Market Entry and Plant Location in Multi-Product Firms

Juanma Castro–Vincenzi (University of Chicago)
Eugenia Menaguale (Princeton University)
Eduardo Morales (Princeton University)
Alejandro Sabal (Yale University)

New Thinking in Industrial Policy:
Perspectives from Developed and Developing Countries.

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Motivation

- Multinational firms are often multi-product, with each product manufactured and sold in many (but not all) countries.

- Decisions on where to produce and where to sell a product are often interdependent.

- Production and sales decisions across products may also be interdependent.

- Nontrivial policy implications: product- & country-specific policies (tariffs or subsidies on production/consumption) may induce changes in production & sales decisions for all products in the firm's portfolio.

- Study the global car industry: firms are multi-product, multi-plant, & multi-market, and industry has recently been the target of large policies.

Model in One Slide

- Static model with firms deciding where to produce and sell each model in a portfolio.

- Fixed selling costs: binary choice of whether sell a model in a location.

- Fixed production costs: binary choice of whether to produce a model in a location.

- Demand function creates substitutabilities across a firm's models sold in a location.

- Minimum-cost sourcing: complementarities between a model's production and selling locations & substitutabilities across a model's production locations.

- Monopolistic competition: no strategic interactions between firms.

- "Solve" problem of a firm; example of binary integer programming problem.

- Ongoing work: "solve" industry equilibrium (joint with Castro-Vincenzi, Liu, and Sabal), and "solve" dynamic firm problem (with same set of coauthors).

Methodological Contribution

- Binary integer programming problems (BIPPs) are NP-complete problems.
- Algorithm to bound solution to BIPPs with complementarities & substitutabilities.
  - Algorithm does not require objective function to be submodular/supermodular or linear.
- Use algorithm & moment inequalities to obtain bounds on model parameters.
  - Avoid potential bias in estimation from heuristic methods that approximate the solution.
- Use algorithm & bounds on model parameters to predict changes in production and sales decisions in response to changes in consumption/production subsidies or tariffs.
- In our application, obtain informative bounds on parameters & model predictions.

Parameter Estimates

Data

- Data on global car industry:
    - Source: IHS Markit (Cosar et al. 2018, Head and Mayer 2019, Alcott et al., 2025).
    - Year: 2019.
    - New car registrations: information by model (1,245) on brand-segment (375), production (assembly) country (53) and registration country (77).
    - Model price, quantity sold, and characteristics for Australia, Brazil, China, Spain, France, Germany, UK, India, Italy, Japan, Mexico, and the US.

- Other sources of data:
    - CEPII: geographical distance between countries.
    - MacMap: car tariffs.
    - World Bank: Income per capita and population per country.

Demand Estimation: Cannibalization

Substantial reduction in sales due to cannibalization (60% on average).
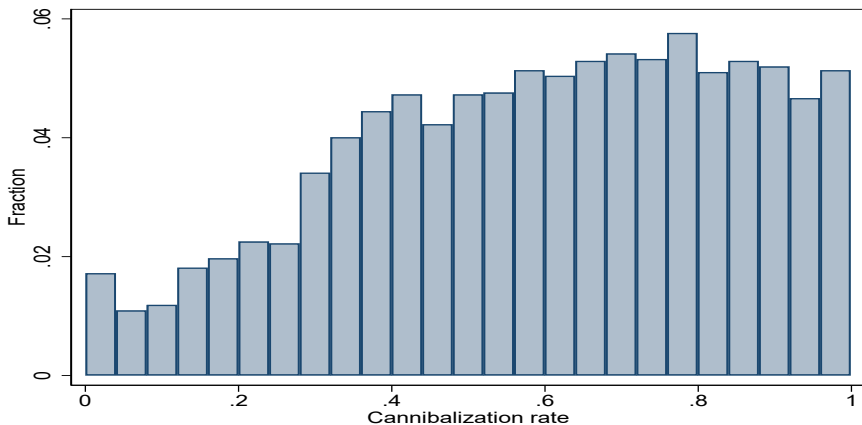
Demand Estimation: Home-bias and Gravity

Substantial home-bias and gravity in preferences for brands.
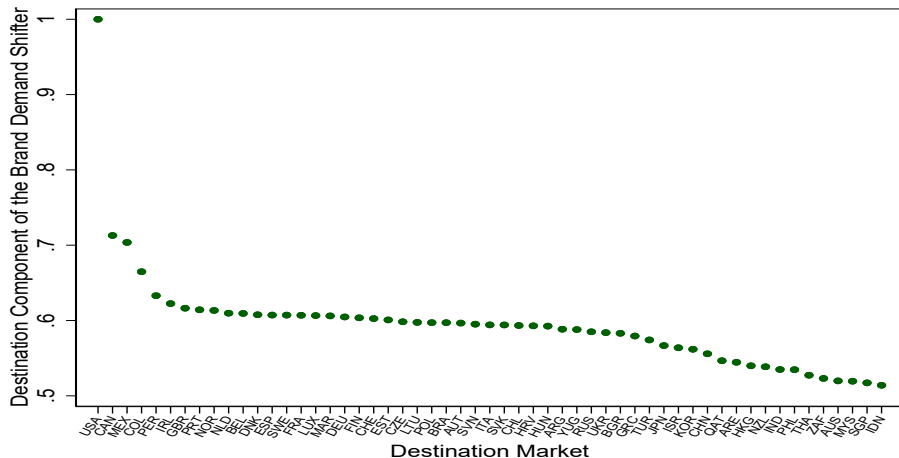
Estimation of Production Costs: Origin

