A Monopolistic Competition Model of Intra-Industry Trade for analysis of Commodity Flows in the United States

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Issue:

Although inflation adjusted energy prices roughly doubled between 2002 and 2007 and remain both high and volatile, food related energy use and food miles remain on the rise. If high energy prices are not affecting these outcomes, what role might food related energy policies play in affecting spatial attributes of the domestic food system, and will they be effective?

Research Application:

A model of intra-industry trade is developed with market structure assumptions that are consistent with observed features of most U.S. commodity markets; regionally differentiated products produced using increasing returns technologies and marketed to consumers that value variety and pay substantial shipping charges to obtained this variety. A wine industry case study illustrates the application of this model framework.

Approach:

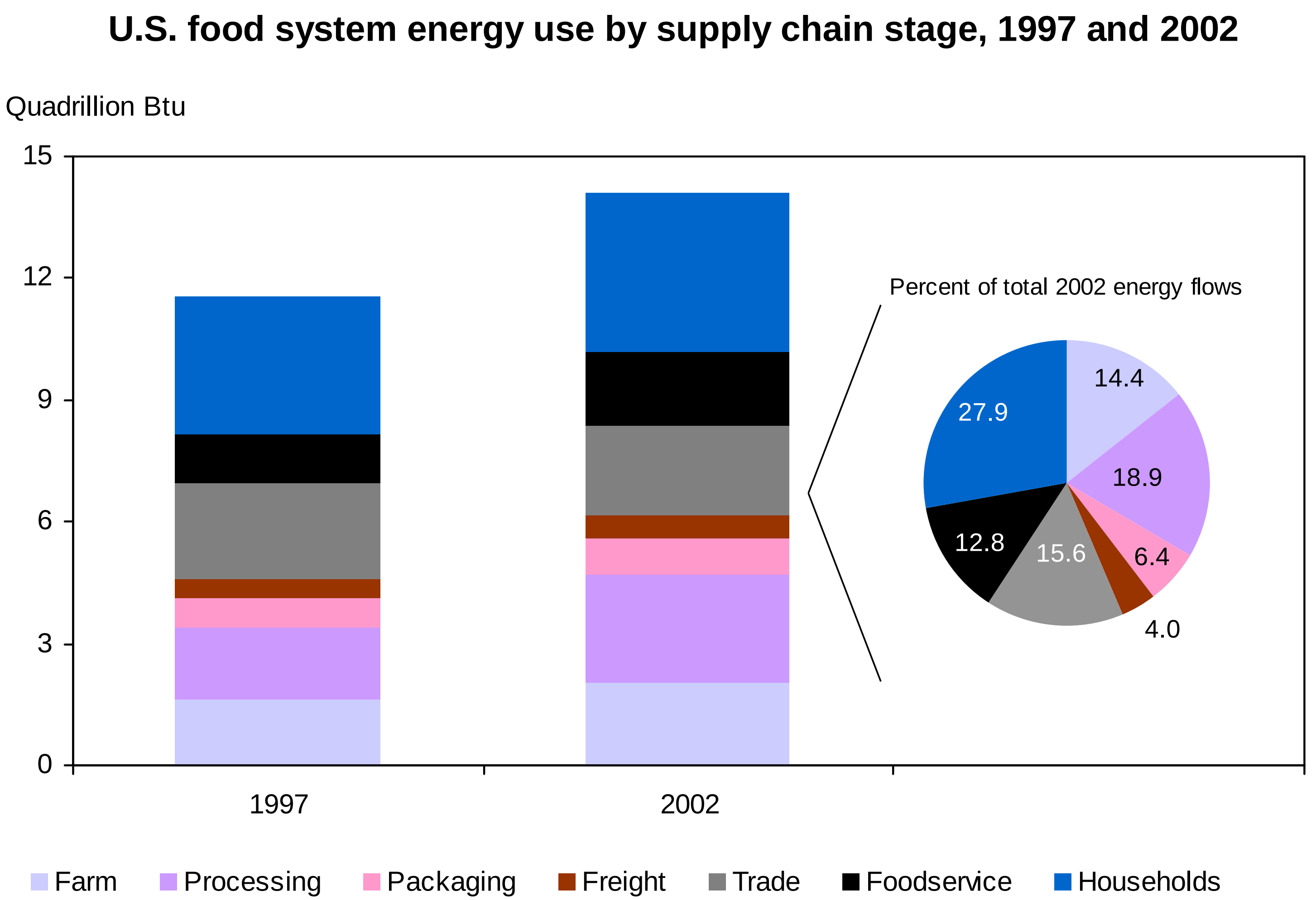
- Objective I—Reconcile an underdetermined national system of regional industry accounts with a theory of spatial equilibrium
    - Allow for ‘only and all’ market information to inform the calibration of unobserved technical and behavioral parameters
    - Use the assumed adherence of data to a specified theory of spatial equilibrium to estimate a fully determined data system
- Objective II—Using the fully determined data system and estimated model parameters, carry out an analysis of new firm location and freight mile elasticity

