Emission projections for long-haul freight trucks and railways through 2050 in the United States

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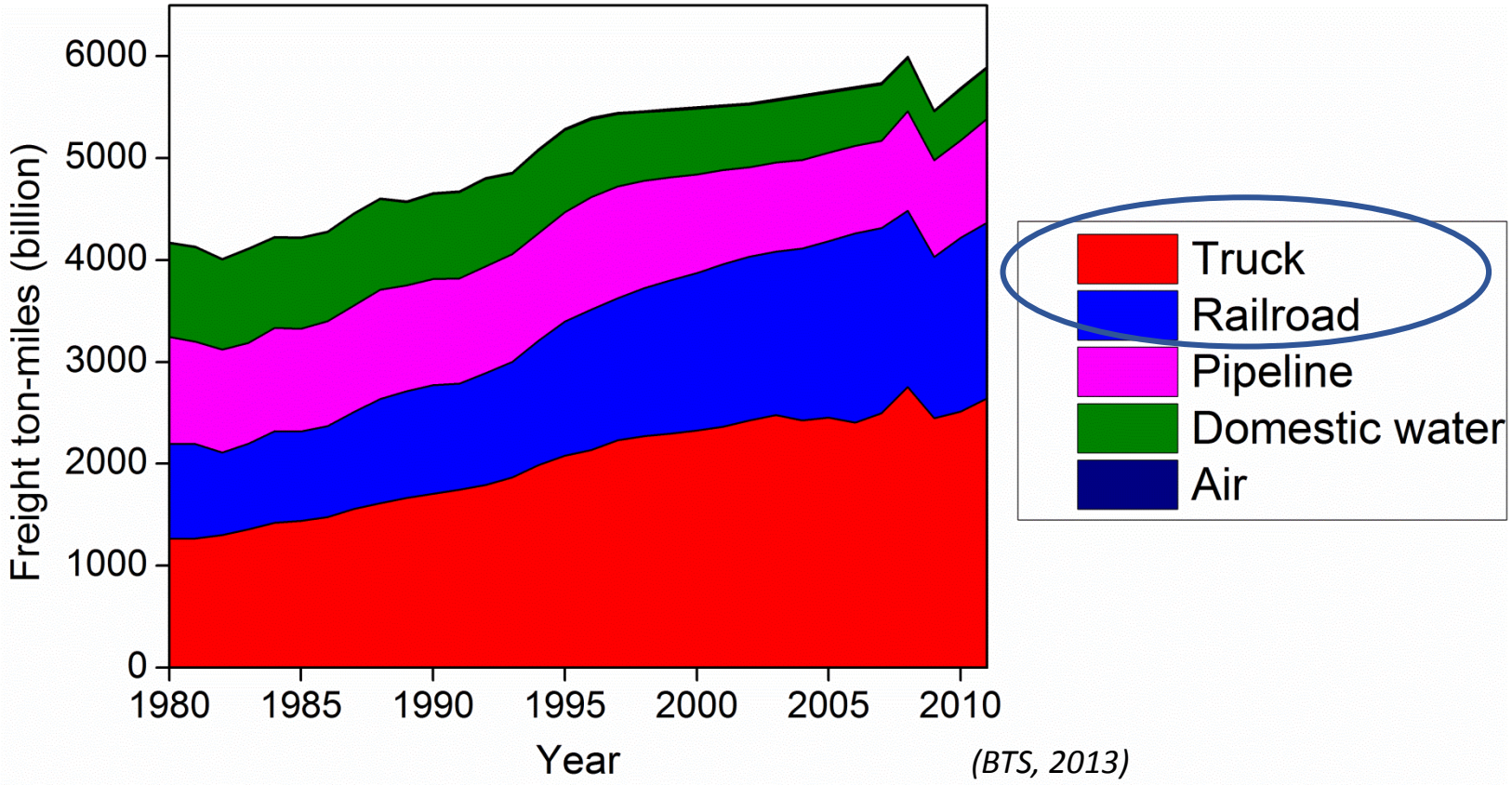
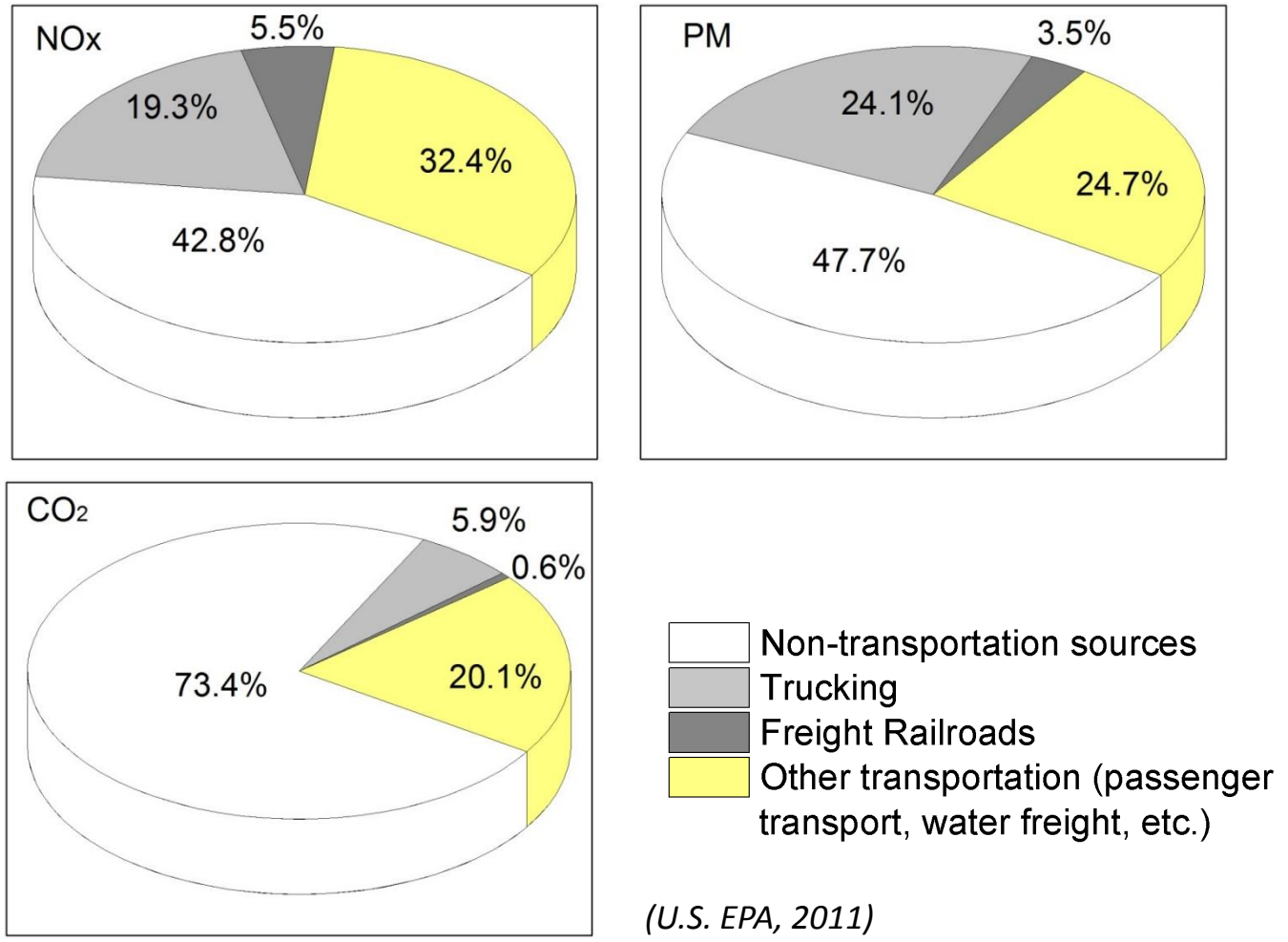
U.S. freight shipments have grown by 45% in the last three decades.