Heterogeneity in marginal production costs depending on origin country.
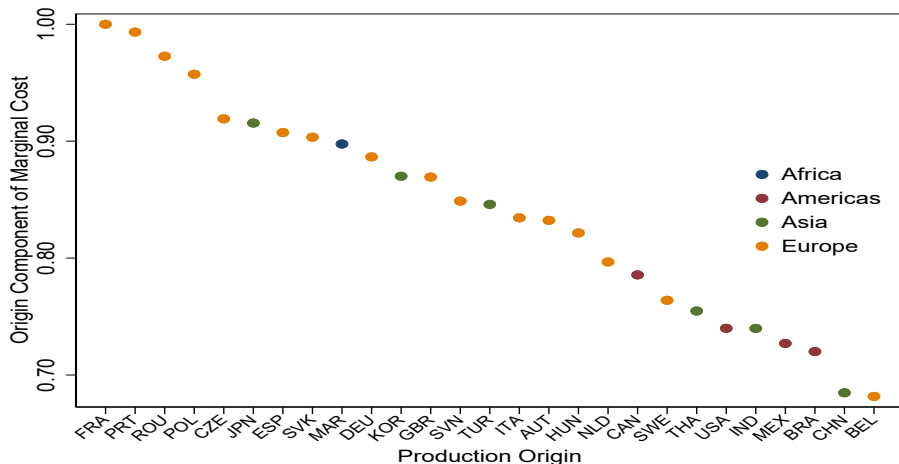
Estimation of Selling Costs from the US

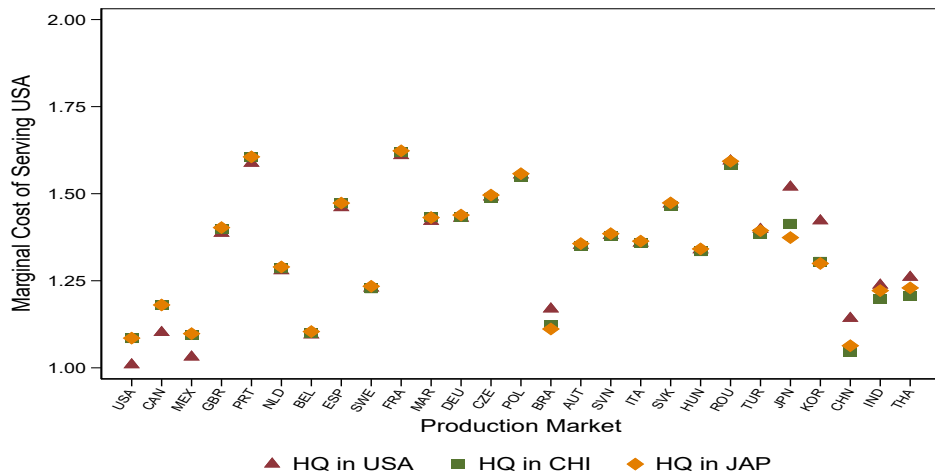*Heterogeneity in marginal costs of selling for models produced in the US.*
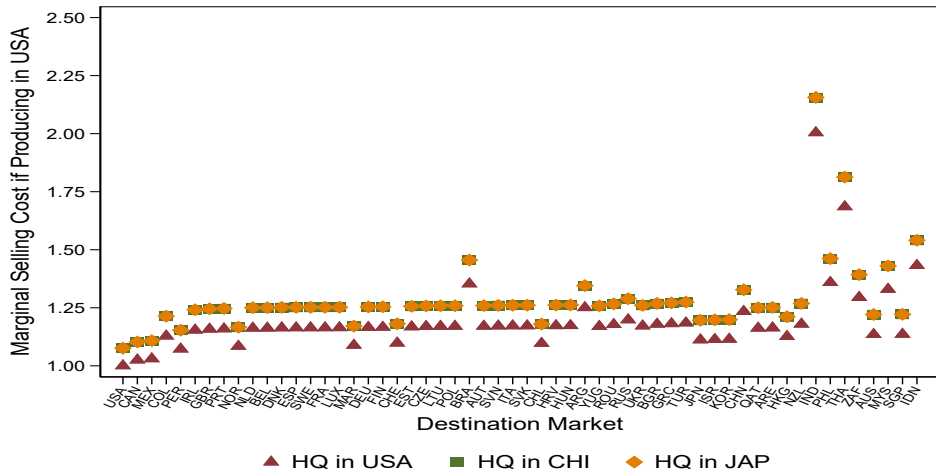
Estimation of Selling Costs from China