Background:

Freight industry characteristics			
	1997	2002	2007
Average distance per shipment			
Commodity group:		*(Miles)*	
Fresh produce, oilseeds, and other horticulture	438	481	374
Meat, fish, and preparations	137	162	243
Milled grain products and preparations, and bakery products	122	189	262
Other prepared foodstuffs and fats and oils	127	179	230
Energy use by freight mode			
Freight mode:		*(Btu)*	
Energy use per truck mile	21,340	23,461	23,260
Energy use per freight car rail mile	15,784	15,003	14,990

Sources: USDA, Economic Research Service using data from the U.S. Department of Transportation (www.bts.gov), and U.S. Department of Energy (http://cta.ornl.gov/cta/).

Background (cont.):



Source: USDA, Economic Research Service.

Intra-Industry Trade (IIT) Defined:

Overlapping trade of the same or very similar goods between countries or between sub-national regions

Contributions to the theory of IIT

- Dixit and Stiglitz. 1977. “Monopolistic Competition and Optimum Product Diversity”, *American Economic Review*, Vol. 67 (3)
  - A framework for modeling firm size and product diversity

- Krugman, P. 1991. "Increasing Returns and Economic Geography," *Journal of Political Economy*, vol. 99(3)
  - A theory of spatial equilibrium modeled within the Dixit & Stiglitz framework

A Spatial Equilibrium Model of U.S. Commodity Flows

- Firms are Monopolistic Competitors with increasing returns:

1. $$l_e = \beta_0 + \beta_1 X_e,$$

2. $$p_s = \frac{\sigma}{\sigma - 1} \beta_1 w_s$$

  - l_e total establishment production inputs
  - β_0 total establishment fixed input requirement
  - β_1 establishment variable input requirements per output unit
  - X_e total establishment output
  - p_s producer (fob) price in region s
  - σ regional price elasticity of demand
  - w_s unit rental price of variable production inputs

A Spatial Equilibrium Model of U.S. Commodity Flows (cont.)

- Regional households like variety; are sensitive to price:

3. $$x_{s,r} = [\eta_s \times \alpha_{s,r} \times (M / \bar{P}_r)] \times \left[\frac{p_{s,r}}{\bar{P}_r} \right]^{-\sigma}$$

4. $$\sum_s \eta_s \alpha_{s,r} = 1$$

  - $x_{s,r}$ shipments from region s to household r
  - η_s regional variety indicator (production share)
  - $\alpha_{s,r}$ index of region r preference across regions
  - M_r region r's total expenditures on commodity x
  - $p_{s,r}$ region r price for region s commodity inclusive of freight
  - $\bar{P}_r = \sum_{s \in S} \eta_s \times \alpha_{s,r} \times p_{s,r}$

A Spatial Equilibrium Model of U.S. Commodity Flows (cont.)