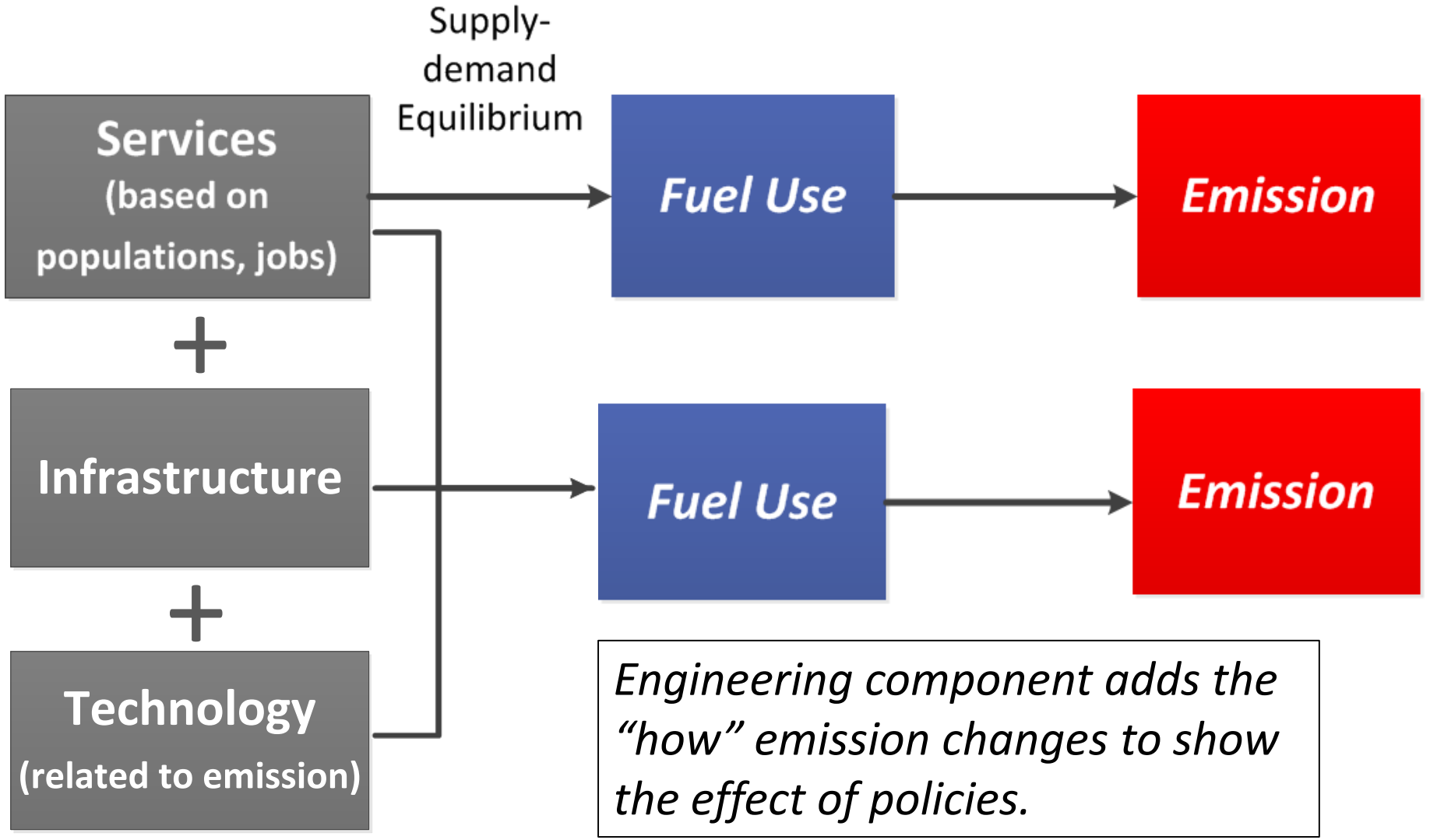
Ton-mile: A single ton of goods that is transported for one mile.

Freight truck and rail transport are major sources of CO_2 and air pollutants.



(U.S. EPA, 2011)

We integrated socioeconomic, infrastructure and technology factors affecting future freight emissions.



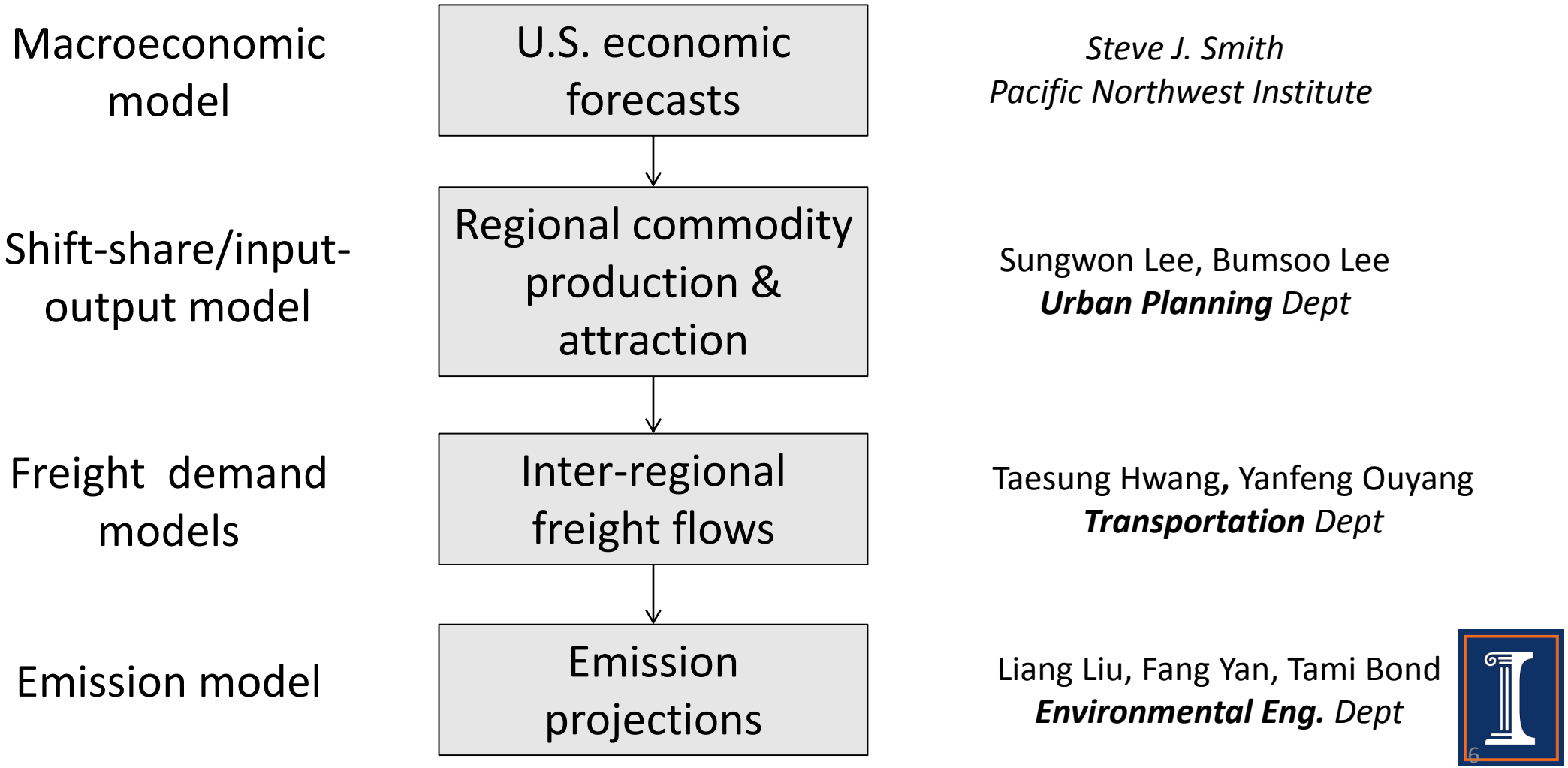
Engineering component adds the "how" emission changes to show the effect of policies.

