**Representing shipping and transport networks in global energy models**

**Outline**

Introduction

* Global energy models generally lack spatial granularity needed to understand trade relations
  + But trade underpins national energy systems
* Important to understand where energy comes from for energy security reasons

Data

* BACI trade data
  + Conversion to physical energy flows (TJ) using IEA NCV data
* IEA World Energy Balances
  + For data validation
* Variables that can impact trade
  + Gravity variables
  + War and conflict
  + Trade sanction
  + Distance
  + Tariffs (World Bank)

Methods

* Short introduction to MESSAGE
  + 14 regions
  + Energy exports treated as global pool
  + Main idea is to adjust variable costs to reflect additional friction in trade
* Converting global schema to bilateral schema in MESSAGE
  + Each region can (theoretically) trade with any other region
    - Land-locked regions can only trade with adjacent regions (the cost is prohibitive)
  + Focus on crude oil, fuel oil, light oil, coal, LNG shipped via sea routes
* Calculating sea distance (regardless of its impact on trade cost)
* Estimating causal effect of variables on “trade cost”
  + Use LASSO for variable selection
  + Run OLS regression to assign coefficient values
* Representing shipping capacity in MESSAGE
  + Separate shipping technologies into 3 types (liquid, solid, LNG), fueled by 3 resources (diesel, LNG, electricity)
  + Only allow shipping of energy commodities if it requires less than the global shipping capacity
  + Allows us to add the cost of shipping investment, technological transitions, and shipping emissions
  + Shipping demand (fixed) are adjusted to only include demand from non-energy trade
* Building scenarios
  + High-conflict scenario
  + Low-conflict scenario
  + Carbon tax scenario

Results

* The effect of trade variables on the variable cost parameter
  + This is input to MESSAGE
* Understanding bilateral trade in MESSAGE
  + Show baseline exports/imports under global schema
  + Show exports/imports under bilateral schema
* The impact of representing maritime shipping in MESSAGE for energy commodities
  + System cost goes up?
  + Shipping technology investments (new capacity)
  + Transition of shipping industry from diesel to LNG
* Scenario results
  + High-tariff scenario
  + Low-tariff scenario
  + NAM-CPA sanction scenario
  + Shipping technology advancement scenario

Discussion  
Conclusion

Appendix

* IEA-BACI data validation figures
* Table of shipping technology assumptions
* Table of total systems costs, by scenario and schema