- Transportation costs and market clearing:

5) $$p_{s,r} = \rho_S(1+\gamma h_{s,r}),$$

6) $$X_s = \sum_{e \in s} X_e = \sum_r x_{s,r}$$

7) $$M_r = \sum_s p_{s,r} x_{s,r}$$

8) $$\sum_s \sum_r (p_{s,r} - \rho_s) x_{s,r} = T$$

A Spatial Equilibrium Model of U.S. Commodity Flows (cont.)

- Additional constraints and objective function:

9) additional eqality and/or inequality constraints using 'only and all' information

10) $$\underset{\gamma}{Min}\sum_{s}\left(\eta_s[\rho_s(\gamma)-1]^2\right)+\sum_{s}\sum_{r}\left(\eta_s[\alpha_{s,r}(\gamma)-1]^2\right)$$

A Spatial Equilibrium Model of U.S. Commodity Flows (cont.)

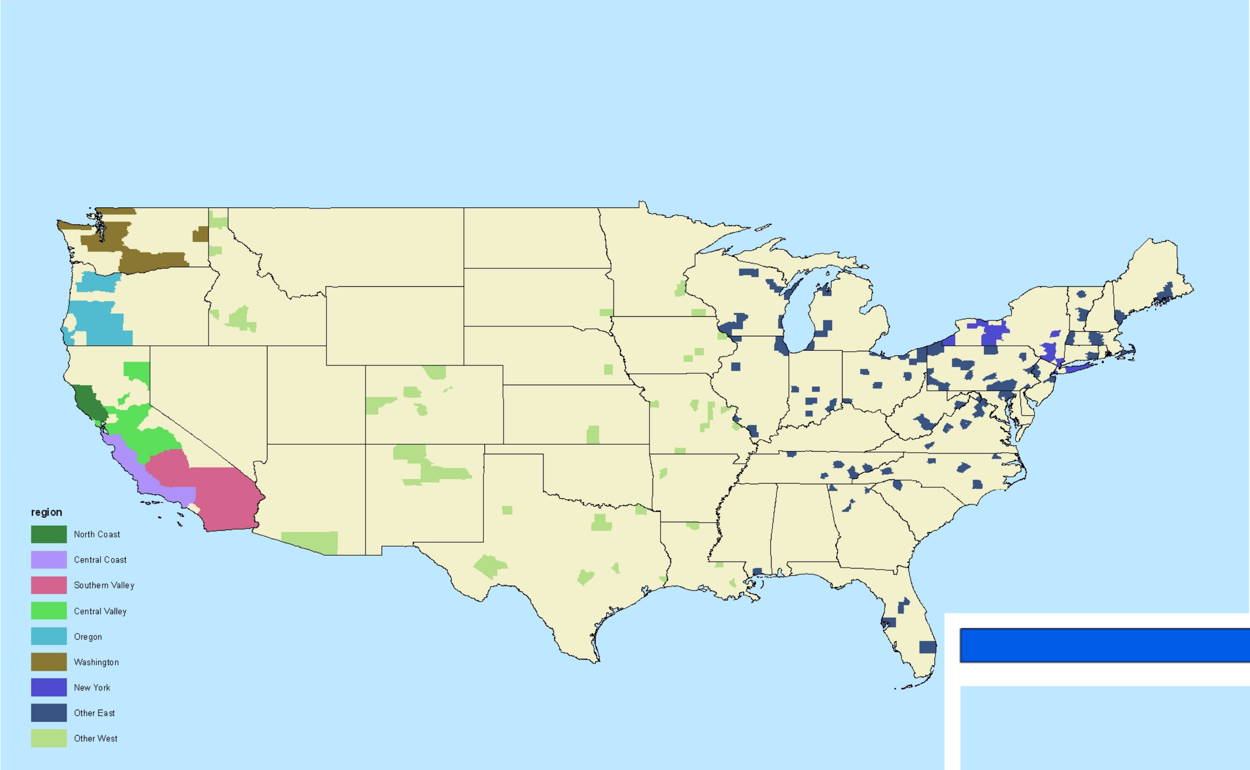
- To solve…
  - Estimate supply parameters (equation 1)
  - Combine supply parameters, median firm size, and assumption of free entry to derive estimate for sigma (price elasticity)
  - Use fob regional market shares as estimate for regional product variety (η_s)
  - Minimize equation 10 subject to equations 3 to 9

