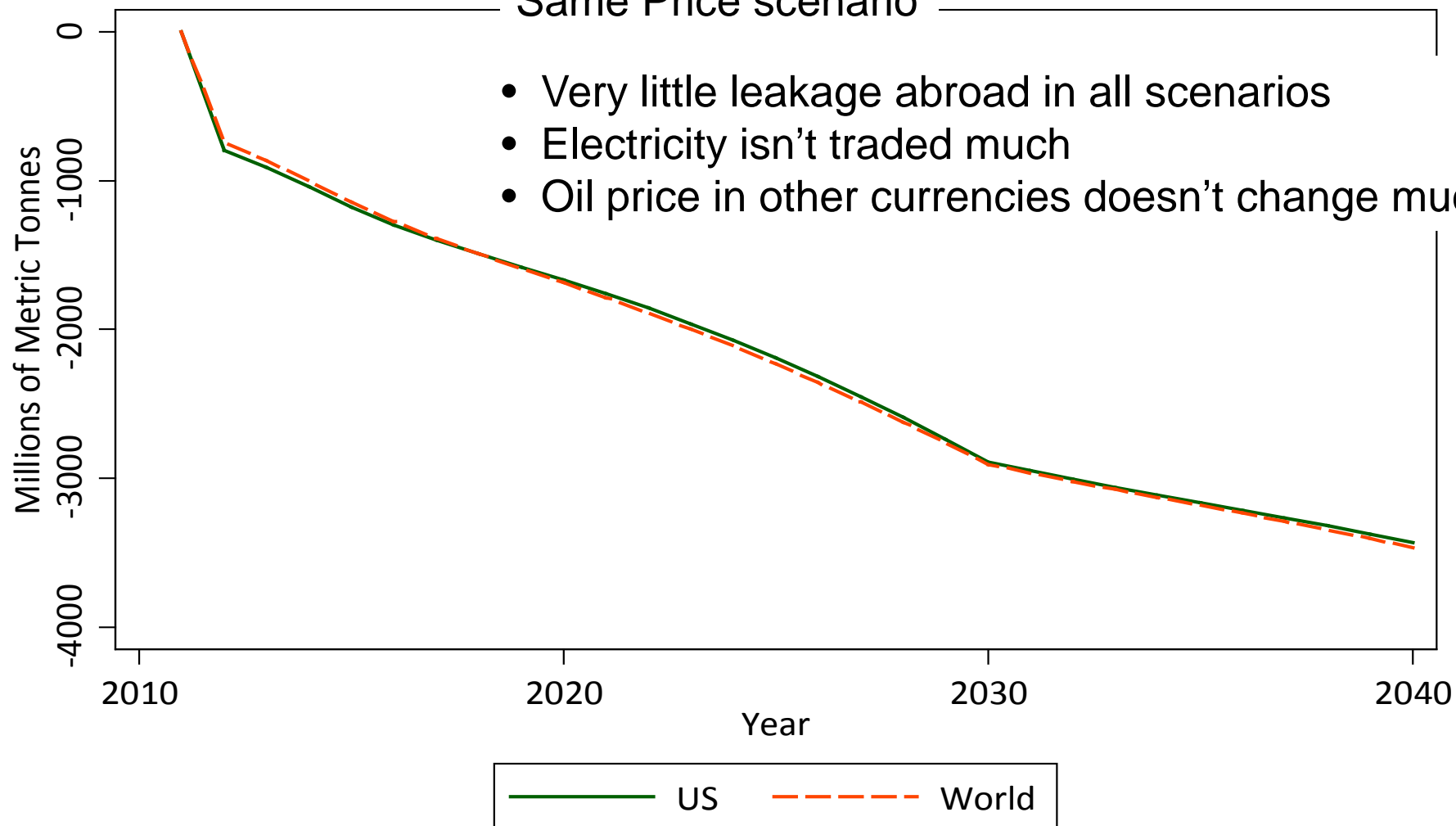


All policies reduce investment, but Same Price reduces it most.

Change in US and World CO2 Emissions

Same Price scenario

- Very little leakage abroad in all scenarios
- Electricity isn't traded much
- Oil price in other currencies doesn't change much



Summary

	Carbon Price 2012 to 2030	Electricity Price Increase 2012 to 2030	Approx Annual Revenue	Cumulative Reductions 2012 to 2040 Bmt	Approx Effect on Fuels
Core	\$23 to \$46	10% to 38%	\$40 b	37 (17%)	Nearly all coal, with some gas
Same Price	\$23 to \$46	10% to 38%	\$100 b	66 (30%)	½ oil, ¼ coal, ¼ gas
Same Emissi ons	\$13 to \$25	5% to 18%	\$65 b	37 (17%)	½ oil, ¼ coal, ¼ gas

Preferred policy depends on the goal...