Heterogeneity in marginal costs of selling for models produced in China.
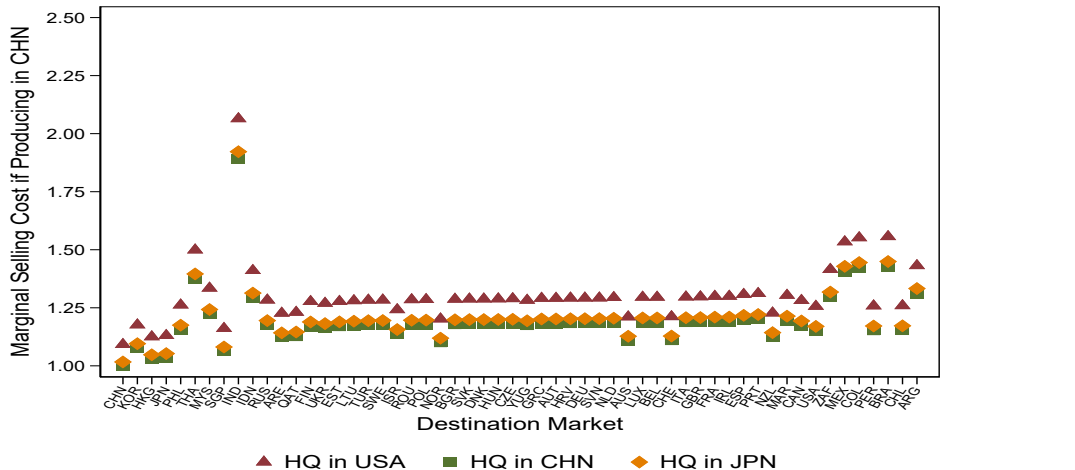
Estimation of Selling Costs to the US

Heterogeneity in marginal costs of selling to the US.

Estimation of Selling Costs to China

Heterogeneity in marginal costs of selling to China.
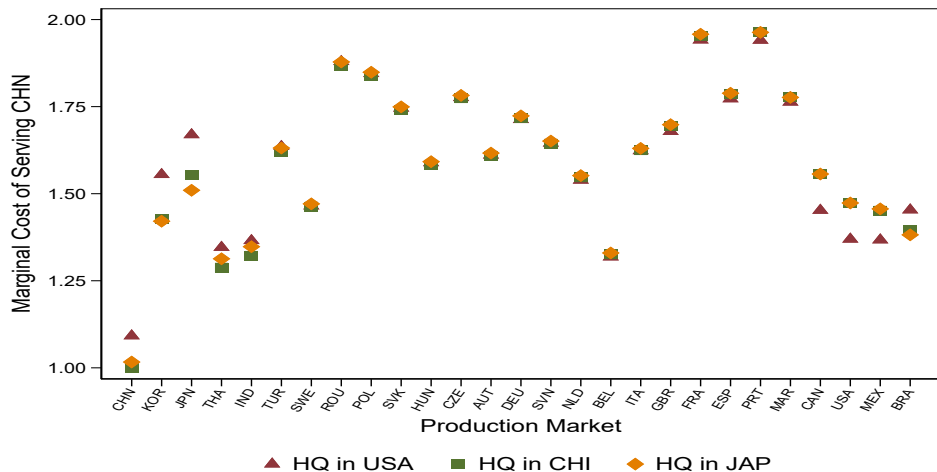
Evaluation of Counterfactual Policies

Evaluation of Policies For a Particular Firm

- Brand & segment: Audi & wagon.

- Two models: Audi A4 and Audi A6.

- Both models are produced only in Germany.

- Both models are sold in the UK and in the EU; only the Audi A4 is sold in the U.S.

- Select draws of producing and selling fixed costs that match baseline choices.

- Evaluate impact of U.S. policies: tariffs and subsidies to consumption or production.

- Confidence interval on counterfactual predictions reflect:
  1. Parameter uncertainty (as reflected in confidence sets); and,
  2. Solution uncertainty.

- For clarity, report here midpoint of confidence interval.

Tariffs on Audi A4 - Sold but Not Produced in the U.S.