    (GAMS with CONOPT3 nonlinear programming solver)

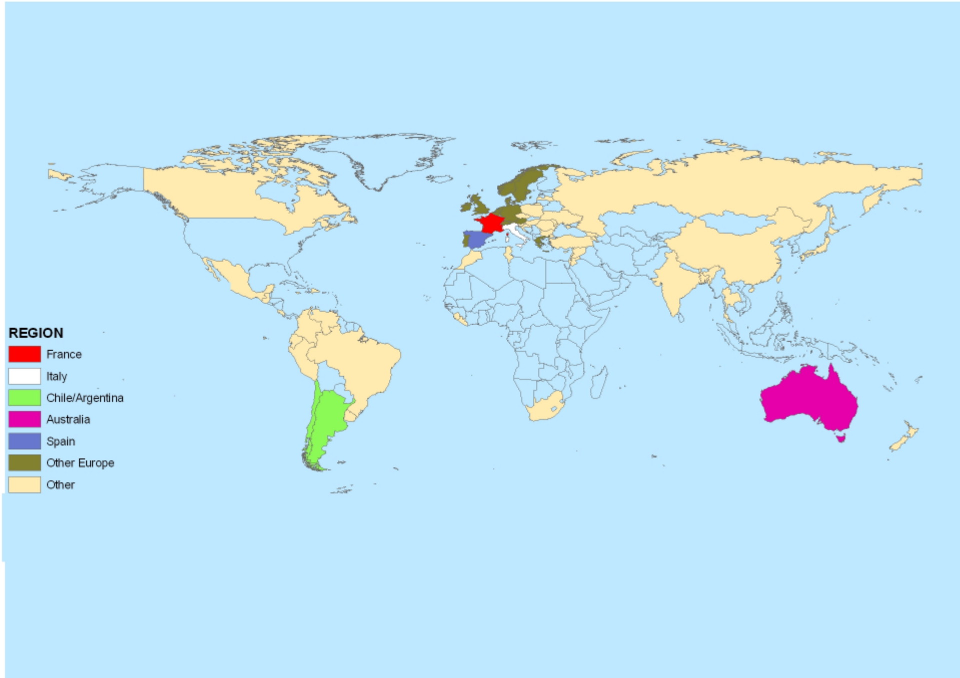
A Wine Industry Case Study

www.wine-economics.org/workingpapers/AAWE_WP22.pdf

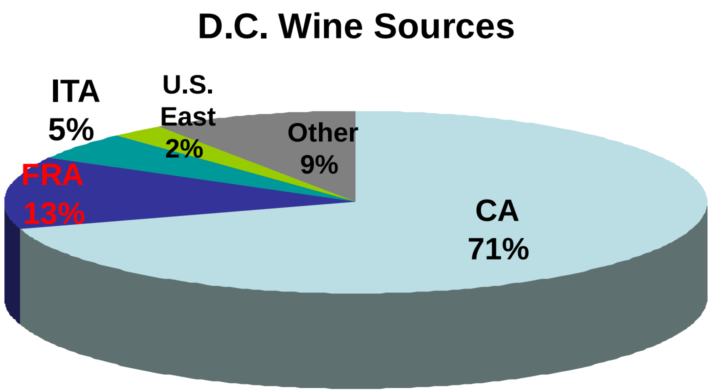
FIGURE 1: U.S. AND WORLD MODEL REGIONS