Objectives of this study

- Develop a **comprehensive** freight emission forecast system
  - U.S. inter-regional transport: long-haul trucks and rail
  - Time period: 2010-2050

- Identify **robust decisions** regarding the freight handling infrastructure under future uncertainties

Schematic method of projecting emissions from U.S. inter-regional freight transport



Macroeconomic model makes global economic forecasts.

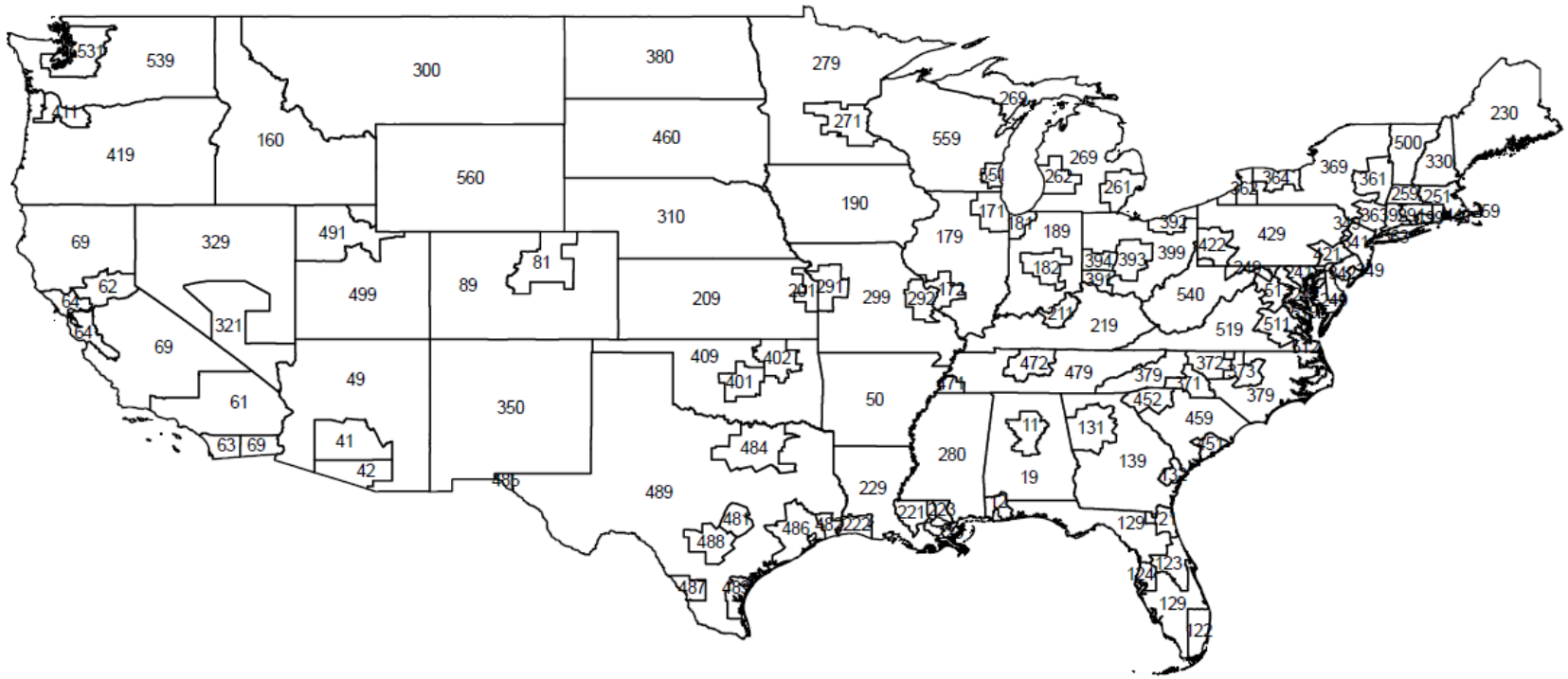
- **Phoenix model**
  - Projects activities in broad economic sectors by seeking supply-demand equilibrium
  - Commodity, population & GDP in U.S.
- **Four scenarios** to capture future uncertainties (2005-2050).

	Business as usual (BAU)	Climate policy (carbon tax)
High GDP (180% increase)	S1	S3
Low GDP (60% increase)	S2	S4

(Fisher-Vanden et al. 2012)

Downscale national level economic projections to regional level (FAZs)

- **Shift-share & input-output model**
  - Trip production & attraction in 120 Freight Analysis Zones (FAZs)

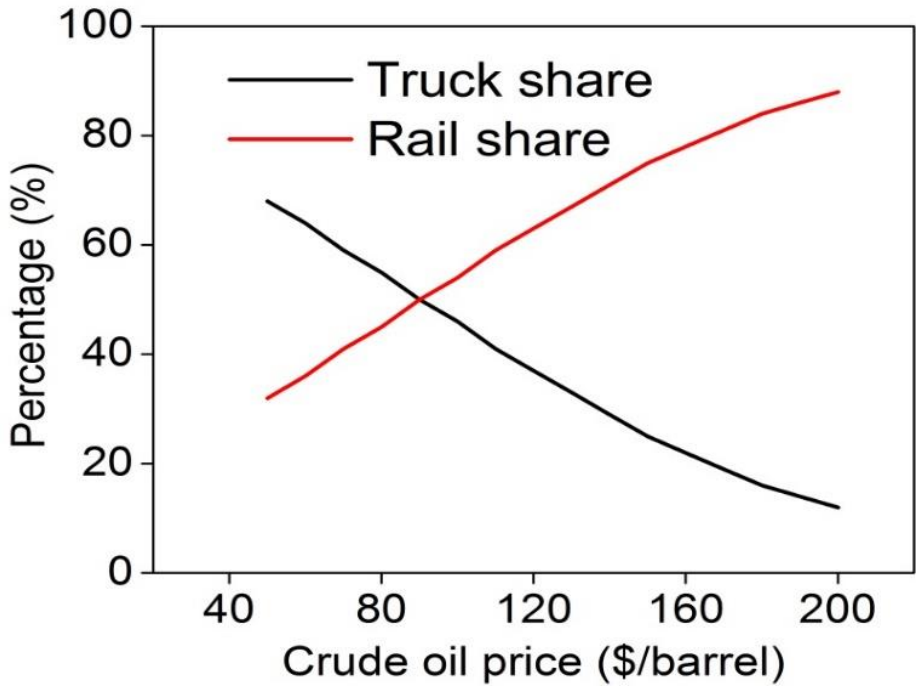


(FHWA, 2011)