U.S. tariffs are (quite) ineffective at inducing production relocation to the U.S.
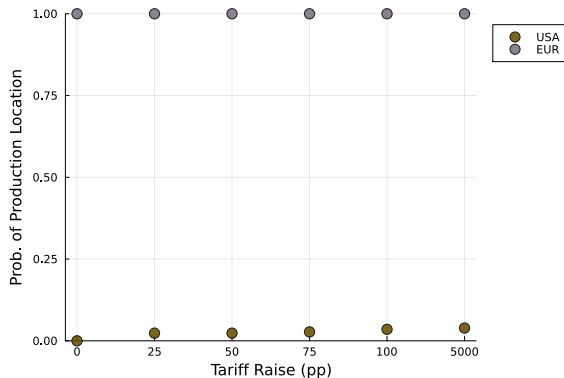
U.S. Tariffs on the ROW
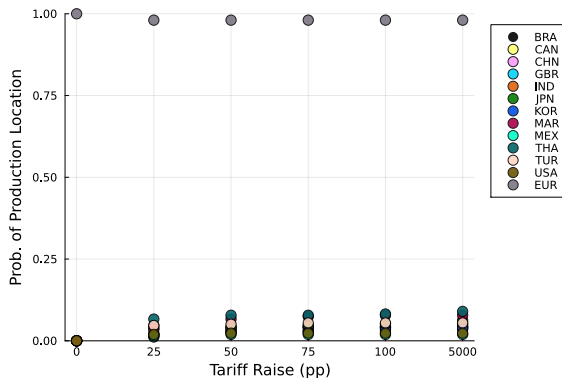
U.S. Tariffs on the EU

Tariffs on Audi A4 - Sold but Not Produced in the U.S.

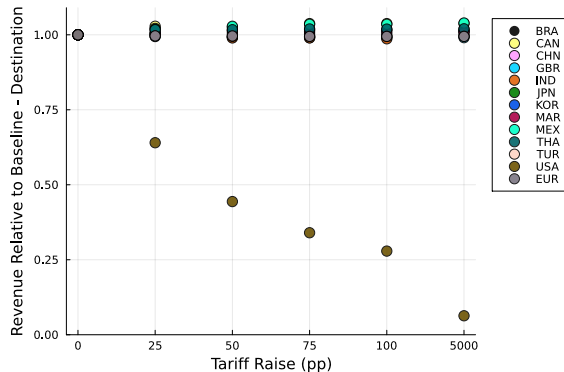*U.S. tariffs (particularly on the ROW) limit product entry into the U.S.*
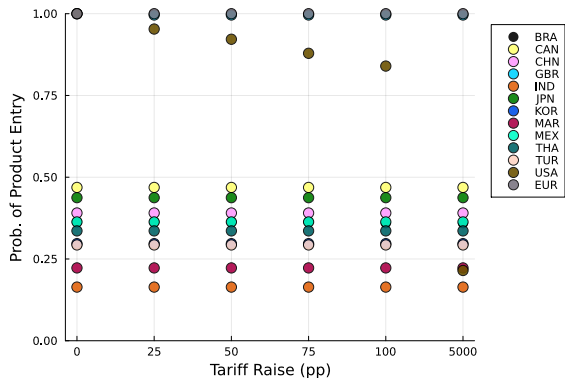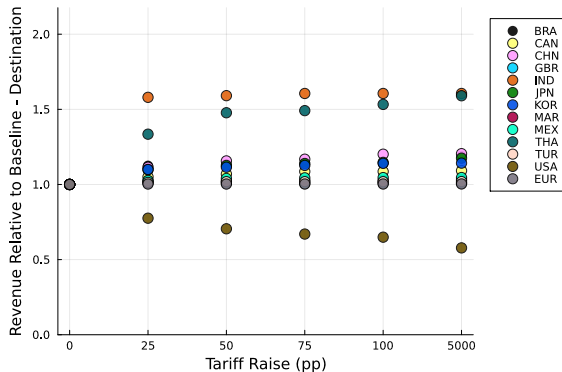

U.S. Tariffs on the ROW
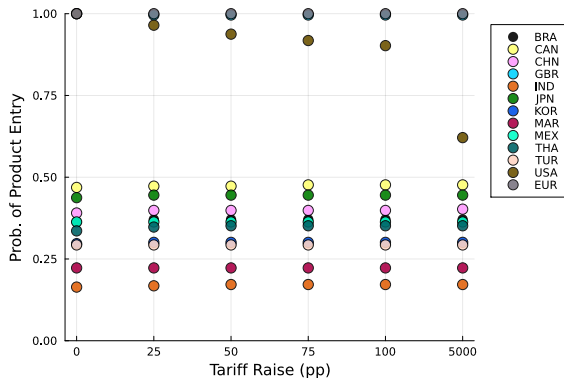
U.S. Tariffs on the EU

Tariffs on Audi A4 - Sold but Not Produced in the U.S.

U.S. tariffs (particularly on the EU) shift firm sales toward other destinations.

U.S. Tariffs on the ROW

U.S. Tariffs on the EU

Production Subsidy on Audi A6 - Neither Sold Nor Produced in U.S.