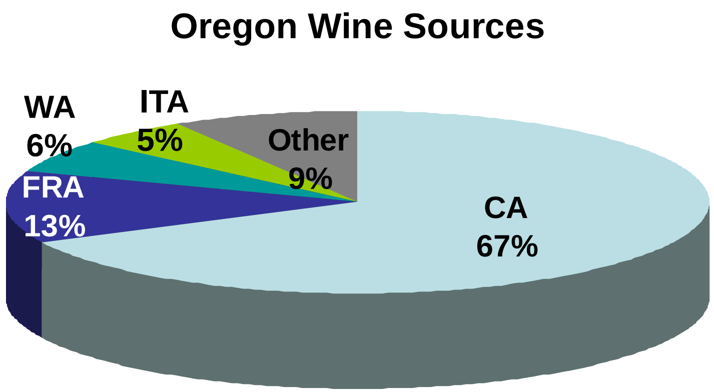


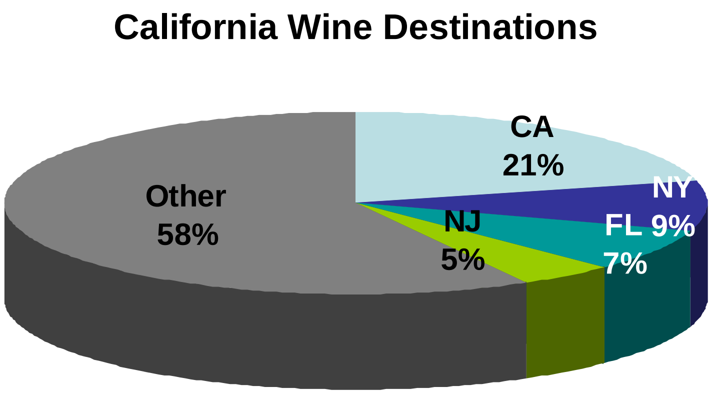
WORLD MODEL REGIONS

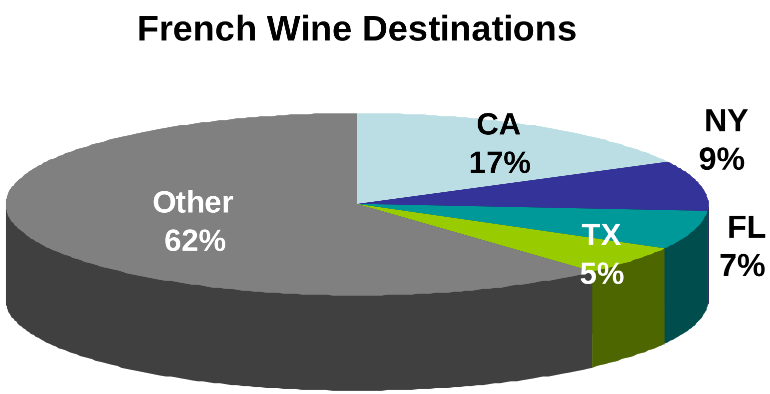


Spatial equilibrium U.S. wine trade: monopolistic competition model