Policy:	Goal:					
	Min GDP Loss	Min Electricity Price Increase	Min Job Loss	Max. Rev	Max Emissions Abatement	Spread effect more evenly across fuels/sectors
Core	X		X			
Same Price				X	X	X
Same Emissions		X				X

Adele Morris

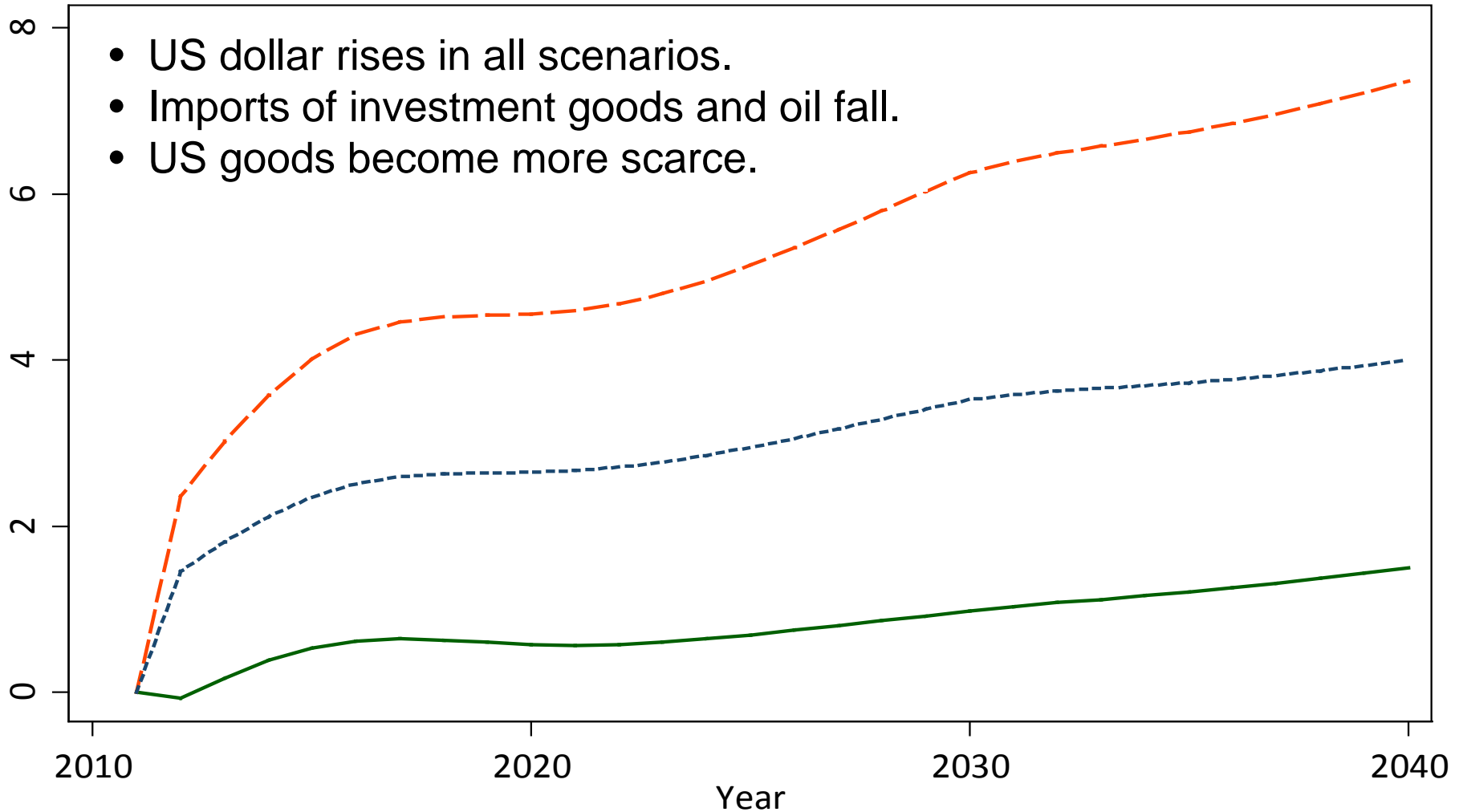
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Trade-Weighted Real Exchange Rate



- US dollar rises in all scenarios.
- Imports of investment goods and oil fall.
- US goods become more scarce.