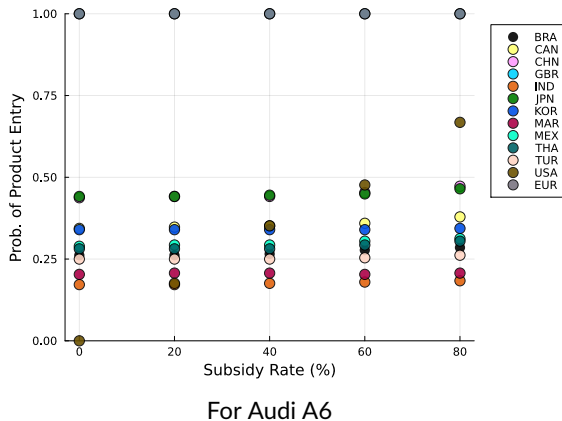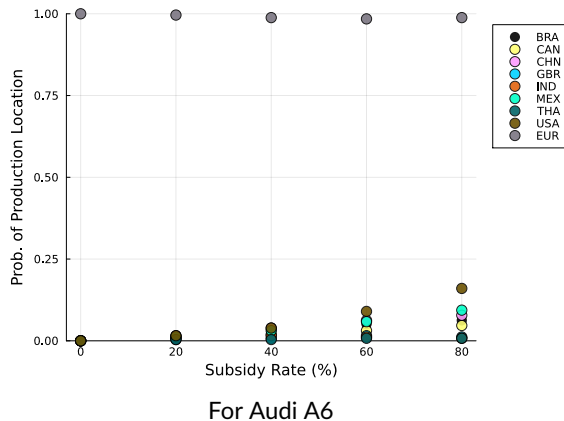*Production subsidies induce changes in production and sales locations…*
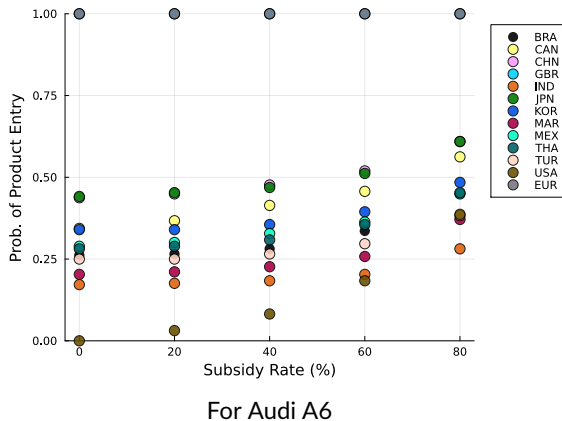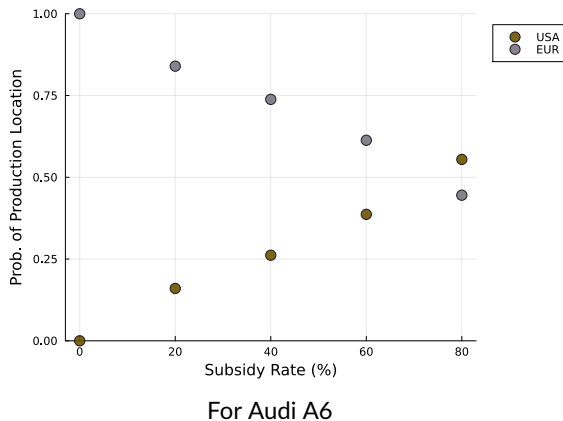
For Audi A6

For Audi A6

Production Subsidy on Audi A6 - Neither Sold Nor Produced in U.S.

*...including for the model not impacted by the subsidy.*
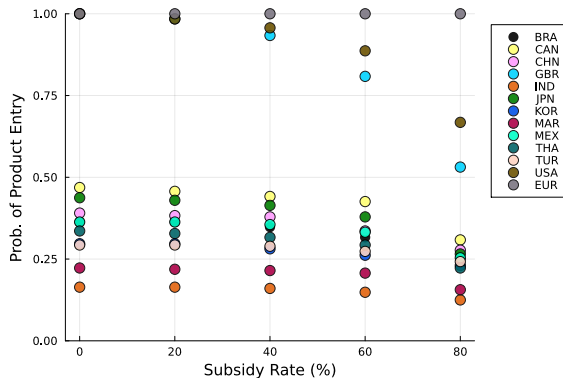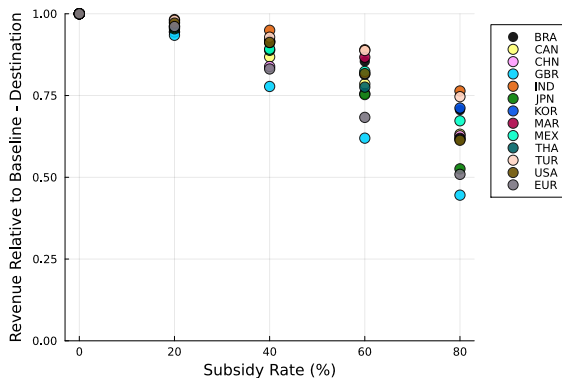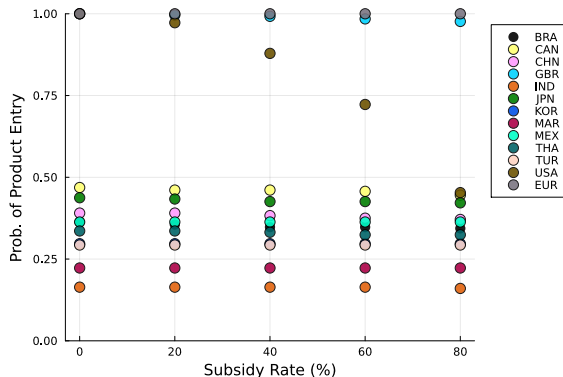