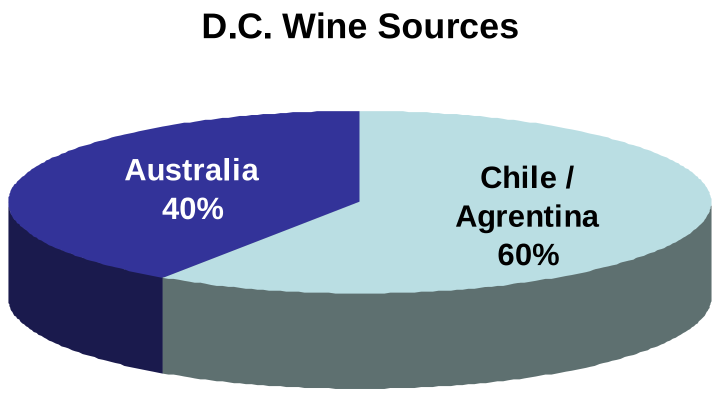


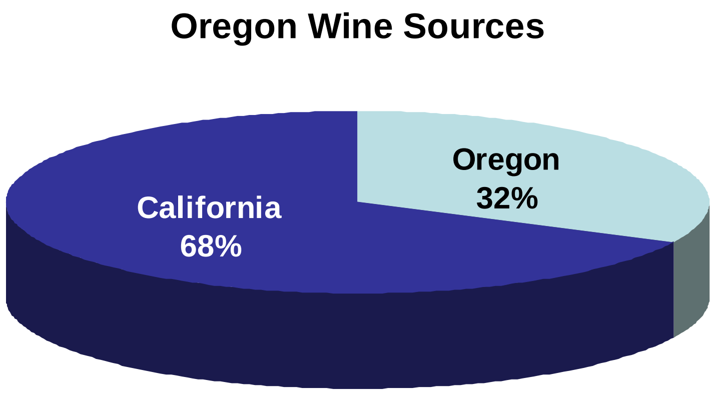


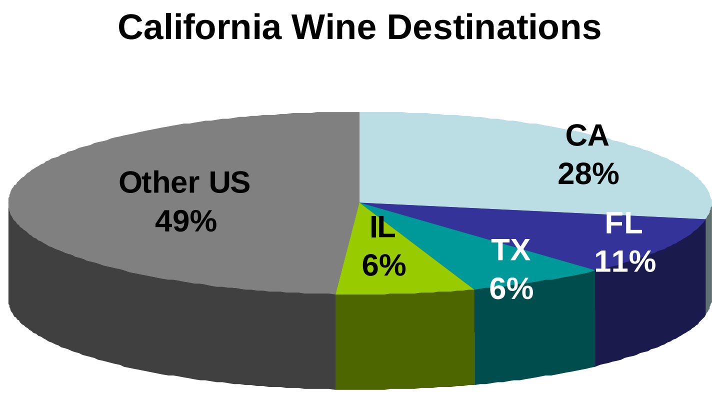


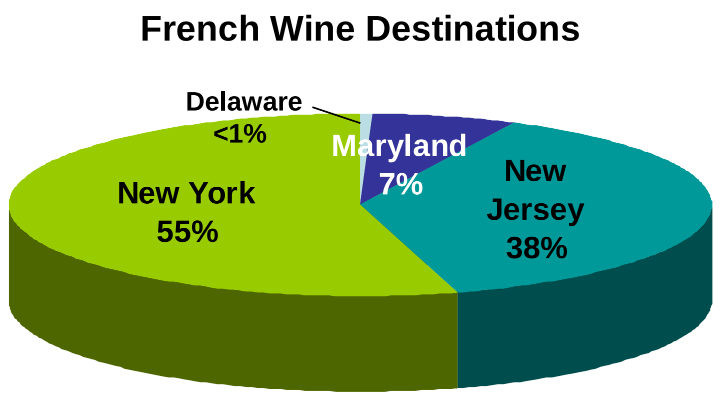
Average distance of wine shipments to U.S. markets: 2,861 miles