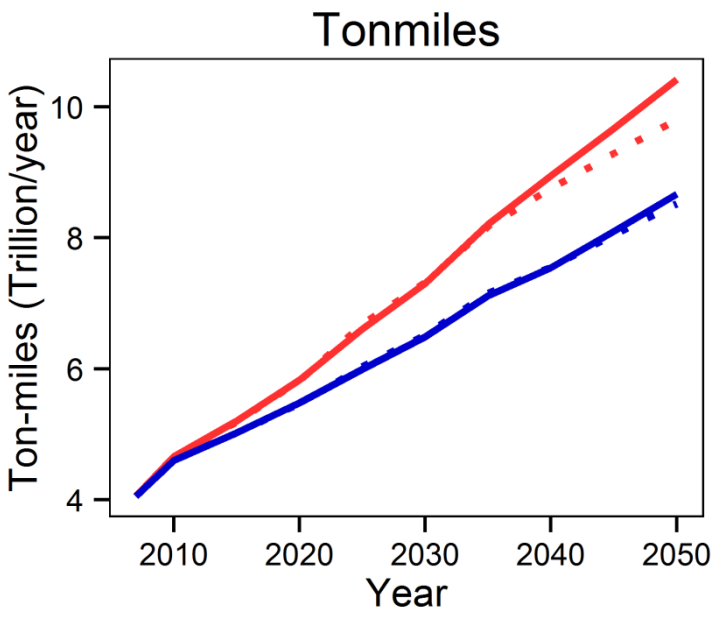
Distribute freight flows via truck and rail

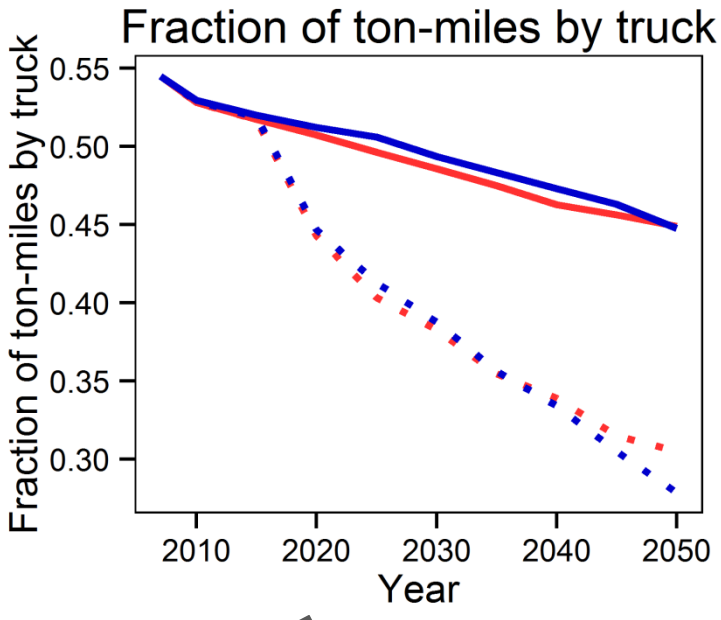
- **Mode split: binomial logistic regression model (*Hwang et al., 2013)***
  - (based on 69,477 observations, 10 commodity types)
  - commodity value
  - average shipment distance
  - crude oil price

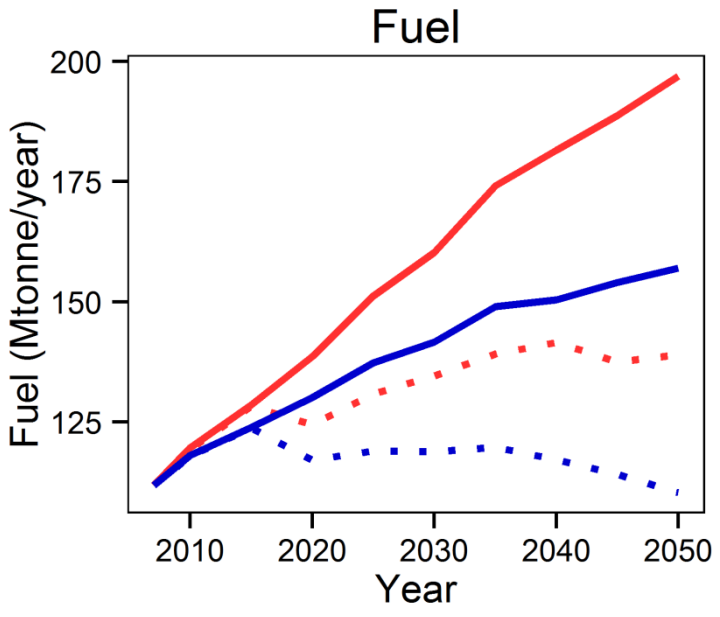
- **Trucks**
  - less energy efficient
  - preferred for transporting high value products over short distances.

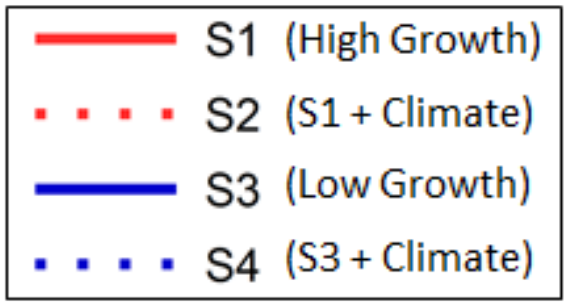


U.S. inter-regional freight activity and fuel use projections







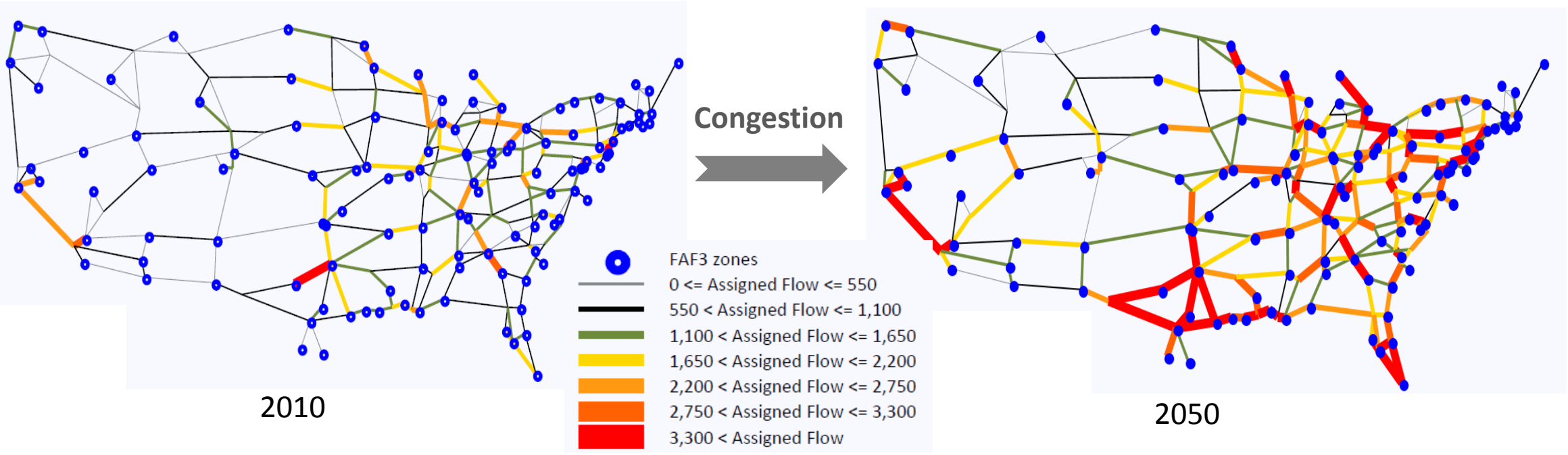


Climate policy (carbon tax) causes a modal shift to railway.