For Audi A4

For Audi A4

Consumption Subsidy on Audi A6 - Neither Sold Nor Produced in U.S.

Consumption subsidies induce changes in production and sales locations…

For Audi A6

For Audi A6

Consumption Subsidy on Audi A6 - Neither Sold Nor Produced in U.S.

*...including for the model not impacted by the subsidy.*

For Audi A4

For Audi A4
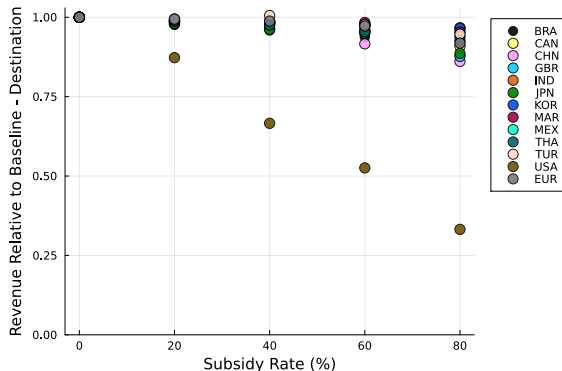
Evaluation of Policies For Average Firm

- Evaluate policies on electric vehicles.

- Report average across all firms with at least one electric model in their portfolio.

- Draws of producing & selling fixed costs do not match baseline choices for each firm.

- Evaluate impact of U.S. policies: tariffs and subsidies to consumption or production.

- Confidence intervals on counterfactual predictions reflect:
    1. Parameter uncertainty (as reflected in confidence sets); and,
    2. Solution uncertainty.

Tariffs on Electric Vehicles

U.S. tariffs are (quite) ineffective at inducing production relocation to the U.S.
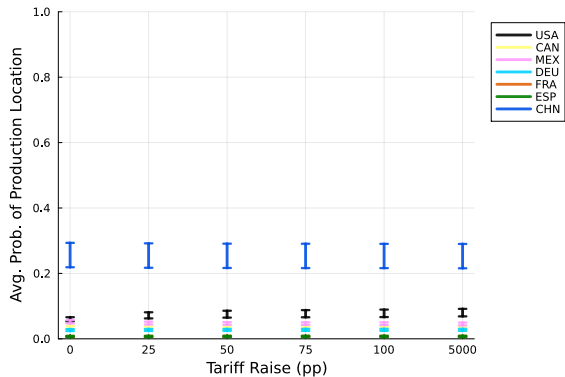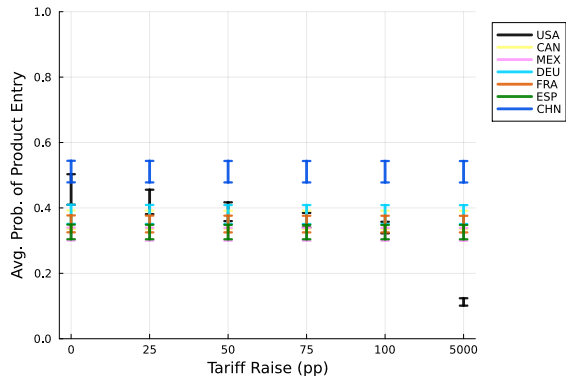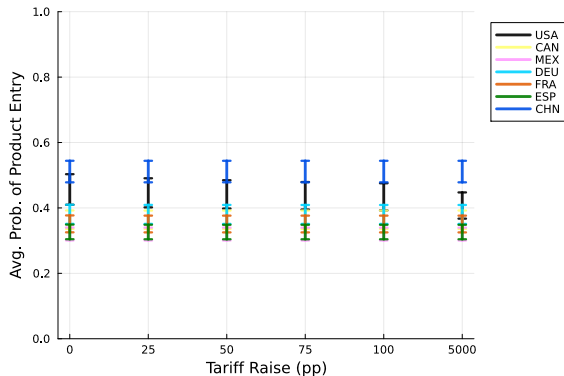