Spatial equilibrium U.S. wine trade: competitive (undifferentiated) model









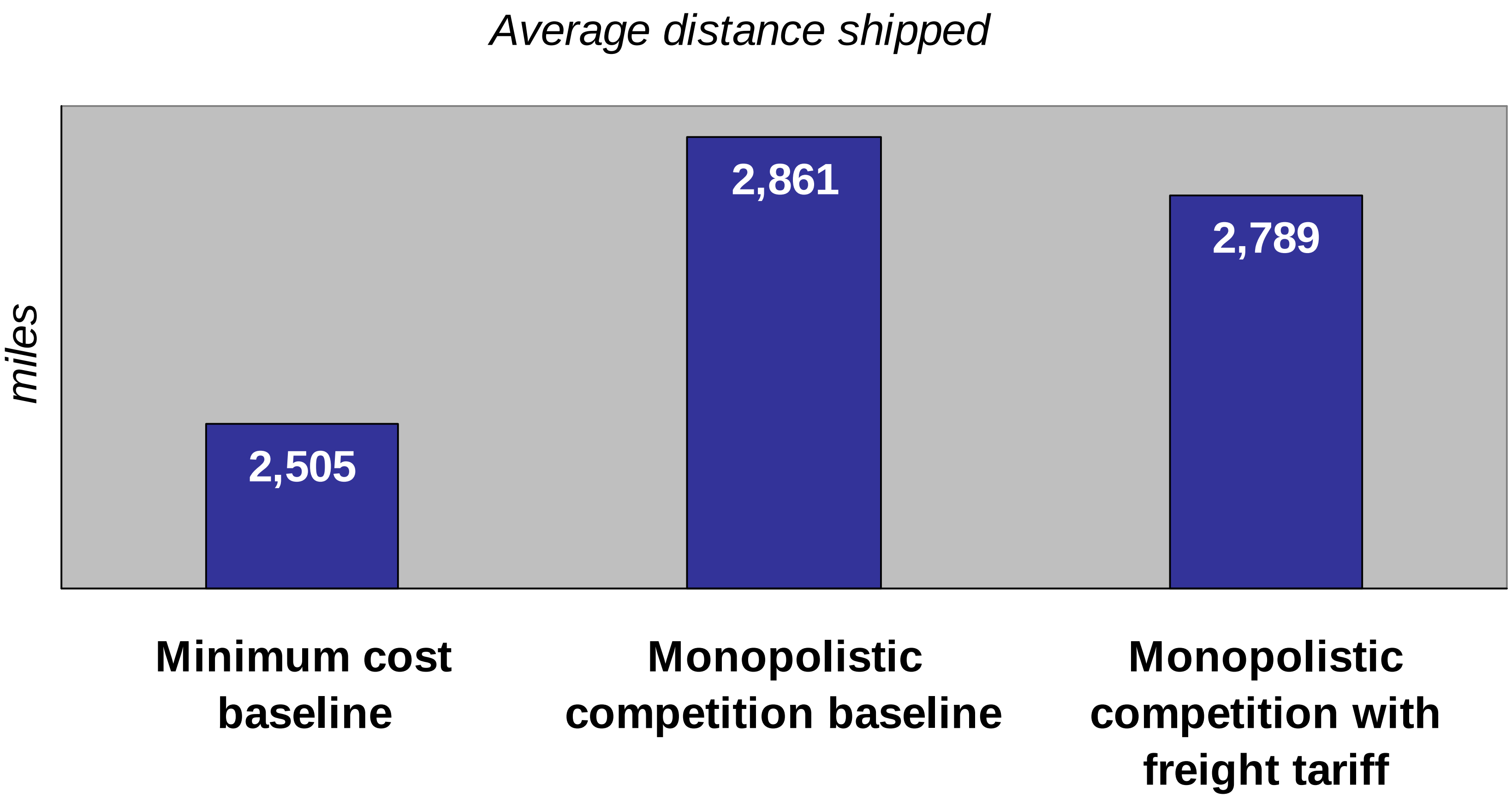
Average distance of wine shipments to U.S. markets: 2,505 miles

Policy Analysis: Energy Induced Trade Tariff

Assumptions:

1. a global energy price spike doubles the price per ton-hour of freight services
2. the average fob price for wine changes at the same rate as the price of the numeraire good (dq=0)
3. regional nominal incomes remain unchanged
4. short-run variable input supply to the wine industry is at a constant elasticity
   - two scenario's considered
     1. a 'flex' scenario with a 0.4 supply elasticity
     2. a 'rigid' scenario with a 0.04 supply elasticity

Average shipping distance comparisons: cost minimizing and differentiated product models*



*** Between 8 and 9 million tons of wine products were shipped to U.S. markets in 1997 (1997 Commodity Flows Survey and Census Bureau Foreign Trade Statistics), or roughly 1-billion ton/miles per 120 miles of shipping**

SUMMARY & FUTURE DIRECTIONS

- The degree of product differentiation within an industry has a substantial impact on the effectiveness of market based incentives, such as taxation on food miles or energy use, in affecting the spatial equilibrium intra-industry trade outcomes

- A multi-industry extension of this framework could be useful in examining the market for carbon trading, in which less differentiated industries could sell their excess carbon emission allotments to the more differentiated industries.

- Modal disaggregation, introduction of modal capacity constraints and network congestion, and explicit treatment of transshipments are natural extensions of this model framework that can enhance its usefulness for freight related policy analysis.

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