Climate policy causes ~30% reduction in fuel use

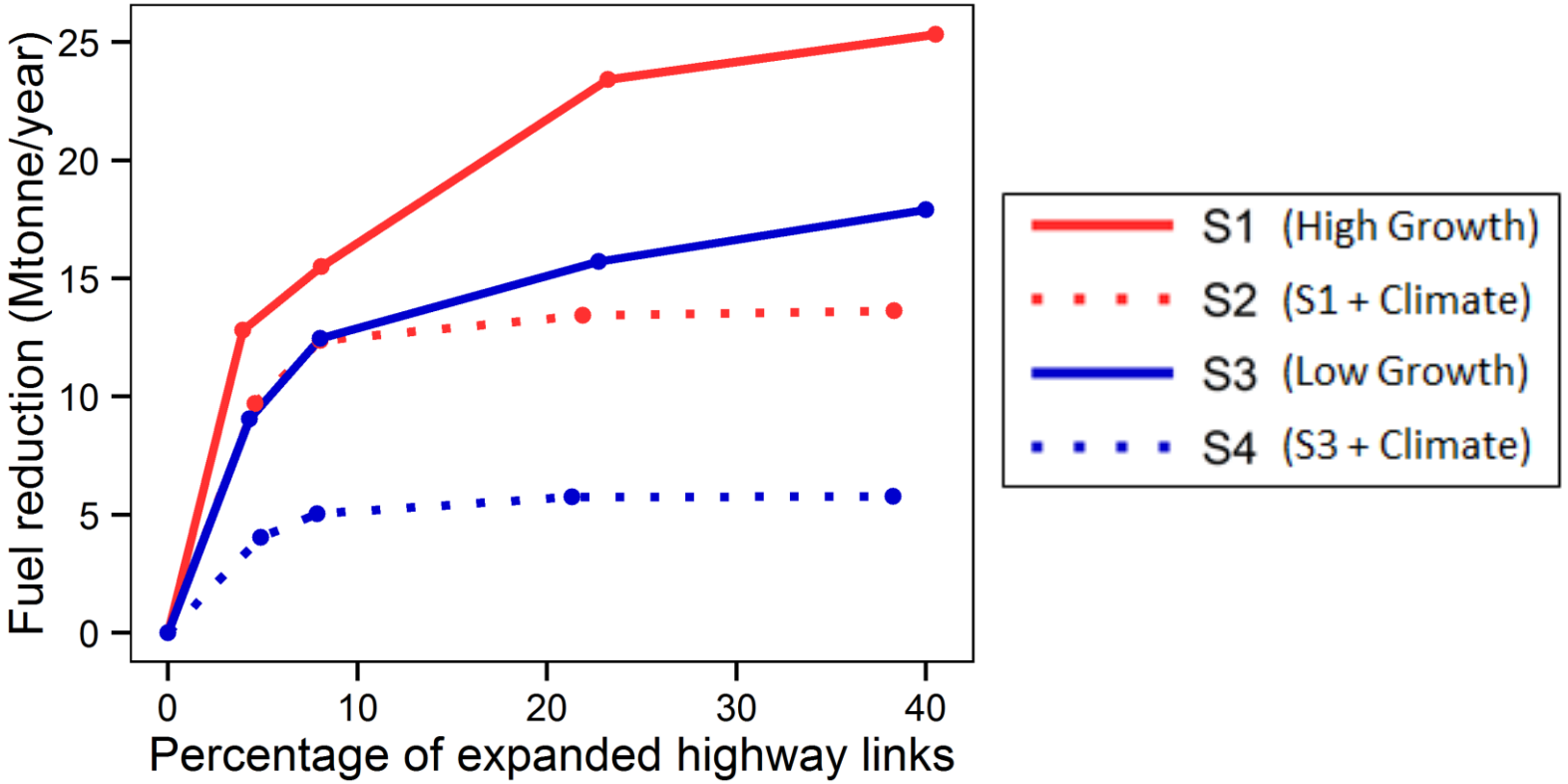
Freight network assignment under congestion

- **Assumption**: each motorist knows all network information and chooses the route with shortest travel time.



- Congestion -> Low speed -> Low fuel efficiency -> More emissions

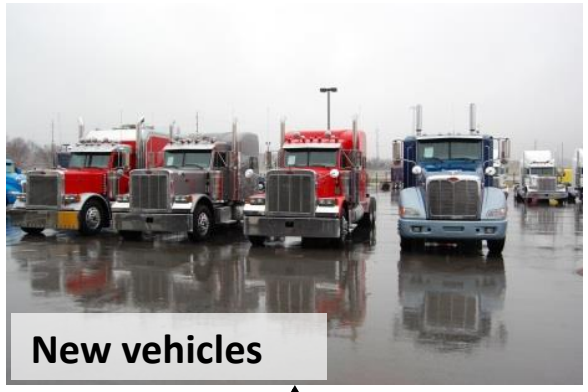
Highway expansion helps ease congestion and reduce fuel consumption



- The incremental fuel reduction diminishes as more links are expanded.
- A higher baseline level of congestion benefits more