U.S. Tariffs on the ROW
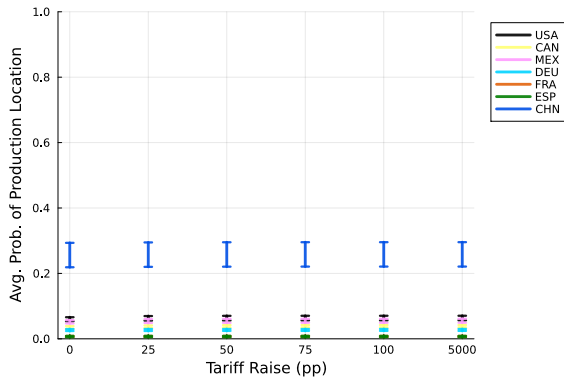
U.S. Tariffs on the EU

Tariffs on Electric Vehicles

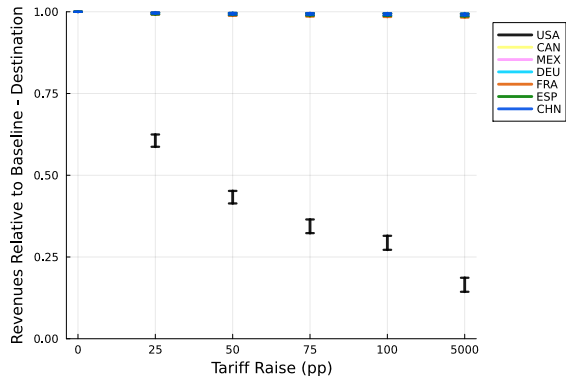*U.S. tariffs (particularly on the ROW) limit product entry into the U.S.*
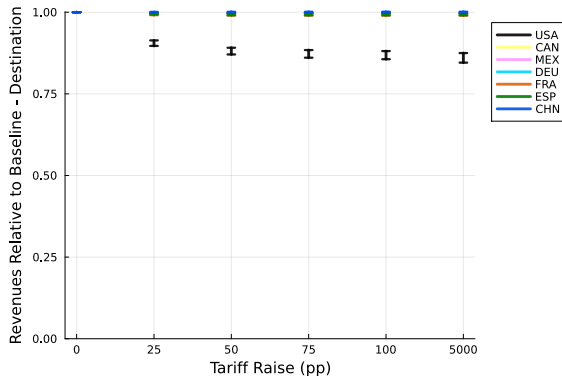

U.S. Tariffs on the ROW

U.S. Tariffs on the EU

Tariffs on Electric Vehicles

U.S. tariffs have minimal impact on sales toward other destinations.
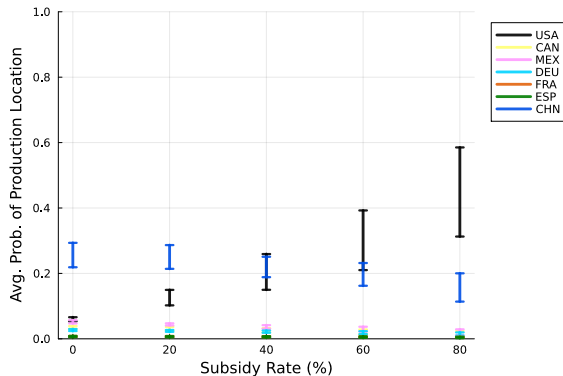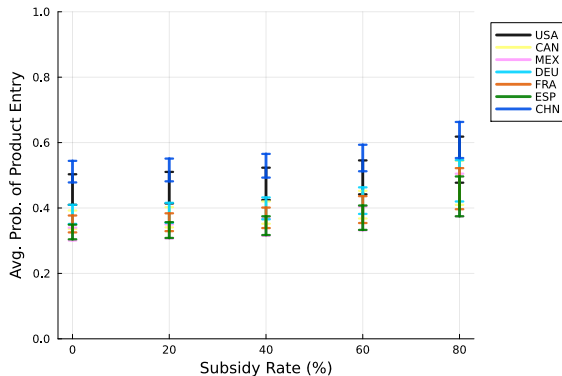

U.S. Tariffs on the ROW

U.S. Tariffs on the EU

Production Subsidies on Electric Vehicles

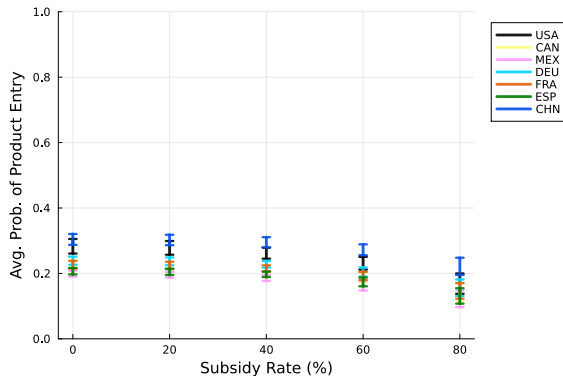*Production subsidies induce changes in production and sales locations…*
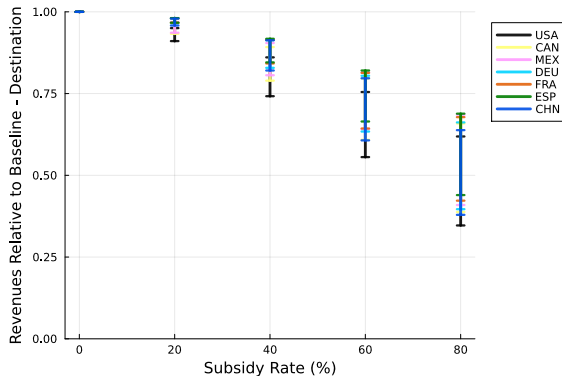

For Electric Vehicles

For Electric Vehicles

Production Subsidies on Electric Vehicles
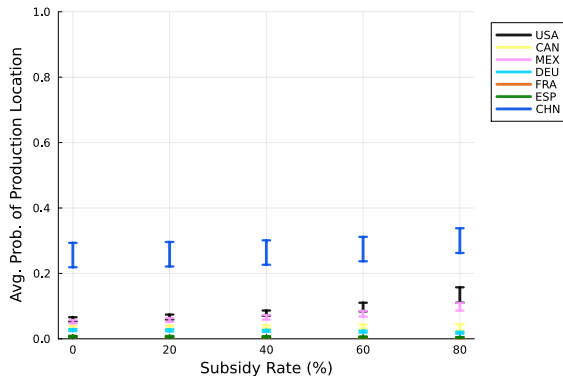
…including for non-electric vehicles.
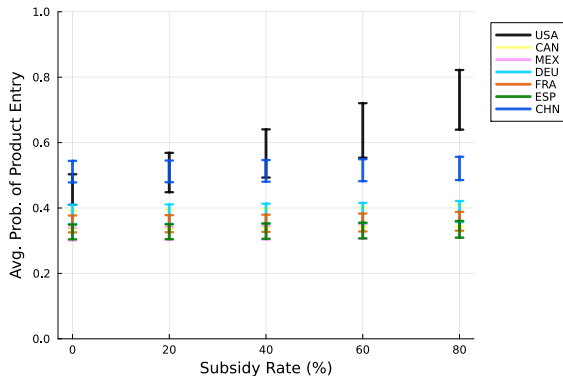

For Non-Electric Vehicles

For Non-Electric Vehicles

Consumption Subsidies on Electric Vehicles

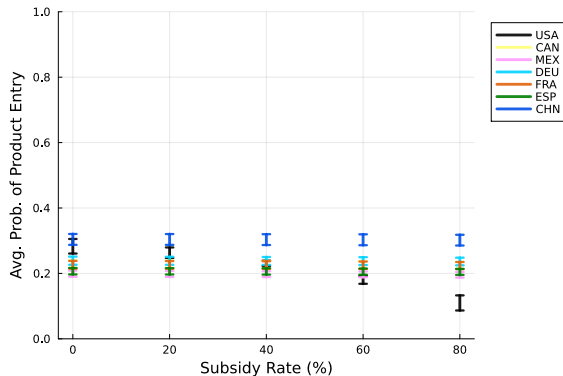*Consumption subsidies induce changes in production and sales locations…*

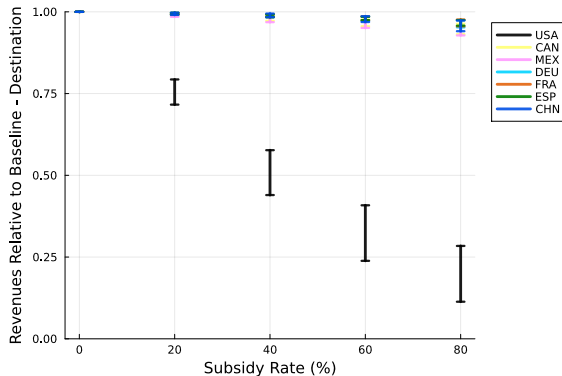For Electric Vehicles

For Electric Vehicles

Consumption Subsidies on Electric Vehicles

…including for non-electric vehicles.

For Non-Electric Vehicles

For Non-Electric Vehicles

Conclusion

- Model of multi-product, multi-plant, and multi-market firms.

- Novel algorithm for BIPPs with pairwise complementarities and substitutabilities.

- Algorithm requires that, for any two coordinates, the sign of the cross-partial is known and independent of third choices.

- Moment inequalities to use algorithm in estimation.

- Tariffs are ineffective at inducing production reallocation to the U.S.

- Consumption subsidies (if large) induce significant production reallocation to the U.S. and neighboring countries. Sales of competing products impacted.

- Production subsidies (if large) induce significant production reallocation to the U.S. Sales in other destinations and sales of competing products impacted.