SPEWTrend vehicle fleet model

SPEWTrend: a dynamic vehicle fleet model that captures the technology change



Regular degradation

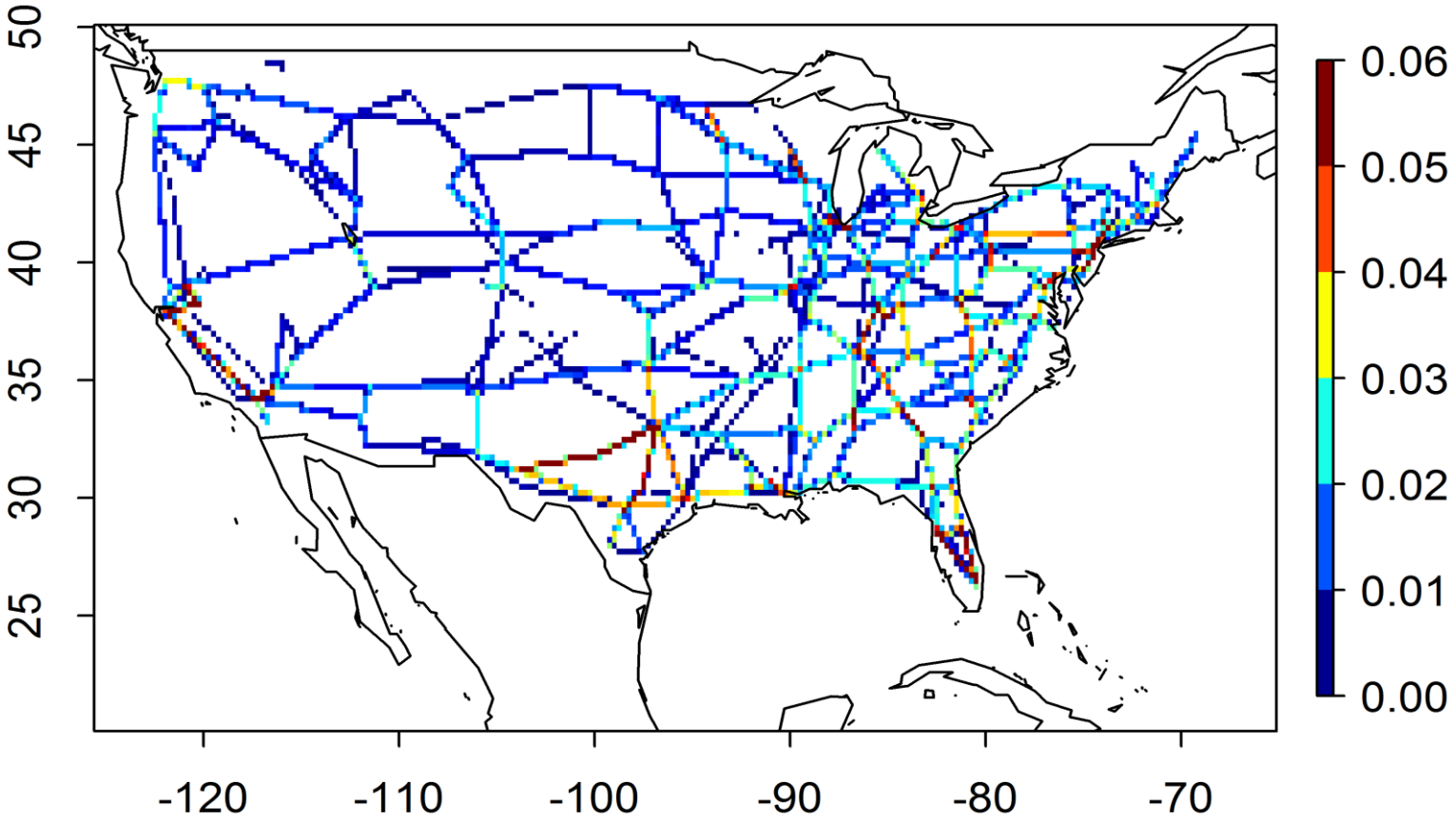
Retire

Current emission standard

Technology 'slip'

Retire

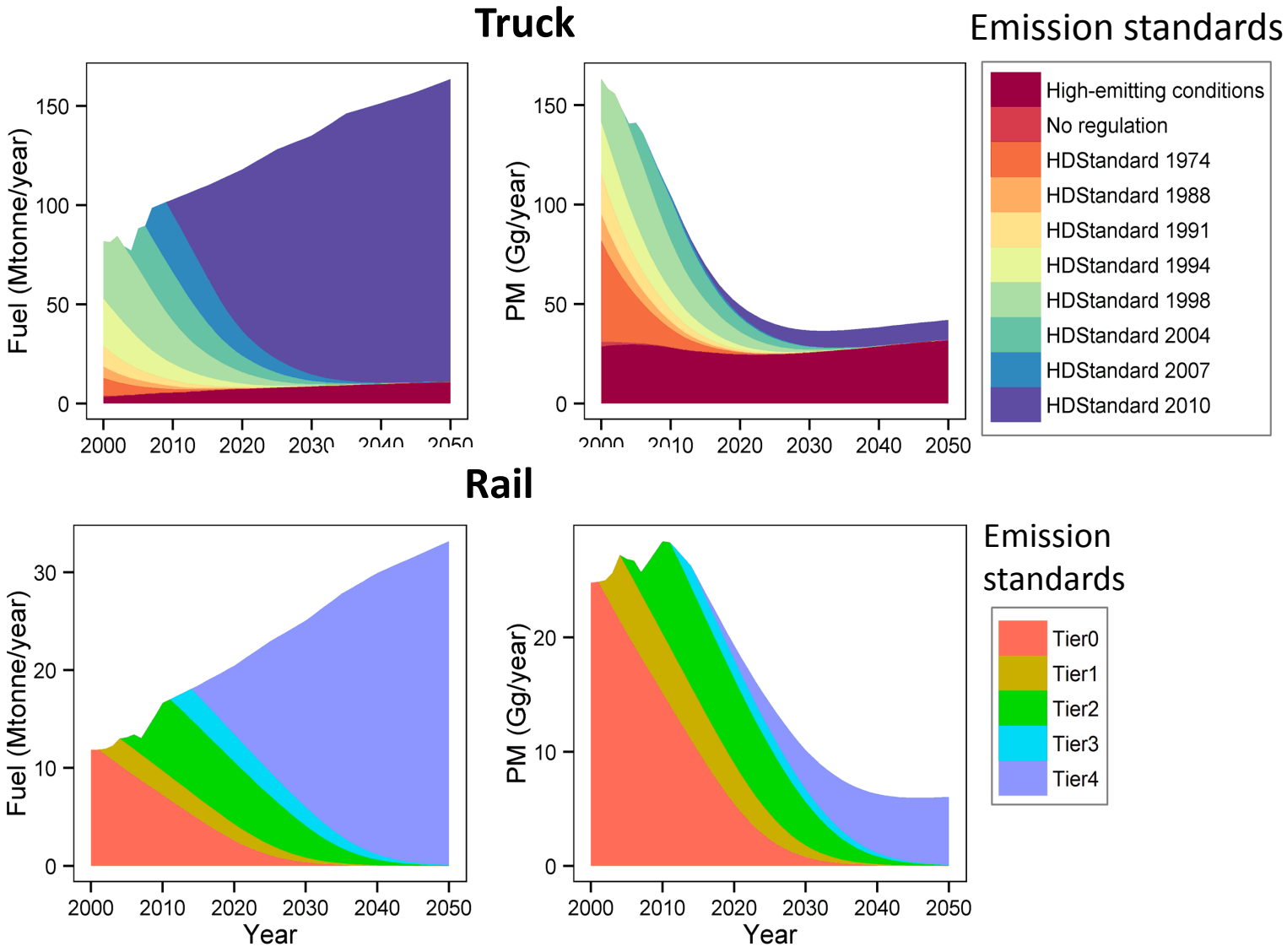
Spatial distribution of PM emission by freight flows in 2050 (S1 scenario).



Unit: Gg/year/cell, 0.25 × 0.25 degree

Emission distribution by freight flows provides more accurate information on exposure risks.

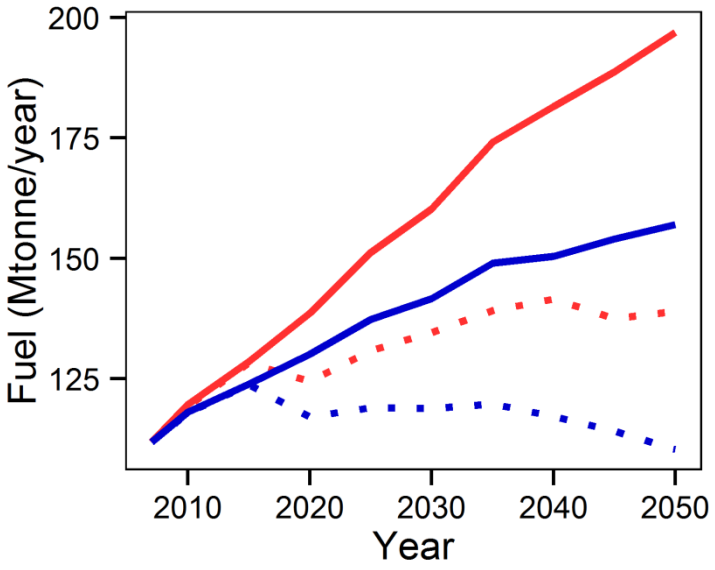
PM emission trend by technology group



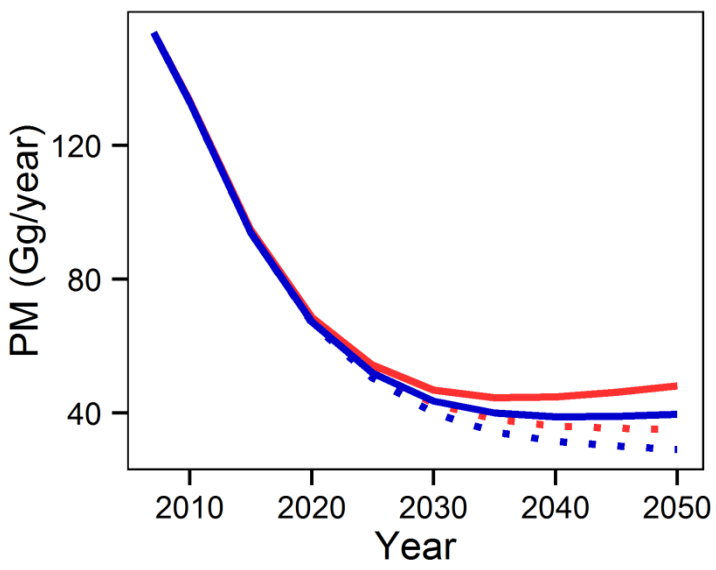
- Most vehicles built under less stringent standards are removed by 2030.
- High-emitting conditions become increasingly important, affecting emission by up to 65% in 2050.

U.S. inter-regional freight fuel use and emission projections

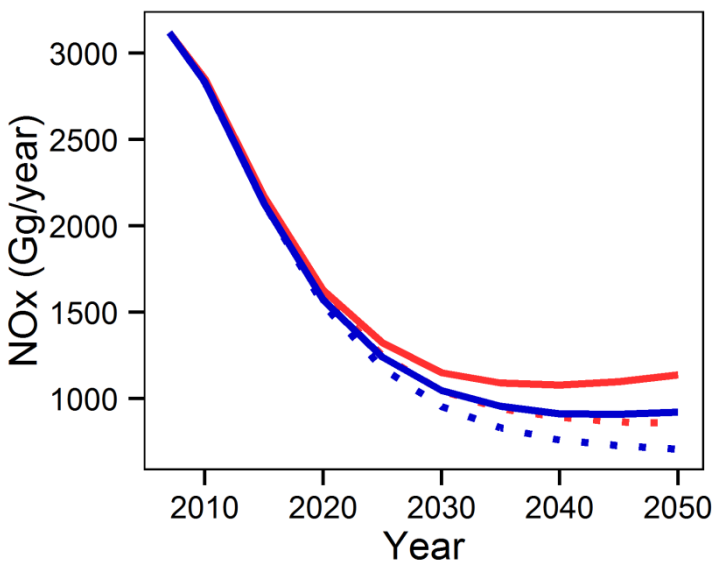
Fuel use

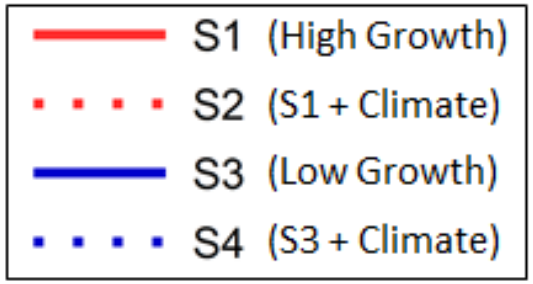


PM emission

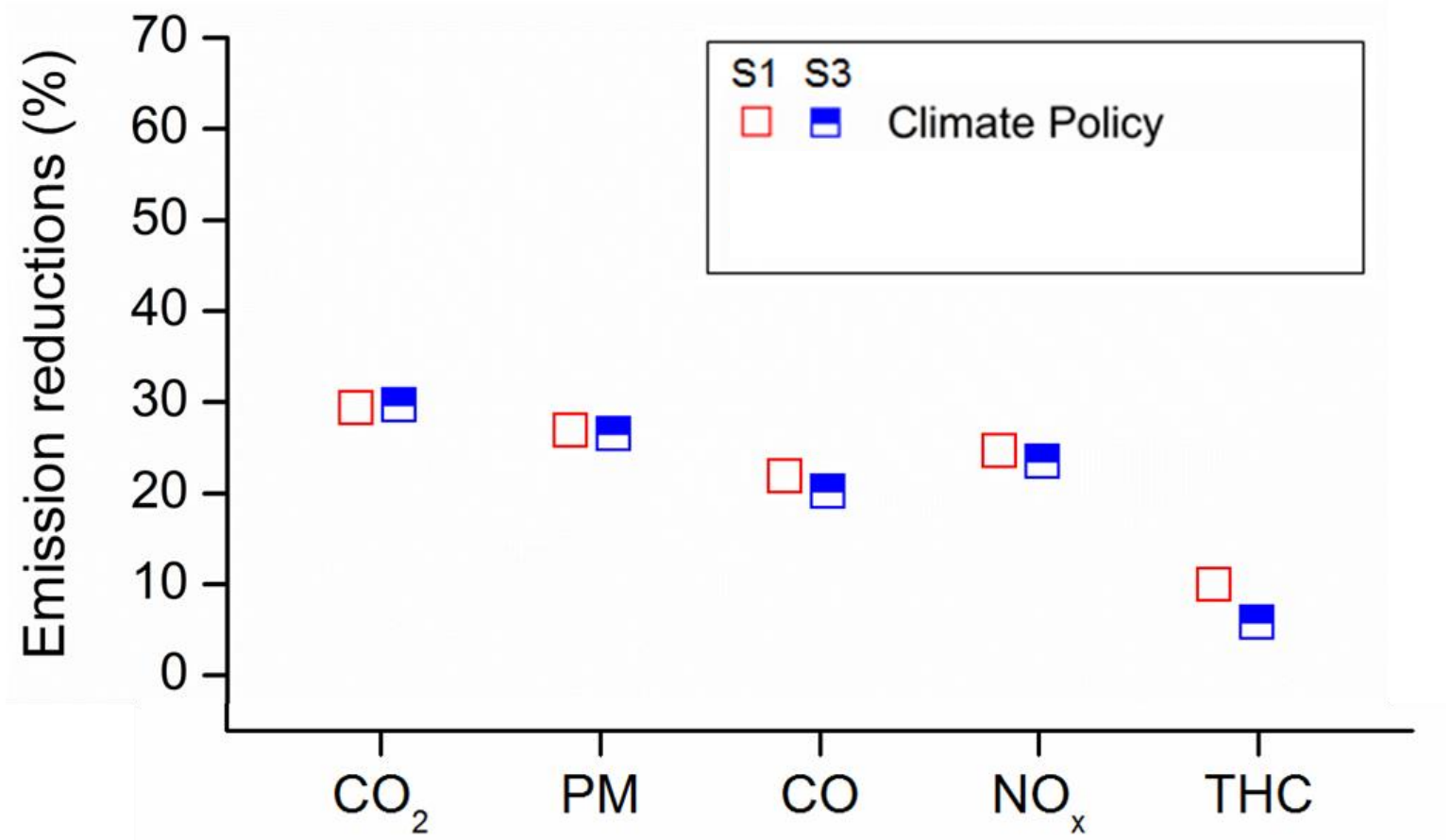


NO_x emission



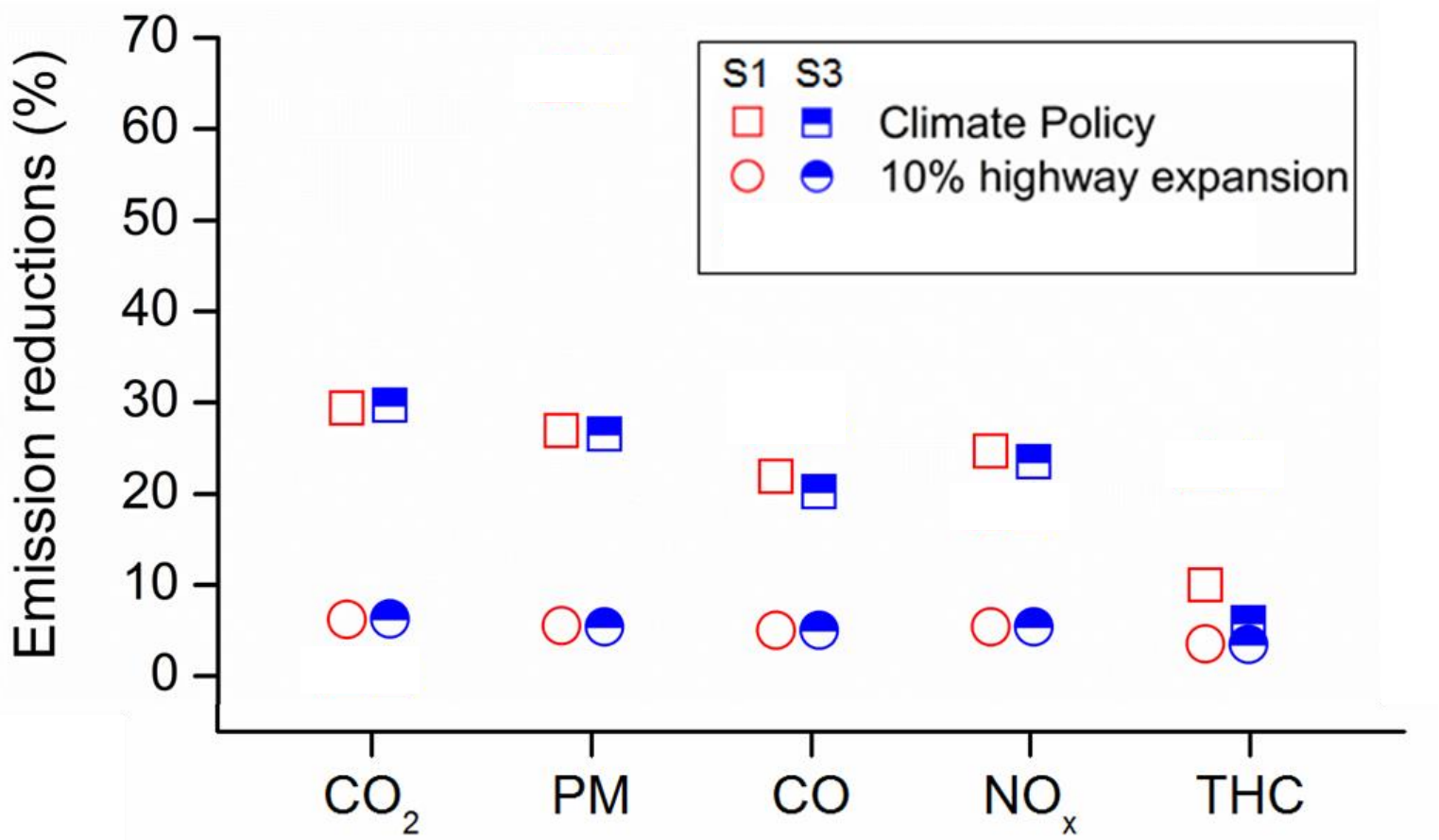


Emission reductions from baseline by different mitigation policies in 2050



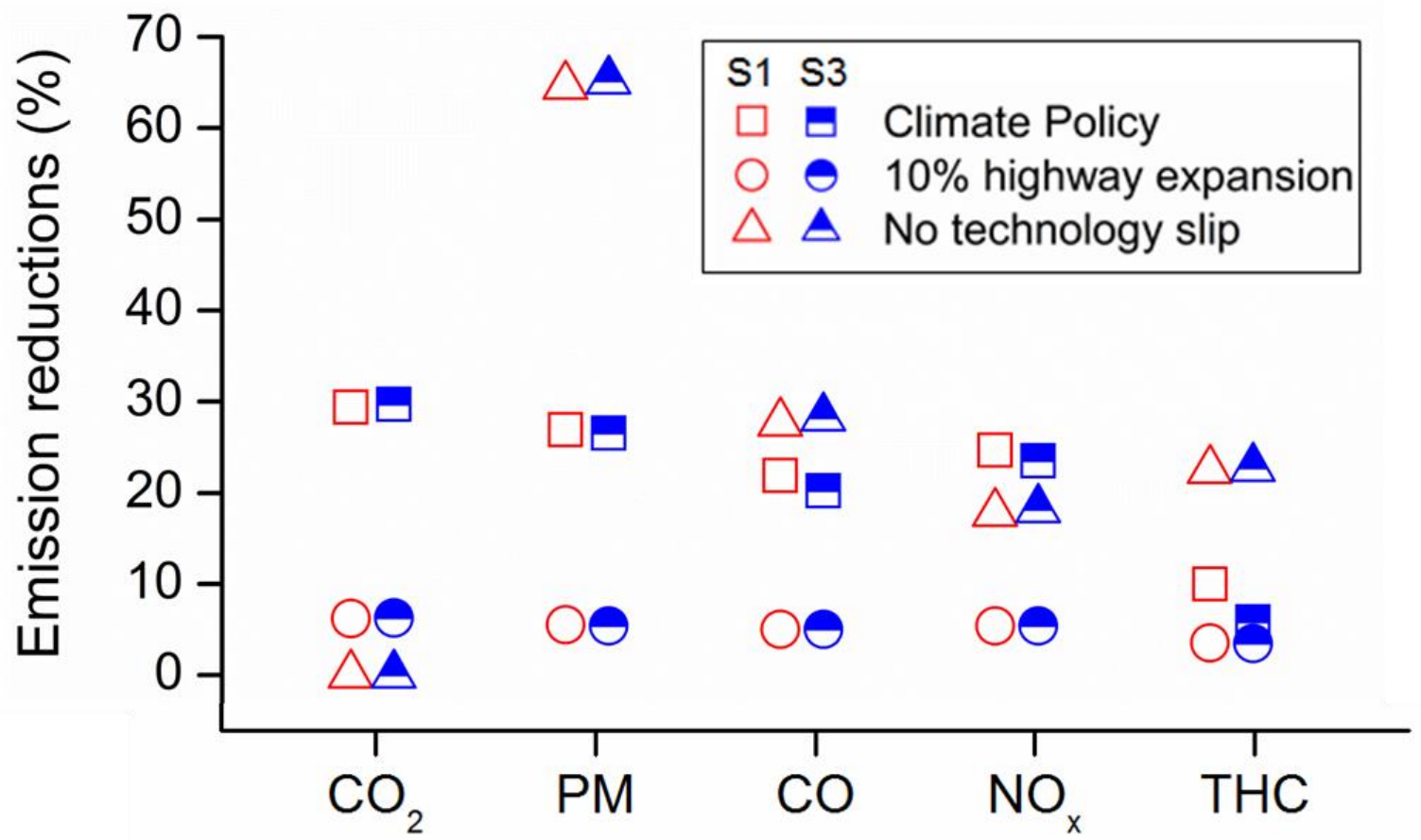
- S1 and S3 scenario as high and low GDP growth **baselines**.
- Climate policy in S2 and S4:
  - Robust to changes of GDP growth rates
  - 30% reduction in CO_2
  - 10%-28% reduction in pollutants

Emission reductions from baseline by different mitigation policies in 2050



- S1 and S3 scenario as high and low GDP growth **baselines**.
- 10% highway expansion:
  - ~10% emission reduction

Emission reductions from baseline by different mitigation policies in 2050



- S1 and S3 scenario as high and low GDP growth **baselines**.
- Eliminating technology slip
  - No CO_2 reduction
  - 65% PM reduction, 20%-30% reduction of other pollutants

Conclusions

- First step in long-term development of linked models to illustrate freight emission evolution
- Climate policy causes modal shift from truck to rail, resulting in emission reduction ~30%
- Maintain durability and control technology slip in the truck fleet reduces emission by 20% -65%
- Infrastructure investment help alleviate congestion; emission benefits are greater under high-growth scenarios.

Thank you!

Questions & Comments?

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